Annual Report of the Board of Regents

of the

SMITHSONIAN INSTITUTION

PUBLICATION 4354

Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30

1958

UNITED STATES
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LETTER OF TRANSMITTAL

SMITHSONIAN INSTITUTION,
Washington, December 31, 1958.

To the Congress of the United States:

In accordance with section 5593 of the Revised Statutes of the United States, I have the honor, on behalf of the Board of Regents, to submit to Congress the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year ended June 30, 1958. I have the honor to be,

Respectfully,

LEONARD CARMICHAEL, *Secretary.*

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THE SMITHSONIAN INSTITUTION

June 30, 1958

Presiding Officer ex officio.—DWIGHT D. EISENHOWER, President of the United States.

Chancellor.—EARL WARREN, Chief Justice of the United States.

Members of the Institution:

DWIGHT D. EISENHOWER, President of the United States.
RICHARD M. NIXON, Vice President of the United States.
EARL WARREN, Chief Justice of the United States.
JOHN FOSTER DULLES, Secretary of State.
ROBERT B. ANDERSON, Secretary of the Treasury.
NEIL H. MCELROY, Secretary of Defense.
WILLIAM P. ROGERS, Attorney General.
ARTHUR E. SUMMERFIELD, Postmaster General.
FRED A. SEATON, Secretary of the Interior.
EZRA TAFT BENSON, Secretary of Agriculture.
SINCLAIR WEEKS, Secretary of Commerce.
JAMES P. MITCHELL, Secretary of Labor.
MARION B. FOLSOM, Secretary of Health, Education, and Welfare.

Regents of the Institution:

EARL WARREN, Chief Justice of the United States, Chancellor.
RICHARD M. NIXON, Vice President of the United States.
CLINTON P. ANDERSON, Member of the Senate.
LEVERETT SALTONSTALL, Member of the Senate.
H. ALEXANDER SMITH, Member of the Senate.
OVERTON BROOKS, Member of the House of Representatives.
CLARENCE CANNON, Member of the House of Representatives.
JOHN M. VORYS, Member of the House of Representatives.
JOHN NICHOLAS BROWN, citizen of Rhode Island.
ARTHUR H. COMPTON, citizen of Missouri.
ROBERT V. FLEMING, citizen of Washington, D.C.
CRAWFORD H. GREENEWALT, citizen of Delaware.
CARYL P. HASKINS, citizen of Washington, D.C.
JEROME C. HUNSAKER, citizen of Massachusetts.

Executive Committee.—ROBERT V. FLEMING, *chairman*, CLARENCE CANNON, CARYL P. HASKINS.

Secretary.—LEONARD CARMICHAEL.

Assistant Secretaries.—J. L. KEDDY, A. REMINGTON KELLOGG.

Administrative assistant to the Secretary.—MRS. LOUISE M. PEARSON.

Treasurer—T. F. CLARK.

Chief, editorial and publications division.—PAUL H. OEHSER.

Librarian.—RUTH E. BLANCHARD.

Buildings Manager.—L. L. OLIVER.

Chief, personnel division.—J. B. NEWMAN.

Chief, supply division.—A. W. WILDING.

Chief, photographic laboratory.—F. B. KESTNER.

UNITED STATES NATIONAL MUSEUM

Director.—A. Remington Kellogg.
Administrative Assistant.—Mrs. Mabel A. Byrd.
Registrar.—Helena M. Weiss.

MUSEUM OF NATURAL HISTORY

Director.—A. Remington Kellogg, acting.

Department of Anthropology: F. M. Setzler, head curator.

Division of Archeology: W. R. Wedel, curator; Clifford Evans, Jr., Ralph S. Solecki, associate curators.

Division of Ethnology: S. H. Riesenberg, acting curator; R. A. Elder, Jr., assistant curator.

Division of Physical Anthropology: T. D. Stewart, curator; M. T. Newman, associate curator.

Department of Zoology: Herbert Friedmann, acting head curator.

Division of Mammals: D. H. Johnson, curator; C. O. Handley, Jr., H. W. Setzer, associate curators.

Division of Birds: Herbert Friedmann, curator; H. G. Deignan, associate curator.

Division of Reptiles and Amphibians: Doris M. Cochran, curator.

Division of Fishes: L. P. Schultz, curator; E. A. Lachner, W. R. Taylor, associate curators.

Division of Insects: J. F. G. Clarke, curator; O. L. Cartwright, R. E. Crabill, W. D. Field, associate curators; Sophy Parfin, junior entomologist.

Division of Marine Invertebrates: F. A. Chace, Jr., curator; F. M. Bayer, T. E. Bowman, C. E. Cutress, Jr., associate curators.

Division of Mollusks: H. A. Rehder, curator; J. P. E. Morrison, associate curator.

Department of Botany (National Herbarium): J. R. Swallen, head curator.

Division of Phanerogams: L. B. Smith, curator; R. S. Cowan, E. C. Leonard, Velva E. Rudd, E. H. Walker, associate curators.

Division of Ferns: C. V. Morton, curator.

Division of Grasses: J. R. Swallen, curator.

Division of Cryptogams: C. V. Morton, acting curator; P. S. Conger, M. E. Hale, Jr., associate curators; R. R. Ireland, Jr., assistant curator.

Department of Geology: G. A. Cooper, head curator.

Division of Mineralogy and Petrology: G. S. Switzer, curator; R. S. Clarke, Jr., P. E. Desautels, E. P. Henderson, associate curators.

Division of Invertebrate Paleontology and Paleobotany: G. A. Cooper, curator; R. S. Boardman, P. M. Kier, associate curators.

Division of Vertebrate Paleontology: C. L. Gazin, curator; D. H. Dunkle, P. P. Vaughn, associate curators.

MUSEUM OF HISTORY AND TECHNOLOGY

Director.—F. A. Taylor.
Assistant Director.—J. C. Ewers.
Administrative assistant.—W. E. Boyle.
Chief exhibits specialist.—J. E. Anglim.
Zoological exhibits specialist.—W. L. Brown.
Exhibits specialists.—B. S. Bory, R. O. Hower, B. W. Lawless, Jr.

DEPARTMENT OF SCIENCE AND TECHNOLOGY: R. P. Multhauf, head curator.

Division of Physical Sciences: R. P. Multhauf, curator.

Division of Mechanical and Civil Engineering: E. S. Ferguson, curator; E. A. Battison, associate curator; R. M. Vogel, assistant curator.

Division of Transportation: H. I. Chapelle, curator; K. M. Perry, associate curator.

Division of Agriculture and Wood Products: W. N. Watkins, curator; E. C. Kendall, associate curator.

Division of Electricity: W. J. King, Jr., acting curator.

Division of Medical Sciences: G. B. Griffenhagen, curator; J. B. Blake, associate curator.

DEPARTMENT OF ARTS AND MANUFACTURES: P. W. Bishop, head curator.

Division of Textiles: Grace L. Rogers, acting curator.

Division of Ceramics and Glass: P. V. Gardner, acting curator.

Division of Graphic Arts: Jacob Kainen, curator; A. J. Wedderburn, Jr., associate curator; F. O. Griffith, III, assistant curator.

Division of Industrial Cooperation: P. W. Bishop, curator.

DEPARTMENT OF CIVIL HISTORY: A. N. B. Garvan, head curator; Mrs. Margaret C. Clark, assistant curator.

Division of Political History: W. E. Washburn, acting curator; Mrs. Margaret B. Klapthor, associate curator; C. G. Dorman, Mrs. Anne W. Murray, assistant curators.

Division of Cultural History: C. M. Watkins, curator; G. C. Lindsay, associate curator; Rodris C. Roth, assistant curator.

Division of Philately and Postal History: F. J. McCall, acting curator.

Division of Numismatics: Vladimir Clain-Stefanelli, curator; Mrs. Elvira Clain-Stefanelli, assistant curator.

DEPARTMENT OF ARMED FORCES HISTORY: M. L. Peterson, head curator.

Division of Military History: E. M. Howell, acting curator; C. R. Goins, Jr., assistant curator.

Division of Naval History: M. L. Peterson, curator.

BUREAU OF AMERICAN ETHNOLOGY

Director.—F. H. H. Roberts, Jr.

Anthropologist.—H. B. Collins, Jr.

Ethnologist.—W. C. Sturtevant.

RIVER BASIN SURVEYS.—F. H. H. Roberts, Jr., *Director;* A. L. Stephenson, *Chief, Missouri Basin Project.*

ASTROPHYSICAL OBSERVATORY

Director.—F. L. Whipple.

Associate Directors.—J. A. Hynek, T. E. Sterne.

Assistant Director.—J. S. Rinehart.

Astrophysicists.—R. J. Davis, E. L. Fireman, L. G. Jacchia, Max Krook, F. B. Riggs, Jr., C. A. Whitney.

Mathematician.—R. E. Briggs.

TABLE MOUNTAIN, CALIF., FIELD STATION.—A. G. Froiland, *physicist.*

DIVISION OF RADIATION AND ORGANISMS:

Chief.—W. H. Klein, acting.

Plant physiologists.—V. B. Elstad, Leonard Price, Mrs. Alice P. Withrow.

Electronic engineer.—J. H. Harrison.

Instrument maker.—D. G. Talbert.

NATIONAL COLLECTION OF FINE ARTS

Director.—T. M. Beggs.

SMITHSONIAN TRAVELING EXHIBITION SERVICE.—Mrs. Annemarie H. Pope, *Chief*.

FREER GALLERY OF ART

Director.—A. G. Wenley.

Assistant Director.—J. A. Pope.

Associate in Near Eastern art.—Richard Ettinghausen.

Associate in technical research.—R. J. Gettens.

Associate curators.—J. F. Cahill, H. P. Stern.

NATIONAL AIR MUSEUM

Advisory Board:

Leonard Carmichael, *Chairman*.
Maj. Gen. Reuben C. Hood, Jr., U.S. Air Force.
Rear Adm. R. E. Dixon, U.S. Navy.
Lt. Gen. James H. Doolittle.
Grover Loening.

Director.—P. S. Hopkins.

Head curator and historian.—P. E. Garber.

Associate curators.—L. S. Casey, W. M. Male.

NATIONAL ZOOLOGICAL PARK

Director.—T. H. Reed.

Associate Director.—J. L. Grimmer.

CANAL ZONE BIOLOGICAL AREA

Resident Naturalist.—M. H. Moynihan.

INTERNATIONAL EXCHANGE SERVICE

Chief.—J. A. Collins.

NATIONAL GALLERY OF ART

Trustees:

EARL WARREN, Chief Justice of the United States, *Chairman*.
JOHN FOSTER DULLES, Secretary of State.
ROBERT B. ANDERSON, Secretary of the Treasury.
LEONARD CARMICHAEL, Secretary of the Smithsonian Institution.
F. LAMMOT BELIN.
DUNCAN PHILLIPS.
CHESTER DALE.
PAUL MELLON.
RUSH H. KRESS.

President.—CHESTER DALE.

Vice President.—F. LAMONT BELIN.

Secretary-Treasurer.—HUNTINGTON CAIRNS.

Director.—JOHN WALKER.

Administrator.—ERNEST R. FEIDLER.

General Counsel.—HUNTINGTON CAIRNS.

Chief Curator.—PERRY B. COTT.

Honorary Research Associates, Collaborators, and Fellows

Office of the Secretary

John E. Graf

United States National Museum

MUSEUM OF NATURAL HISTORY

Anthropology

Mrs. Arthur M. Greenwood.
N. M. Judd, Archeology.
H. W. Krieger, Ethnology.
Betty J. Meggers, Archeology.
W. W. Taylor, Jr., Archeology.
W. J. Tobin, Physical Anthropology.

Zoology

Paul Bartsch, Mollusks.
J. Bruce Bredin.
M. A. Carriker, Insects.
C. J. Drake, Insects.
Isaac Ginsberg, Fishes.
D. C. Graham.
Horton H. Hobbs, Jr., Marine Invertebrates.
A. B. Howell, Mammals.
Laurence Irving, Birds.
W. L. Jellison, Insects.
Allen McIntosh, Mollusks.
J. P. Moore, Marine Invertebrates.
C. F. W. Muesebeck, Insects.
W. L. Schmitt.
Benjamin Schwartz, Helminthology.
C. R. Shoemaker, Marine Invertebrates.
R. E. Snodgrass, Insects.
T. E. Snyder, Insects.
Alexander Wetmore, Birds.
Mrs. Mildred S. Wilson, Copepod Crustacea.

Botany

Mrs. Agnes Chase, Grasses.
E. P. Killip, Phanerogams.
F. A. McClure, Grasses.
J. A. Stevenson, Fungi.

Geology

R. S. Bassler, Paleontology.
R. W. Brown, Paleobotany.
Preston Cloud, Invertebrate Paleontology.
C. Wythe Cooke, Invertebrate Paleontology.
J. B. Knight, Invertebrate Paleontology.
J. B. Reeside, Jr., Invertebrate Paleontology.
W. T. Schaller, Mineralogy.

MUSEUM OF HISTORY AND TECHNOLOGY

Arts and Manufactures

F. L. Lewton, Textiles.

History

Elmer C. Herber.
F. W. MacKay, Numismatics.
Carroll Quigley, Political History.
P. A. Straub, Numismatics.

Bureau of American Ethnology

J. P. Harrington.
Sister M. Inez Hilger.
M. W. Stirling.
A. J. Waring, Jr.

Astrophysical Observatory

C. G. Abbot.

Freer Gallery of Art

Oleg Grabar.
Grace Dunham Guest.
Max Loehr.
Katherine N. Rhoades.

National Air Museum

Frederick C. Crawford.
John J. Ide.

National Zoological Park

W. M. Mann.
E. P. Walker.

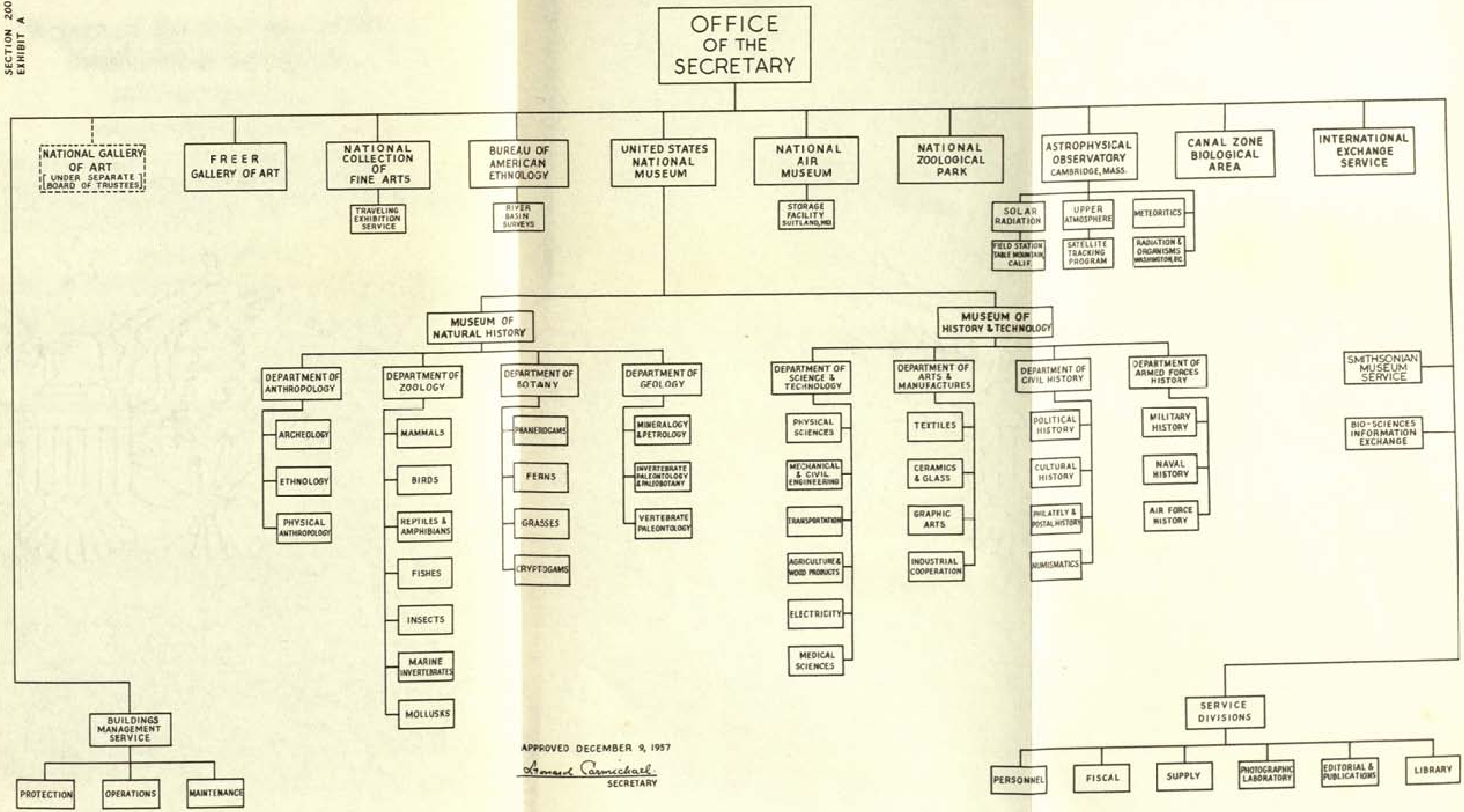
Canal Zone Biological Area

C. C. Soper.
James Zetek.

SECTION 200
EXHIBIT A

SMITHSONIAN INSTITUTION

ORGANIZATION CHART



APPROVED DECEMBER 9, 1957

Leonard Carmichael
SECRETARY

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Report of the Secretary of the Smithsonian Institution

LEONARD CARMICHAEL

For the Year Ended June 30, 1958

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: I have the honor to submit a report showing the activities and condition of the Smithsonian Institution and its branches for the fiscal year ended June 30, 1958.

GENERAL STATEMENT

The 112th year of the Smithsonian Institution, whose activities are recorded in this report, has demonstrated anew that James Smithson's scientifically and philosophically oriented mind conceived an effective enterprise when he specified that the establishment he founded and endowed should devote itself to "the increase and diffusion of knowledge among men." These two related objectives still guide and inspire the varied and constructive activities of his Institution. *Increase of knowledge* well describes the scientific and scholarly research that is effectively carried on by Smithsonian staff members. *Diffusion of knowledge* aptly summarizes the development of public museum displays, the presentation of lectures, the conduct of a great official correspondence about science and related matters, and the issuing of scientific and popular publications by the Institution.

During the year here reported upon 10,365,872 individuals visited the Smithsonian, if all its branches are considered. This is a truly amazing and significant fact, for probably no other museum group anywhere, comparable at all to the Smithsonian Institution, has ever been visited by so many people in a single year. It is interesting to note, however, that a growth in the recognition of the importance of national museums seems to characterize not only America but also many of the other nations of the world at the present time. As the United States becomes more certain of its established place in the world, its citizens seem to become increasingly interested in the unique type of knowledge about American natural resources and American civilian, military, and technological history that can be acquired at their Smithsonian. Our records show that the Institution now has

nearly 51 million cataloged objects in its collections. In number of items, therefore, as well as of visitors, the Smithsonian Institution is certainly one of the largest museum complexes, if not the largest, on the face of the globe.

The fact that the Smithsonian possesses such great collections and also attracts such armies of visitors makes it very important that the public displays of its museums be prepared and presented in the most interesting and instructive manner for the benefit of all who come through its doors. It is a pleasure, therefore, to report that real progress was made during the year in the renovation of exhibits in the older buildings of the Smithsonian. Detailed planning has also been carried on in preparation for the construction of the great exhibits that must be ready for immediate installation when the structure of the Institution's new Museum of History and Technology building is completed in 1961.

Since the Institution's program of modernizing exhibitions began about 5 years ago, more than a dozen new exhibit halls have been opened in our older buildings—the First Ladies Hall, two halls portraying North American Indians and Eskimos, the Hall of Latin American Archeology, Birds of the World, North American Mammal Hall, Everyday Life in Early America, the Hall of Power Machinery, the Hall of Health, the Printing Arts Hall, the Hall of Gems and Minerals, and the Halls of Naval and Military History. These new halls represent notable accomplishments and have attracted wide and favorable notice, not only from the general public but also from museum technicians and specialists in visual education here and abroad.

This current improvement of Smithsonian museum units is thus really part of a new worldwide regard for the educational function of museums. This growth is attested by the reports of the International Museums Office in Paris. Hardly a nation can be named that is not now engaged in new developments of buildings or displays in its national museums. It is interesting that such projects are being carried out on a large scale in Russia and its satellite states as well as in western nations.

This new emphasis upon the preservation for posterity and the effective display of objects that represent the resources and the physical development of each nation may well have been fostered by mankind's recognition of the destruction of its heritage that was brought about by two world wars. In this sense every great museum stands as a tribute to mankind's faith in the continuity of human achievement. Each such institution attests a recognition that the future is best when it is solidly grounded upon a knowledge of past achievements.

The objective of the new museum development at the Smithsonian is to display examples of the mineral and biological resources of our nation and of the world and to epitomize the human achievements that have made our country great and strong.

More than 60 years ago a notable museum scholar, George Brown Goode, Assistant Secretary of the Smithsonian Institution, defined a museum as "an institution for the preservation of those objects which best illustrate the phenomena of nature and the works of man, and the utilization of these for the increase of knowledge and for the culture and enlightenment of the people." This fundamental conception has not changed with the years. But methods and techniques for meeting this objective do change. Dr. Goode further stated, "The museum of the past must be set aside, reconstructed, transformed from a cemetery of bric-a-brac into a nursery of living thoughts. The museum of the future must stand side by side with the library and the laboratory . . . as one of the principal agencies for the enlightenment of the people." What could better describe what has been going on in the Smithsonian's museums during recent years? Those who have these renovations in charge are trying to give the Smithsonian educational exhibitions that are appropriate and adequate to the mental outlook of a 20th-century America.

In the Smithsonian's new Museum of History and Technology building, now under construction, there will be displayed from our vast collections the truly breathtaking story of the rise and interrelated growth of the civilian, military, and technological aspects of American life. In this building the relationship of pure and applied science will be presented in an effective way, patterned to some extent upon the manner in which this relationship is so well displayed in a number of great European museums. In the new Smithsonian building, however, the strands that have been woven together in the making of our modern American civilization will be shown in a way that it is hoped will be unique and particularly appropriate to the special genius of our country.

The existing exhibits of the Smithsonian Institution and the new exhibits now being planned can be thought of as significant not only in the knowledge but also in the motivation that they may instill in many of the millions of high-school visitors who come to the Smithsonian each year. In a free society, boys and girls are not drafted and forced to study mathematics or physics or any other subject that may be required by the state. Our society depends upon the slower, but certainly in the long run the sounder, technique of first arousing the students' interest and then providing them with needed educational opportunities. Certainly great museums, such as those directed by the Smithsonian, are able in an important way to inspire

and provide educational motivation for not a few of its millions of visitors each year. Because of the present importance of interesting enough talented students in scientific studies to assure that our country will remain scientifically and technologically strong, it is especially fortunate that at just this time the work of the Smithsonian is becoming so effective in displaying the essential relationship between pure and applied science and in demonstrating how research has led to progress in many fields in recent years.

It should be recorded also that forward steps were made during the year in planning new wings for the Natural History Building, as authorized by Congress last year.

As the detailed statements of the various bureau directors of the Smithsonian presented in this report demonstrate, the Institution is by no means exclusively concerned with museum displays. This year's record of publications indicates that the Institution is now, as in past years, playing a vital role in the communication of scientific information to the laboratories and research centers of the nation and the world. This year also the Smithsonian has issued some popular works based upon its collections for the information of a broader public.

One of the most dramatic aspects of the work of the Institution during the time covered by this report is that of the Smithsonian Astrophysical Observatory. Funds have been provided for some of the work of this bureau by grants from foundations and from the committee in charge of the International Geophysical Year. As a result of the use of these special funds, it has been possible to establish Smithsonian Institution observing centers for artificial satellites in the following locations: Argentina, Australia, Florida, Hawaii, Japan, India, Iran, Curaçao, New Mexico, Peru, South Africa, and Spain. The observations at these centers have also been made more adequate by the installation in each of them of a newly devised type of astronomical camera or recording telescope that has unique features. Information obtained from these stations is communicated to the headquarters of the Smithsonian Astrophysical Observatory at Cambridge, Massachusetts. At this center calculations are made that have allowed the Institution to describe the orbits of all the major artificial satellites and to make accurate predictions concerning the characteristics of their motions.

As noted below in special sections, this report year has indeed been one of progress in many aspects of the work of the Institution.

THE ESTABLISHMENT

The Smithsonian Institution was created by act of Congress in 1846, in accordance with the terms of the will of James Smithson, of

England, who in 1826 bequeathed his property to the United States of America "to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men." In receiving the property and accepting the trust, Congress determined that the Federal Government was without authority to administer the trust directly, and, therefore, constituted an "establishment," whose statutory members are "the President, the Vice President, the Chief Justice, and the heads of the executive departments."

THE BOARD OF REGENTS

There was no change during the current year in the membership of the Board of Regents. The roll of Regents at the close of the fiscal year was as follows: Chief Justice of the United States Earl Warren, Chancellor; Vice President Richard M. Nixon; members from the Senate: Clinton P. Anderson, Leverett Saltonstall, H. Alexander Smith; members from the House of Representatives: Overton Brooks, Clarence Cannon, John M. Vorys; citizen members: John Nicholas Brown, Arthur H. Compton, Robert V. Fleming, Crawford H. Greenewalt, Caryl P. Haskins, and Jerome C. Hunsaker.

The informal dinner meeting of the Board, preceding the annual meeting, was held on the evening of January 16, 1958, in the main hall of the Smithsonian Building. Here various exhibits were displayed showing phases of present-day projects. Dr. G. Arthur Cooper spoke on brachiopods as a key to the past, Dr. Anthony N. B. Garvan talked about colonial silver, Dr. Ralph S. Solecki spoke on "The Discovery of the First Neanderthals in Mesopotamia," and Archibald G. Wenley compared the Far Eastern collections in the Freer Gallery of Art with those abroad.

The regular annual meeting of the Board was held on January 17, 1958. The Secretary presented his published annual report on the activities of the Institution together with the 1957 annual report of the United States National Museum. Dr. Robert V. Fleming, chairman of the executive and permanent committees of the Board, gave the financial report for the fiscal year ended June 30, 1957.

FINANCES

A statement on finances, dealing particularly with Smithsonian private funds, will be found in the report of the executive committee of the Board of Regents, page 223.

APPROPRIATIONS

Funds appropriated to the Institution for its regular operations for the fiscal year ended June 30, 1958, totaling $6,102,319 were obligated as follows:

Management	$82,411
United States National Museum	2,491,164
Bureau of American Ethnology	61,197
Astrophysical Observatory	384,237
National Collection of Fine Arts	51,346
National Air Museum	139,646
Canal Zone Biological Area	35,128
International Exchange Service	77,386
Buildings Management Service	1,888,183
Other general services	765,995
Additional costs due to increase in pay scales, Act of January 20, 1958 (P.L. 85-462)	125,626

In addition, the sum of $800,000 was appropriated for the preparation of plans and specifications for the additions to the Natural History Building.

Besides these direct appropriations, the Institution received funds by transfer from other Government agencies as follows:

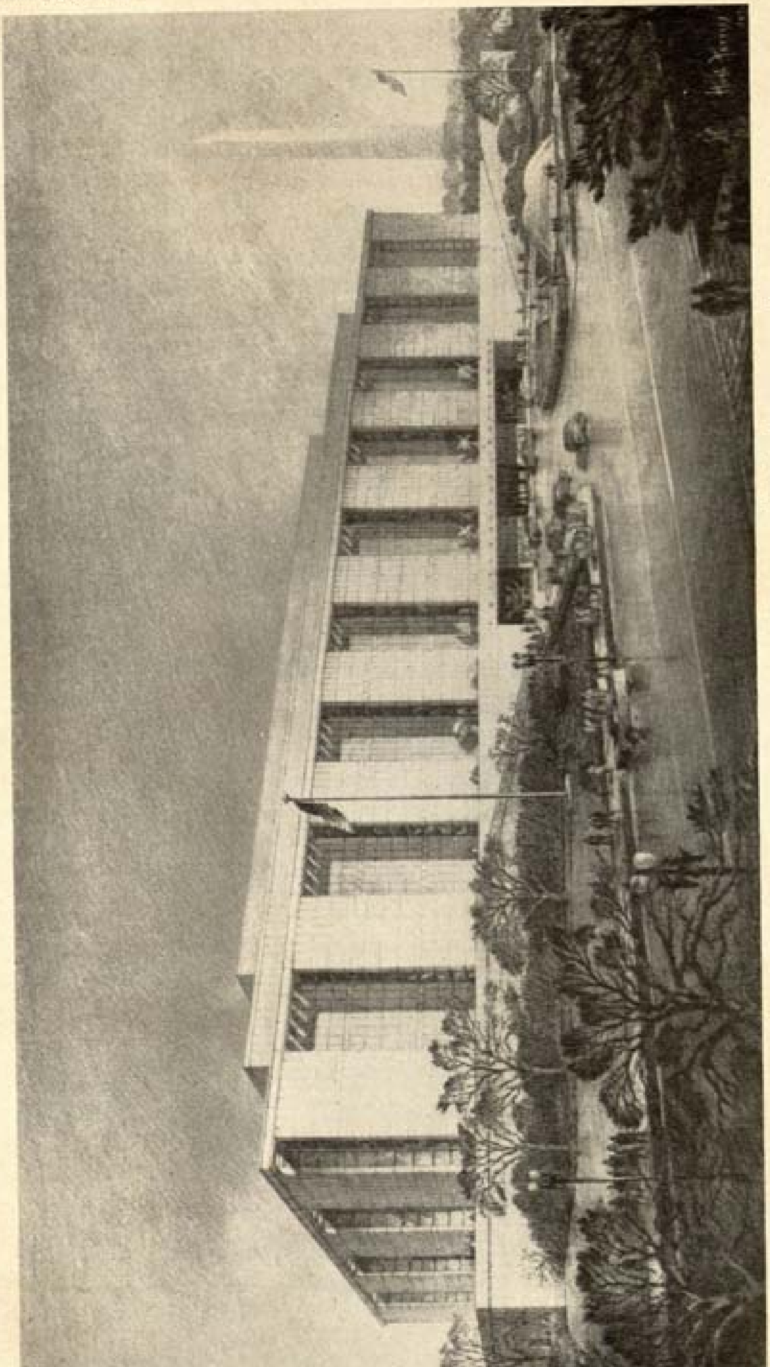
From the District of Columbia for the National Zoological Park	$840,650
From the National Park Service, Department of the Interior, for the River Basin Surveys	175,624

VISITORS

Again this year an all-time high was reached in the number of visitors to the Smithsonian group of buildings on the Mall. The total was 5,423,771, about 582,000 more than the previous year. April 1958 was the month of largest attendance, with 864,451; August 1957 second, with 765,129; July 1957 third, with 763,817. Largest attendance for a single day was 69,349 on April 27, 1958. On the same day—the first Sunday of the Churchill exhibition of paintings, 42,524 came to the Natural History Building alone. Table 1 gives a summary of

TABLE 1.—*Visitors to certain Smithsonian buildings during the year ended June 30, 1958*

Year and month	Smithsonian Building	Arts and Industries Building	Natural History Building	Aircraft Building	Freer Building	Total
1957						
July	123,261	364,045	150,915	109,751	15,845	763,817
August	120,842	370,605	157,392	99,085	17,205	765,129
September	47,693	139,838	76,694	55,156	7,687	327,068
October	37,482	116,432	78,094	27,893	5,902	265,803
November	41,119	104,186	80,824	34,724	5,971	266,824
December	28,066	69,904	56,043	25,075	3,813	182,901
1958						
January	26,645	57,466	61,422	21,269	4,853	171,655
February	19,599	51,369	46,272	15,737	3,517	136,494
March	36,522	140,041	102,677	37,494	6,209	322,943
April	106,023	392,292	236,565	115,032	14,539	864,451
May	119,713	330,738	210,515	89,134	12,107	762,207
June	108,843	251,939	144,359	75,312	14,026	594,479
Total	815,808	2,388,855	1,401,772	705,662	111,674	5,423,771



Architect's rendering of the Smithsonian's new Museum of History and Technology now under construction.

the attendance records for the five buildings. These figures, when added to the 913,482 visitors recorded at the National Gallery of Art and the 4,028,620 estimated at the National Zoological Park, make a total number of visitors at the Institution of 10,365,876.

LECTURES

The annual James Arthur Lecture on the Sun, customarily held in the spring, was postponed this year until fall. The 25th Arthur Lecture, therefore, will be recorded in next year's report.

Dr. Rodney S. Young, curator of the Mediterranean Section of the University Museum at Philadelphia and professor of classical archeology at the University of Pennsylvania, delivered a lecture on "Recent Discoveries at Gordion" in the auditorium of the Natural History Building on the evening of February 27, 1958. This lecture was sponsored jointly by the Smithsonian Institution and the Archeological Institute of America.

Several lectures were also sponsored by the Freer Gallery of Art and the National Gallery of Art. These are listed later in the reports of these bureaus.

BIO-SCIENCES INFORMATION EXCHANGE

The current interest in and growing support of research in the bio-sciences have resulted in a considerable growth in the activities of the Bio-Sciences Information Exchange. This agency, which operates within the Smithsonian Institution under funds made available to the Institution by other agencies, remains the most comprehensive clearinghouse for current research in the life sciences. Through its extensive and detailed system of indexing it acts as a rapid means of communication among research workers.

The active research projects registered with the Exchange now number more than 17,000. For each project the investigator has prepared a brief summary of his current problem. These summaries are made available upon request and without charge to staff members of research institutions. The Exchange also functions to prevent unknowing duplication of research support by the national governmental and nongovernmental granting agencies. In carrying out this responsibility a vast amount of data on the support of research in the life sciences has been accumulated. Information of this type is continually used by granting agencies in planning their current and future activities.

SUMMARY OF THE YEAR'S ACTIVITIES

National Museum.—Accessions to the national collections during the year brought the total catalog entries in all departments to nearly

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51,000,000. Some of the outstanding items received included: In anthropology, casts of the newly discovered Neanderthal skeleton from Iraq, a selection of ethnological objects from Palau and others from the Orient and Ethiopia, and a large series of artifacts deriving from excavations of the River Basin Surveys; in zoology, a collection of mammals from Panama, birds from Ghana, Rhodesia, and Yukon Territory, a cast of the recently discovered living coelacanth, the Carl J. Drake collection of over 100,000 Hemiptera, the Tippmann collection of nearly 98,000 wood-boring beetles, the Buys collection of over 12,000 leafhoppers, the Osburn collection of about 3,500 Bryozoa, and a large lot of mollusks collected on the Smithsonian-Bredin Pacific Expedition; in botany, a collection of nearly 11,000 lichens from eastern and southern United States and 15,000 phanerogams from Brazil; in geology, 10 new meteorites and many rare and fine minerals and gems, 21,000 fossil crinoids, and 330 specimens of middle Eocene vertebrates from southeastern Wyoming; in armed forces history, several rare firearms and a group of naval ordnance materials recovered from a 1595 wreck off Bermuda; in science and technology, a foot-power milking machine, 1,400 important wood samples in the form of walking sticks, several interesting electronic items, an 1844 steam pump, and the "transparent woman" exhibited in the new Hall of Health; in arts and manufactures, a model of the Hargreave spinning jenny and ceramic and glass items from the Aaron Straus collection; and in civil history, a valuable collection of Lincoln memorabilia, the inaugural dress of Dolley Madison, furnishings and fittings of the Stohlman Confectionery Shop of Georgetown, D.C. (dating from about 1900), and 5,801,500 United States obsolete revenue stamps transferred from the Internal Revenue Service.

Members of the staff conducted fieldwork in Iraq, Japan and Okinawa, Africa, Panama, Europe, and many parts of the United States.

Under the exhibits-modernization program three new halls were opened to the public during the year—the Hall of Health, the Hall of North American Indians and Eskimos, and the Hall of Military History.

Bureau of American Ethnology.—Dr. Frank H. H. Roberts, Jr., was made Director of the Bureau on January 1, 1958, filling the position made vacant by the retirement of Dr. M. W. Stirling. The staff members continued their research and publication activities: Dr. Roberts continued as Director of the River Basin Surveys, Dr. Collins continued his Eskimo and Arctic studies, Dr. Sturtevant carried on ethnologic fieldwork in South Carolina, New York, and Florida, and Mr. Miller renewed his excavations at Russell Cave, Alabama.

Astrophysical Observatory.—The work of the Smithsonian Astrophysical Observatory continued along four principal lines—solar astrophysics, upper atmosphere, meteors, and the satellite tracking program. The last-named operation was, of course, fully activated following the Russian launching of the first artificial earth satellite on October 4, 1957. The division of radiation and organisms continued its researches on photomechanisms in plants.

National Collection of Fine Arts.—The Smithsonian Art Commission accepted for the Gallery 1 bronze, 2 oil paintings, 1 watercolor on ivory, and the Gothic library and 18th-century French Renaissance drawingroom from "Miramar," Newport, R.I. The Gallery held 13 special exhibitions during the year, and the Smithsonian Traveling Exhibition Service circulated 96 exhibitions in 264 museums and galleries.

Freer Gallery of Art.—Purchase for the Freer Gallery collections included Chinese bronzes, ivory, jade, painting, and pottery; Japanese painting, wood sculpture, and pottery; Egyptian glass; Persian metalwork, pottery, and manuscript; and Mesopotamian pottery. The Gallery continued its program of illustrated lectures in the auditorium by distinguished scholars in eastern art, the 1957–58 series numbering 6.

National Air Museum.—Good progress was made toward locating a site for a new building for the museum. During the year 193 specimens in 52 separate accessions were added to the aeronautical collections, including a "Falcon" GAR–1 guided missile, a Verville-Sperry "Messenger" airplane of 1920, the Herrick "Vertoplane" of 1937, a bronze statue of Brig. Gen. William Mitchell, and a "Vanguard" rocket-powered satellite vehicle.

National Zoological Park.—The Zoo accessioned 1,411 individual animals during the year. The net count at the close of the year was 2,316. Noteworthy among the additions were a pair of trumpeter swans, three Tasmanian devils, a pair of great black-casqued hornbills, and a linsang from Malaya. A snow leopard was born in captivity, an extremely rare event. Visitors totaled more than 4 million.

Canal Zone Biological Area.—Of the approximately 570 visitors to the island during the year, 43 were scientists, students, and observers using the station for special researches, particularly in wildlife observation, plant and insect studies, and photography.

International Exchange Service.—As the official United States agency for the exchange of governmental, scientific, and literary publications between this country and other nations, the International Exchange Service handled during the year 1,094,798 packages of such publications, weighing 743,329 pounds.

National Gallery of Art.—The Gallery during the year received 1,730 accessions by gift, loan, or deposit. Ten special exhibitions were held, and 18 traveling exhibitions of prints from the Rosenwald Collection were circulated elsewhere. Exhibitions from the "Index of American Design" were given 26 bookings in 9 States. Nearly 44,000 persons attended the general tours conducted by Gallery personnel, and over 8,000 attended tours and lectures by special appointment. The Sunday afternoon lectures drew a total attendance of about 13,000 persons. The Sunday evening concerts in the east garden court were continued.

Library.—The library received a total of 53,274 publications during the year; 128 new exchanges were arranged. Outstanding among the gifts were a large collection of philatelic items and nearly 2,700 books and reprints on Diptera. At the close of the year the holdings of the library and all its branches aggregated 974,893 volumes, including 586,722 in the Smithsonian Deposit at the Library of Congress but excluding unbound periodicals and reprints and separates from serial publications.

Publications.—Eighty-one new publications appeared under Smithsonian imprint during the year. (See Report on Publications, p. 215, for full list.) Outstanding among these were: "Araucanian Child Life and Its Cultural Background," by Sister M. Inez Hilger; "The Medical and Veterinary Importance of Cockroaches," by Louis M. Roth and Edwin R. Willis; "Geology of Barro Colorado Island, Canal Zone," by W. P. Woodring; "The History of Entomology in World War II," by Emory C. Cushing; "Life Histories of North American Blackbirds, Orioles, Tanagers, and Allies," by Arthur Cleveland Bent; "Studies in Foraminifera," by Alfred R. Loeblich, Jr., and collaborators; "The Bromeliaceae of Colombia," by Lyman B. Smith; "Archeological Investigations at the Mouth of the Amazon," by Betty J. Meggers and Clifford Evans; "Orbital Data and Preliminary Analyses of Satellites 1957 Alpha and 1957 Beta," by various authors; and Ars Orientalis, volume 2. Three popular publications were issued. In all, 530,662 copies of printed matter were distributed.

CHANGES IN ORGANIZATION AND STAFF

John E. Graf, Assistant Secretary, retired on December 31, 1957, after more than 26 years with the Institution, first as Associate Director of the United States National Museum and since 1945 as Assistant Secretary of the Institution.

On February 4, 1958, Dr. Remington Kellogg was appointed Assistant Secretary of the Institution. Dr. Kellogg has been a member of the Smithsonian staff since 1928—since 1948 as Director of the

United States National Museum. He is continuing his directorship of the Museum.

Frank A. Taylor was made Director of the Museum of History and Technology on April 16, 1958, having served from 1932 to 1948 as curator of the division of engineering, from 1948 to 1955 as head curator of the department of arts and industries, and then as Assistant Director of the United States National Museum.

Dr. Matthew W. Stirling retired as Director of the Bureau of American Ethnology on December 31, 1958. He had headed the Bureau since 1928, prior to which he had served the Institution in the National Museum's department of anthropology. Dr. Frank H. H. Roberts, Jr., Associate Director of the Bureau and since 1946 director of the River Basin Surveys, was appointed the new Director to succeed Dr. Stirling.

Dr. Theodore H. Reed was made Director of the National Zoological Park effective March 12, 1958. He was first appointed to the staff in July 1955 as chief veterinarian, a position he held until November 1956, when he became Acting Director upon the retirement of Dr. William M. Mann. Also on March 12, J. Lear Grimmer, Assistant Director of the Park, was made Associate Director.

Philip S. Hopkins, professor of aviation and head of the department of aviation at Norwich University, Northfield, Vt., was appointed Director of the National Air Museum effective October 28, 1957. At the same time Paul E. Garber, head curator of the Air Museum, was given the title head curator and historian to reflect an extension of his duties.

Jeremiah A. Collins was appointed Chief of the International Exchange Service on March 10, 1958, succeeding Dan G. Williams, Jr., who transferred to the Department of Health, Education, and Welfare.

On August 12, 1957, Dr. Martin H. Moynihan was appointed Resident Naturalist of the Canal Zone Biological Area.

Miss Ruth E. Blanchard, former chief of the catalog section, was made chief librarian of the Institution on September 23, 1957, filling the position made vacant by the retirement of Mrs. Leila F. Clark on August 31.

Report on the United States National Museum

Sir: I have the honor to submit the following report on the condition and operations of the United States National Museum for the fiscal year ended June 30, 1958:

COLLECTIONS

Because of the reorganization of the Museum effected at the beginning of the year (as described on p. 43), it was necessary to reassign some of the specimens among the now eight departments of the Museum. This accounts for lower totals in some instances. Specimens were added to the national collections and distributed among the departments as follows: Anthropology, 4,373; zoology, 525,458; botany, 57,795; geology, 43,275; armed forces history, 1,283; arts and manufactures, 230; civil history, 5,858,683; and science and technology, 3,457. Most of the specimens were received as gifts from individuals or as transfers from Government departments and agencies. The Annual Report of the Director of the Museum, published as a separate document, contains a detailed list of the year's accessions, of which the more important are summarized below. Catalog entries in all departments now total 50,963,147.

Anthropology.—One of the most unique accessions received in the department of anthropology is a set of casts of the restorable parts of a Neanderthal skeleton from northern Iraq. The skeleton casts of this newly discovered fossil man represent the work of two men in the department: Dr. Ralph S. Solecki, recently appointed associate curator in the division of archeology, who made the discovery in his excavation of Shanidar Cave in northern Iraq; and the curator of physical anthropology, Dr. T. Dale Stewart, who went to Baghdad, restored the original skull and long bones, and made plaster replicas. These casts, the first to reach this country, were donated to the national collections by the Directorate General of Antiquities, Iraq.

The division of ethnology received a special selection of objects from Palau in the Caroline Islands through Dr. Delmas Nucker, High Commissioner, Trust Territory of the Pacific Islands. This accession includes a model abai or men's house, wooden bowls, tortoise-shell money, and native implements. From the Aaron and Lillie Straus

Foundation, Inc., of Baltimore, the ethnological collections were enriched by 148 objects consisting of glass snuff bottles, carved minerals, and ivory netsukes from China and Japan. The division received as a gift from Mrs. Elizabeth George a collection from Ethiopia of six large contemporary oil paintings depicting scenes of battle and of daily life, an Abyssinian manuscript Bible, silver buttons, and other objects illustrating Ethiopian craftsmanship in embossing, etching, and silver-wire filigree.

Of outstanding interest among the year's accessions in archeology were two prehistoric specimens from Peru—one, a wooden doll dressed in native textiles, from the Central Coast, and the other, a gold mummy mask of the Chimu Period (ca. A.D. 1100), presented by Mrs. Virginia Morris Pollak. A large series of pottery, stone, bone, and other artifacts from the Black Widow site, and a smaller series from the Buffalo Pasture site in Stanley County, S. Dak., represent the results of River Basin Surveys excavations at two sites that will be destroyed by the lake created by the Oahe Dam a few miles north of Pierre. These two collections throw important light on the native village Indian culture of the Upper Missouri region in the 16th and 17th centuries. Mention should also be made of a large, well-documented collection of archeological material from 23 States and the District of Columbia presented by Richard Gates Slattery.

Zoology.—The most important collection of mammals received during the year comes from Panama, where Dr. C. O. Handley, Jr., associate curator, collected over 1,300 specimens in cooperation with the Gorgas Memorial Laboratory. Valuable cetaceans were received from three different sources: An embalmed pigmy sperm whale (*Kogia*) from the Marine Institute of the University of Georgia, the skull of an Alaskan beaked whale (*Ziphius*) from Dr. Robert Rausch, and the complete skeleton of another kind of beaked whale (*Mesoplodon*) from Florida salvaged by John L. Paradiso, museum aide.

Among birds received during the year the following lots are the most important: 193 specimens from Ghana, collected and presented by D. W. Lamm, form the Museum's first sizable collection from that part of western Africa; 200 skeletons of Rhodesian birds, received from the Smithsonian Institution, through Dr. A. Wetmore, has added importantly to our skeletal material; 358 birds from Yukon Territory, received by transfer from the Arctic Health Research Center, through Dr. Laurence Irving, enhances the usefulness of the division's Arctic American material.

Important type specimens received in the division of reptiles and amphibians include 6 paratypes of Cuban frogs, in exchange from the Museum of Comparative Zoology; 2 paratypes of lizards from

New Guinea and Borneo obtained as an exchange from the Chicago Natural History Museum; 17 paratypes of Mexican reptiles and amphibians from the University of Illinois Museum of Natural History; a valuable lot of 128 reptiles and amphibians from Formosa collected by Naval Medical Research Unit No. 2, and the Museum's first example of a leatherback turtle from Cuba, presented by the Museo Ignacio Agramonte.

Among fishes received is a cast of the recently discovered living representative *Latimeria chalumnae* of the otherwise wholly fossil coelacanths purchased from the Muséum National d'Histoire Naturelle, Paris. This interesting specimen was placed on exhibition. A collection of 15,897 fresh-water fishes from West Virginia was presented by Dr. F. J. Schwartz; another lot of 3,398 fishes, mostly seahorses, was received from Dr. Kirk Strawn; and 1,185 Australian fishes were received in exchange from Prof. L. R. Rivas of the University of Miami—an important addition to the Museum's Australian collections, since it included numerous species not previously represented here. The New York Zoological Society presented 73 holotypes and 62 paratypes of tropical fishes, through Dr. William Beebe.

Insect material constitutes the bulk of the year's accessions numerically. The largest single lot is the famous Carl J. Drake collection of Hemiptera, worldwide in scope and comprising over 100,000 specimens and containing more than 1,000 types. The valuable and important Tippmann collection of wood-boring beetles, Cerambycidae, comprising 97,830 specimens, was purchased with assistance of a grant from the National Science Foundation. This material, with 611 holotypes, 1,415 paratypes, and cotypes, is a useful supplement to the specimens already in the collections since it originates largely from regions not heretofore represented. Other important accessions of insects are the John L. Buys collection of 12,128 leafhoppers (Homoptera), presented by Mrs. Buys, and the David Dunavan collection of 4,386 North American beetles, presented by Mrs. Dunavan.

The Raymond C. Osburn collection of 3,572 bryozoans, including 145 type lots, together with extensive manuscript notes and microfilm of Dr. Osburn's library catalog and bibliography, was presented by Mrs. Osburn to the division of marine invertebrates. This accession is an important enrichment of the Museum's facilities in this area of research. Other notable accessions include 4,956 miscellaneous invertebrates from the Palau Islands received from the George Vanderbilt Foundation and the Office of Naval Research, through Dr. F. M. Bayer; 10,991 specimens from waters off Surinam, transferred from the U.S. Fish and Wildlife Service; 2,850 crustaceans, largely copepods, chiefly from Africa, containing 2 holotypes and 388 paratypes, presented by Dr. A. G. Humes; 685 crustaceans, including the holo-

type and 16 paratypes of one species, given by Dr. James E. Lynch; 2,341 polychaete worms and crustaceans from Lake Pontchartrain, La., a gift from Dr. Rezneat M. Darnell.

The largest important accession acquired by the division of mollusks is the collection totaling 14,350 specimens made mainly by the curator, Dr. Harald A. Rehder, on the Smithsonian-Bredin Expedition to the Society, Tuamotu, and Cook Islands. Other notable accessions are 1,600 specimens of marine mollusks from the Palau Islands received from the George Vanderbilt Foundation and the Office of Naval Research through Dr. F. M. Bayer; 3,550 marine shells collected by Dr. Cadet Hand on Kapingamarangi Atoll, Caroline Islands, under the auspices of the Pacific Science Board; and 2,034 specimens from the Samoan Islands, Palaus, and New Guinea, received from the Academy of Natural Sciences of Philadelphia. The U.S. Fish and Wildlife Service transferred to the Museum 113 cephalopods from the Gulf of Mexico through Harvey R. Bullis, Jr., and 311 land and fresh-water mollusks of South America were received in exchange from the Chicago Museum of Natural History.

Botany.—The largest gift to the department of botany consists of 10,847 lichens, constituting the personal herbarium of Dr. Mason E. Hale, Jr., associate curator of the division of cryptogams; most of the material is from the eastern and southern United States. Another notable gift received from Dr. José Cuatrecasas, resident investigator of the department, comprised 1,165 specimens of his own collections from Colombia, mostly a comprehensive collection of the Hepaticae (liverworts). These are being studied by Prof. Margaret Fulford, a principal specialist on the Hepaticae. Other gifts include 162 specimens from William O. Douglas, Associate Justice of the Supreme Court, representing his personal collection of Himalayan plants, and 1,735 plants of the Philippine Islands collected by Dr. José Vera Santos and presented by the University of the Philippines. To be mentioned especially are the 117 samples of diatoms from the Antarctic collected by the British Australian-New Zealand Antarctic Expedition and presented by the University of Adelaide in Australia.

Dr. Lyman B. Smith, curator of phanerogams, collected 15,133 specimens in southern Brazil. Other botanists and institutions in Brazil have been collaborating with Dr. Smith in his study of the Brazilian flora and have contributed specimens as follows: 422 from Father Raulino Reitz, 378 from the Instituto Agronómico do Norte, Belém, 163 from Dr. Amaro Macedo, and 90 from Sr. G. Hatschbach. Dr. Egbert H. Walker, associate curator of phanerogams, obtained 291 plant specimens on his field trip to Okinawa in connection with his current studies of the flora of the Ryukyu Islands. In helpful assistance to Dr. Walker's work, Kagoshima University, Kyushu, Japan,

sent in exchange 578 specimens collected by Prof. S. Hatusima, and Dr. J. T. Conover, University of Texas, presented his personal collection of ferns of Okinawa, numbering 668 specimens.

Other important exchanges include: 2,675 Cuban plants, mostly from the now historic collections of Brother León and Brother Clemente, received from the Colegio de la Salle, Havana; 2,697 specimens from Arctic Alaska, received from Stanford University; 1,132 from Canada and Alaska from the Botany and Plant Pathology Laboratory, Department of Agriculture, Ottawa, Canada; 300 from the Naturhistorisches Museum, Vienna, Austria; 1,157 from the University of Michigan; 912, mostly bryophytes of Europe and Africa, from the Institute of Systematic Botany, University of Uppsala; 421 from the collections of Dr. Bassett Maguire and his associates in the "Guayana Highlands" of Venezuela, received from the New York Botanical Garden; and 574 plants of New Guinea, received from the Commonwealth Scientific and Industrial Research Organization, Canberra, Australia.

Two noteworthy lots were acquired by purchase: 631 plants from the Transvaal, Africa, from the collection of Dr. H. J. Schlieben; and 281 Colombian plants of the A. E. Lawrance collection.

Geology.—Among the fine and rare minerals received in the division of mineralogy and petrology are native silver, Honduras, from the New York and Honduras Rosario Mining Co.; amethyst, Korea, from John B. Jago; and pyrolusite, Ghana, from Marcel D. Acrouet. Newly described mineral species received as gifts include ajoite, Arizona, from Miss Mary Mrose, and santafeite, Grants, N. Mex., from the New Mexico Bureau of Mines and Mineral Resources.

Outstanding minerals obtained through exchange are: A very large scheelite crystal from Arizona; a fine helvite crystal from Sweden; a crystal of columbite from Virginia; an exceptionally large ilvaite crystal from Idaho; wulfenite from Arizona; and aragonite from California.

Noteworthy additions to the gem collection were purchased through the Chamberlain fund for the Isaac Lea collection. These include a garnet from Idaho weighing 25.7 carats; a figure of the Chinese god of longevity carved in tigereye; a nephrite jade vase; and a fine series of small Montana sapphires of various colors. A large and ornate jade was received as a gift from Mrs. Marjorie Merriweather Post May.

Outstanding additions to the Roebling collection by purchase and exchange include these items: Native gold, Washington; azurite and cerussite, Australia; becquerelite, kasolite, soddyite and schoepite, Belgian Congo; spodumene, Brazil; huebnerite, Colorado; magnesite and strontianite, Austria; wulfenite, Arizona; uraninite, Colorado;

and a specimen of the Kimble County, Tex., meteorite was added as an exchange.

Several outstanding specimens were purchased through the Canfield fund as additions to the Canfield collection. Among these are sylvanite, Colorado; chrysocolla and quartz, Arizona; scheelite, Korea; apophyllite and amblygonite, Brazil.

Received in exchange are nine meteorites new to the collection: Vengerovo, Krymka, Orlovka, Chebankol, Nikolskoe, Petropavlovsk, and Hressk from the Union of Soviet Socialist Republics; Richland, Navarro County, Tex., and Fayetteville, Washington County, Ark.

Significant among new material received in the division of invertebrate paleontology and paleobotany are: 10 specimens of rare Mississippian goniatites from Chris E. A. Alter; 103 of Lower Cretaceous Foraminifera from Trinidad, B.W.I., presented by Dr. Hans M. Bolli; approximately 10,000 of invertebrate fossils from Silurian formations on the Island of Gotland, from Dr. A. J. Boucot; about 100 of Tertiary echinoids and other Cuban fossils from the Cuba California Oil Co., Havana, through P. B. McGrath; 2 type specimens of Ordovician starfish from Dr. Howard R. Cramer; 2 type specimens of Cretaceous crabs from North Dakota given by Dr. F. D. Holland, Jr.; 2,000 Pliocene mollusks from St. Petersburg, Fla., from Charles Locklin; and the type specimen of an enormous spiriferoid brachiopod, *Dimegelasma*, from the Mississippian of Nevada from Dr. Joseph Lintz, Jr.

Funds from the income of the Walcott bequest permitted the purchase from Mrs. Raymond R. Hibbard of 300 rhomboporoid Bryozoa from the Middle Devonian Hamilton group of New York State and 38 Pliocene brachiopods from Sicily, from Guiseppe Bonafede.

The crinoid collection of Harrell L. Strimple, Bartlesville, Okla., was purchased under the Springer fund. This yielded about 21,000 specimens and represents more than 20 years of collecting by Mr. Strimple, who has made a specialty of Upper Paleozoic crinoids.

Notable among the exchanges are 306 Paleozoic and Mesozoic invertebrate fossils, from the University of Bristol, through Dr. W. F. Whittard.

The significant accession for the year in the division of vertebrate paleontology came as a gift through the income of the Walcott fund bequest, which permitted Dr. C. L. Gazin, curator, and Franklin Pearce, exhibits specialist, to collect 330 specimens from Middle Eocene beds of southwestern Wyoming. These include skull and jaws of the primate *Notharctus tenebrosus* and skeletons of the 4-toed horse *Orohippus*, the primitive tapir *Helaletes*, skulls of assorted rodents, and the large titanothere *Palaeosyops*. Another gift from the Walcott fund consists of portions of four tritylodont (mammal-

like reptile) skeletons and a protosuchian crocodile collected by Dr. David Dunkle, curator, and Dr. G. S. Lewis of the U.S. Geological Survey from Triassic rocks in the Navajo Reservation, Arizona.

An exchange with the Muséum National d'Histoire Naturelle, Paris, brought examples of six genera of ray-finned fishes, new to the collection, from the Triassic of Madagascar and casts of important types in the French museum. An important skull of *Eryops* from the Permian (Dunkard formation) of southwestern Pennsylvania was donated by William E. Moran.

Armed Forces history.—Among the material accessioned in the division of military history, the notable items are: A rare Committee of Safety rampart rifle made at the Rappahannock Forge and a model 1869 pistol with Allin conversion, one of three known specimens, from the Department of the Army, and the famous Frankfort Arsenal cartridge collection from Col. Berkeley R. Lewis.

Of much importance is a collection of naval ordnance materials recovered from the wreck of an unidentified ship which sank on the reefs of Bermuda about 1595. This rare material of the sixteenth century included expanding bar shot of lead and wrought iron, spiked shot that carried tow soaked with tar, which when lighted by the explosion of the charge in the gun formed an incendiary shot; solid iron shot of various sizes, musket balls, and the breechblock of an iron swivel gun.

A built-up model of a warship of the late seventeenth century was received as a loan from Edwin A. Link. It is believed that the model itself dates to that period, and it forms a rare and desirable addition to the exhibition series. Received from the Department of the Navy, also as a loan, through the Naval Historical Foundation, was a fife rail which stood by the foremast of the sloop-of-war *Hartford*, flagship of Admiral Farragut during the actions at Mobile Bay and on the Mississippi River in the Civil War.

Science and technology.—An unusual specimen acquired by the division of agriculture and wood products is a Mehring foot-power cow milker donated by Earl J. Waybright. This type of milking machine was made and sold from the 1890's into the 1920's and provided an inexpensive device that lightened and speeded up the task of milking for the man with a small herd.

The outstanding accession to the section of wood products is a group of 1,400 interesting woods of the world, in cane form, known as the Rudolph Block collection of walking sticks. Mr. Block was long known as a writer of fiction and articles under his pen name of Bruno Lessing, and in his travels he gathered woods from the important worldwide forest regions. These canes represent the gems of the wood world and were presented by the Yale University School of Forestry.

Most of the accessions received in the division of electricity are in the field of electronics. Deserving particular mention are the experimental electron tubes of Drs. Langmuir and Hull donated by the General Electric Research Laboratory. Union College gave examples of early electronic equipment. Bowdoin College sent the core of an electromagnet made by Joseph Henry, while Williams College presented a very early cathode-ray tube. Maj. J. Vanderhoef (USMC, ret.) contributed an unusual example of a Vibroflex key and a number of Japanese electron tubes. Through the Hazeltine Research Corp., Dr. Alan Hazeltine donated the original experimental model of the neutrodyne circuit.

The division of mechanical and civil engineering received for its horological collection two notable clocks: one, an elaborate astronomical clock of 1764, made in South Tyrol, and the other, a 17th-century Dutch pendulum clock built by Johannes Tegelbergh of The Hague, presented by Mr. and Mrs. Dillard B. Laseter.

The machinery collections obtained from the Worthington Corporation Henry R. Worthington's first double-acting, direct-acting steam pump, built in 1844. A fine highly finished quadruple-expansion marine steam engine, built in 1906 by the Dodge Brothers, was received from the University of Michigan. The Boeing Airplane Co. sectioned for display purposes a small gas turbine, which was transferred to the Museum by the Department of the Navy.

The most significant accession acquired in the division of medical sciences is the transparent manikin of a woman which shows by electronic devices, light, and sound the location of the major organs of the human body and explains their functions. This exhibit was obtained from the Deutsches Gesundheits Museum. A collection of gas-oxygen machines, inhalers, and hypodermic syringes was donated by W. Harry Archer, D.D.S., an authority on Horace Wells, primary discoverer of anesthesia. Another outstanding acquisition is a group of unusually rare ceramic drug jars donated by the Bristol-Myers Co. The collection included a 13th-century Rhages (Persia) albarello and a 13th-century Rakka (Mesopotamia) albarello, as well as a 15th-century Hispano-Moresque majolica drug container and an early 16th-century Faenza (Italy) dragonspout ewer.

The division of physical sciences acquired specimens to fill the gaps in its collection of scientific instruments. Among these is a set of apparatus for demonstrating the mechanical powers presented by Middlebury College, a fine vacuum pump from Bowdoin College, an 18th-century chemical furnace from Williams College, the famous set of tuning forks from the United States Military Academy, and a fine Oertling assay balance from Wheaton College.

Outstanding accessions in the division of transportation are rare builders' half-models, including an Eastern Shore of Maryland fish-

ing launch, dated about 1913, donated by James B. Richardson, and the model of a motor garvey from southern New Jersey, donated by the builder, W. R. Main. Other specimens of note are a working scale model of an Italian coal-fired locomotive with tender, flatcar, extra assemblies, and spare parts, donated by Richard D. Boutros, and the Bayly gig, which has been on loan by the heirs of the Bayly and Orem families for a number of years.

Arts and manufactures.—A significant acquisition in the division of textiles is a reconstructed model of John Hargreave's spinning jenny. This model, which demonstrates Hargreave's original conception, was built in the Exhibits Laboratory by Robert Sampson from the specifications in Hargreave's patent of 1770. An interesting collection of handwoven fabrics made in the South during the Civil War was presented by Mrs. N. C. Browder. A beautiful and rare cashmere shawl with a turquoise center was presented by Miss Sabra O. Burgess, and four silk shawls were given by Miss M. Agnes Neill.

The division of ceramics and glass acquired a rare pressed-glass ornamented pane believed to be the earliest marked piece of Wheeling lacy glass manufactured by J. & C. Ritchie, Wheeling, W. Va. This specimen was purchased with funds provided by W. Daniel Quattlebaum of California. Fifty ceramic and glass items from the collection of the late Aaron Straus, Baltimore philanthropist, were given by the Straus Foundation.

The important accessions in the division of graphic arts are a gift by Capt. Emerson E. Morris of 10 etchings by Pierre van der Borcht (1545–1608); a color lithograph, "Go and Catche a Falling Starre" by June Wayne, presented by the Society of Washington Printmakers; and 12 pictorial photographs by Clarence John Laughlin of New Orleans, one of this country's outstanding photographic artists, received as a gift from the Eickemeyer endowment fund. A box-type camera by one of America's earliest daguerreotype photographers, Henry Fitz, Jr., was received as a gift from Mrs. Willard H. Howell. A camera of the pioneer western photographer James Fennemore was presented by Senator Barry M. Goldwater of Arizona.

Civil history.—The most significant acquisition in the division of political history is the collection of Lincoln memorabilia presented by his great-grandson, Lincoln Isham. Mary Todd Lincoln's silver tea and coffee service, President Lincoln's watch, his silver cutlery, and presentation revolver are some of the items in the collection. Additional important pieces of White House china were received. A salad plate and three oyster plates from the state service used during the administration of President Rutherford B. Hayes were given by Col. Theodore Barnes, and a dinner plate from the state service of

President Benjamin Harrison was presented by Mrs. Samuel Schwartz. The First Ladies collection was enhanced by the loan of the inaugural dress of Dolley Madison from the William Rockhill Nelson Gallery of Art, Kansas City.

The division of cultural history acquired the furnishings and fittings of the Stohlman Confectionery Shop originally installed in Georgetown, D.C., in 1900. This remarkable accession with its ice-cream parlor, its ornate cabinetwork, candy jars, fancy ice-cream molds, and countless other minutiae will serve to document a picturesque phase of late Victorian urban life. A complete set of original furnishings from a 19th-century parlor in a Thomaston, Maine, house was donated by the Misses Helen R. and Elizabeth W. Newcombe. The carpet, mirror, sofas, and side chairs will make it possible to reproduce authentically the parlor of a rural Victorian gentleman.

Among the outstanding accessions received in the division of numismatics are 22 die proofs of vignettes used for Canadian currency, donated by the British American Bank Note Co., Ottawa; 664 Chinese cash pieces transferred by the Library of Congress; 1 Continental $60 note, issued September 1778, donated by Consul J. Warner; 4 Byzantine gold solidi and 2 modern Greek gold coins, given by M. Tambakis. Senator Harry Byrd donated three $1,000 bonds and five $500 bonds issued by the Confederate States of America in 1861 and 1863. A rare copper plate made by Charles Toppan & Co. and used about 1835 by the New Haven County Bank for the printing of $10, $20, $50, and $100 notes was presented by the New Haven Bank, Conn., through Comptroller W. F. Hasse, Jr. Showing his continued interest in the growth of the national coin collections, Paul A. Straub donated a group of rare Holy Roman Empire gold coins struck in Hungary and Carinthia, and an unusual Prussian taler struck in 1719 in the name of Frederick Wilhelm I.

The division of philately and postal history received an exceptionally large accession through the transfer of 5,801,500 United States obsolete revenue stamps from the Internal Revenue Service. Former Postmaster James A. Farley converted a loan of 8,835 specimens to a gift. A rarity, the United States 24-cent airmail stamp with inverted center, was donated by the Raymond H. Weill Co. Sidney N. Shure of Chicago presented the first issue of Israel complete in sheets. An airmail collection of Albania and Bulgaria, a stamp collection of Czechoslovakia in 17 volumes, and a 5-volume collection of Rocket Mail were presented by Tom Lowenstein. An official presentation booklet of stamps of the United Nations for use in the European Office (Swiss overprints) was donated by John M. Harlan, Associate Justice of the Supreme Court.

EXPLORATION AND FIELDWORK

Documentary research revealed the existence of an 18th-century courthouse on the south bank of Potomac Creek across from Marlborough Town, Va. To verify the 1743 land survey and to locate and determine the type of structure, F. M. Setzler, head curator, department of anthropology, directed archeological excavations on the Williams site south of Stony Point. During the week of August 19–23, 1957, in collaboration with C. Malcolm Watkins, acting curator of cultural history, and Prof. Oscar Darter of Mary Washington College, Fredericksburg, Va., he exposed the brick foundation of a T-shaped building, which in general outline and size resembled the 1730 type of courthouses, such as those now extant in Hanover, King William, and Charles City Counties, Va. This project is one phase of a research program begun in 1956 at Marlborough Town.

During the period October 7 to November 22, 1957, Head Curator Setzler excavated the Welcome Mound along the Ohio River in West Virginia. The excavation of this large prehistoric Indian mound was made possible through the generous cooperation of the Columbia-Southern Chemical Corporation, on whose property the mound was located. The company furnished laborers, bulldozer, an engineer, and laboratory facilities. The mound measured 110 feet in diameter and 20 feet in height. Even though the quantity of artifacts was limited, the quality exceeded objects from other mounds of this cultural horizon. On the basis of potsherds and projectile points, Welcome Mound is classified as a middle Adena site representing a period of approximately 500 B.C. The most important artifact recovered was a carved effigy tubular smoking pipe in the form of a shoveler duck's head and neck, found at the right knee of one of the adult skeletons. Two others were buried at the base of the mound. In the mouth cavity of one of these skeletons the canine tooth of a mountain lion was found. Based on evidence from other Adena mounds, this tooth could indicate that the body had been interred wearing a mountain-lion facial mask. In connection with this archeological research program, Mr. Setzler visited the Ohio State Museum, Columbus, and the University of Kentucky Museum, Lexington, from April 28 to May 4, 1958, to examine and study the collections of archeological material excavated from other Adena mounds in those States. He also examined collections from other prehistoric cultural levels looking toward the future modernization of the Museum's exhibition halls pertaining to American archeology.

From October 9, 1957, to January 14, 1958, Dr. T. Dale Stewart, curator of physical anthropology, was in Baghdad, Iraq, restoring, studying, and making casts of the Neanderthal skeleton that had been discovered in Shanidar Cave, northern Iraq, by Dr. Ralph S. Solecki

in 1957 prior to his joining the Museum's staff as an associate curator in Old World archeology. Dr. Stewart, invited by the Iraqian Government to repair and restore the skull and postcranial skeleton, not only found it more complex than anticipated but also discovered that owing to an injury of the brachial plexus the right shoulder and arm of the 45,000-year-old Neanderthaler had been paralyzed. This paralysis caused the right humerus to atrophy. The distal end and forearm were missing. After completing this difficult task of restoring a badly broken skull, Dr. Stewart made a mold and plaster casts. He was permitted by the Iraqian Government to bring one of the casts to the Smithsonian Institution, the first to reach this country. On his return trip to Washington he visited with physical anthropologists in Turkey, Rome, France, and England, all of whom were pleased to examine the cast of the Shanidar skull.

In connection with his long-range research program of comparative studies of Micronesian material culture, Dr. S. H. Riesenberg, acting curator of ethnology, spent two weeks examining and studying the Micronesian collections at the Peabody Museum, Salem, Mass.; Dartmouth Museum, Hanover, N. H.; and Fairbanks Museum, St. Johnsbury, Vt. The Peabody Museum collections include some of the objects collected by the first Europeans to explore these islands. While in Chicago during Christmas week he made a similar survey of Micronesian artifacts at the Chicago Natural History Museum. This trip enabled him to interview several specialists in African ethnology in respect to the appointment of an associate curator for his division.

While attending meetings of the American Anthropological Association in Chicago during Christmas week, Dr. Clifford Evans, associate curator in archeology, examined the archeological collections excavated at Cuenca in the highlands of Ecuador by Dr. Donald Collier and found pottery types similar to those excavated on the Río Babahoyo along the coast of Ecuador. From May 11 through 17 Dr. Evans visited Peabody Museum, Cambridge, Mass., the American Museum of Natural History, and the Museum of the American Indian, New York City, to compare the pottery he and Dr. Meggers excavated on the Río Napo in Ecuador, and from sites on the middle Amazon excavated by Peter P. Hilbert, with that from sites in eastern Peru. This constitutes one phase of a long-range program of archeological research in South America.

Dr. M. T. Newman, associate curator of physical anthropology, spent two days at Pennsylvania State University, State College, Pa., conferring with Drs. H. Schraer and P. Baker of the Bone Density Research and Evaluation Center in connection with the data he

accumulated at Hacienda Vicos, Callejon de Huaylas, North Central Sierra, Peru.

The Museum's new associate curator in Old World archeology, Dr. Ralph Solecki, attended an interdisciplinary symposium at the University of Chicago's Oriental Institute from May 8 to 11. This meeting emphasized the contributions that can be made by zoologists, agronomists, geologists, and other specialists in solving problems arising from the excavation of Neolithic and Paleolithic archeological sites. The Shanidar Cave, in Iraq, excavated by Dr. Solecki, produced evidence of a very stable animal population over a period of 100,000 years. He reported that the evidence from Shanidar Cave showed that the earliest animal and plant domestication probably took place within the past 12,000 years.

Assistant Curator of Ethnology R. A. Elder, Jr., spent a day in February and one in April selecting and transporting an unusual collection of Asiatic and Far Eastern objects from Baltimore, Md., donated to the national collections by the Aaron and Lillie Straus Foundation, Inc.

C. V. Morton, acting curator of cryptogams, again participated in the American Fern Society field trip, and from August 21 to 25 collected ferns from Stanford University north along the Redwood highway to Eureka, Calif. He also attended the meetings of the American Institute of Biological Sciences at Stanford University.

From October 8 to December 28, 1957, Dr. Egbert H. Walker, associate curator of phanerogams, traveled to Japan, Okinawa, Taiwan, Thailand, Viet Nam, and the Philippines. He participated in the Ninth Pacific Science Congress in Bangkok, and enroute examined, studied, and collected plants in Japan, Okinawa, and Taiwan, in preparation of a manuscript on the flora of Okinawa and the southern Ryukyus.

Dr. Mason E. Hale, associate curator of cryptogams, spent several days in October examining collections of West Indian lichens at Harvard University, Wellesley College, Yale University, and the Academy of Natural Sciences of Philadelphia. Dr. Hale also collected lichens in Virginia, North Carolina, and the coastal plain of Florida. While in Florida during April he participated in the annual meeting of the Association of Southeastern Biologists at Tallahassee.

In August 1957 and again in May 1958, Dr. Richard S. Cowan, associate curator of phanerogams, spent several days at the New York Botanical Garden checking manuscripts with plant collections and completing his portion of the Index Nomina Genericorum.

In September 1957, Dr. Herbert Friedmann, acting head curator of zoology, attended the annual meeting of the American Ornitholo-

gists' Union at Cape May, N.J. In November he studied and described the African viduine weaverbirds at Yale University and the American Museum of Natural History in order to complete his manuscript on this group.

On June 4, 1958, Dr. Henry W. Setzer, associate curator of mammals, returned from an extended field trip in North Africa. The first 2 weeks of May he spent excavating burrows of rodents in the vicinity of Wadi Natroun, Faiyum Province, and near the village of Abu Rawash. From May 17 to 24 he collected mammals in the vicinity of St. Catherine's Monastery in southern Sinai. The last week was spent in the Delta and eastern desert region.

From January 15 to March 15, 1958, Dr. Charles O. Handley, Jr., associate curator of mammals, continued his mammal survey of Panama, which yielded over 700 specimens of mammals. Several species new to Panama were collected, and evidence was obtained to show that there is more mingling of South and Central American faunas in the isthmus than was heretofore suspected. In November 1957 Dr. Handley studied the greater and lesser pigmy sperm whales at the Museum of Comparative Zoology at Harvard and at the American Museum of Natural History. In September 1957 he spent 2 weeks with museum aides J. L. Paradiso and B. R. Feinstein collecting small mammals along the Clinch Mountain range in southwestern Virginia. In March 1958 Mr. Paradiso roughed out and shipped to the Museum from Vero Beach, Fla., the skeleton of a beaked whale.

From July 5 to August 4, 1957, Dr. J. F. Gates Clarke, curator of insects, visited Europe principally to pack and ship a large collection of insects assembled by Eng. F. Tippmann in Vienna, Austria. In England he conferred with the entomologists at the British Museum. In January 1958 Dr. Clarke spent 2 days at St. Lawrence University, Canton, N.Y., where he acquired the John Buys collection of leafhoppers (Cicadellidae), which contains specimens from Formosa and new forms from Honduras heretofore not represented in the Museum. On May 5, 1958, he returned from an extensive collecting trip on the Smithsonian-Bredin Caribbean Expedition. He accompanied the leader of the expedition, Dr. Waldo L. Schmitt, former head curator of zoology, and now research associate. This expedition was made possible through the continued generosity of Mr. and Mrs. J. Bruce Bredin, of Greenville, Del. For 6 weeks the scientists were enabled to collect zoological specimens among the Leeward Islands of the Lesser Antilles.

Two and a half weeks were spent by Dr. R. E. Crabill, Jr., associate curator of insects, studying type specimens at Harvard and collecting myriapods and spiders in Massachusetts, Vermont, and the Lake Placid section of New York.

Dr. L. P. Schultz, curator of fishes, spent 2 weeks in November 1957 repacking and shipping the Col. John K. Howard collection of fishes at the University of Miami, Fla. Enroute Dr. Schultz visited the U.S. Fish and Wildlife Service laboratories and university laboratories in North Carolina, South Carolina, Georgia, and Florida. From April 7 to 11, 1958, Dr. Schultz attended a symposium in New Orleans, La., on the attacks made by sharks.

Dr. Alexander Wetmore, research associate, represented the Smithsonian Institution at the Pan African Ornithological Congress, held at Livingstone, Northern Rhodesia, from July 15 to 20, 1957. Over 200 persons were in attendance, including delegates from several countries of western Europe and from the United States, in addition to those engaged in investigations in this field in the various countries of Africa. The occasion was especially important as it was the first meeting of the kind on that continent. Enroute to the Congress there was opportunity to cross through the Wankie Game Reserve and afterward to spend 6 days observing the birds and mammals of the Kruger National Park. Following this Dr. Wetmore visited scientific institutions and laboratories in Johannesburg, Pretoria, Durban, and Capetown, Union of South Africa, and had 3 days for observations near Dakar in Senegal. He returned to Washington via Lisbon on August 13.

In January 1958 he returned to Panama to continue field investigations of the birdlife of the Isthmus. Through the kindness of H. V. T. Mais, agent for the Chiriquí Land Co. in Panama, and G. D. Munch, manager of the Bocas del Toro Division of that company, arrangement had been made for quarters in Almirante, Province of Bocas del Toro, an area not previously visited. This is an important region for study because of species of birds found farther north along the Caribbean that here enter Panama and reach their southern limits in this section. Field equipment was shipped on January 13 by Cessna–180 4-passenger plane since the airport serving Almirante at the town of Bocas del Toro was closed temporarily to larger aircraft. There is no true dry season in this section of Panama, and rains came almost daily. While the higher areas of level land had been cleared for cultivation, forest remained over extensive sections of swamp, and on the hills bordering small stream valleys, as well as on the large islands in Almirante Bay.

Fieldwork continued here 2 months, with a trip each week up the line of railroad into the banana plantations that extend from the Changuinola River to Guabito on the Costa Rican border. Travel elsewhere from Almirante was mainly by dugout canoe powered by an outboard motor, with occasional trips with friends in other craft. T. W. Dunn was especially helpful through his knowledge of Almirante

Bay gained through fishing excursions. And in the Changuinola area Roy Roig gave important aid. A nesting colony of red-billed tropicbirds on Swan Cay in the Caribbean outside the entrance of the pass Boca del Drago, and another of Audubon's shearwaters on Tiger Rock off Chiriquí Point at the end of the Valiente Peninsula, were of particular interest since these are the only locations known for these birds in the western Caribbean. Through the help of Mr. Munch in providing a larger launch, collections were made for 2 days on the island Escudo de Veraguas 10 miles off the base of the Valiente Peninsula. A wren, a manakin, and a spiny rat obtained here are forms previously unknown to science, marked particularly by much larger size, compared to their relatives on the mainland.

On return to the Canal Zone on March 10 Dr. Wetmore was occupied the following 2 weeks with further collecting in the savanna areas of Coclé and in the Province of Panama, including 3 days at La Jagua, east of Pacora, where the first cattle egrets to be collected in Panama were taken. This heron has been seen here for 2 years past and appears now to be fully established. Work for the season ended with return by air to Washington on March 29.

During September 1957 and again in May 1958 Dr. G. A. Cooper, head curator of geology, accompanied by R. E. Grant, research assistant, carried forward his long-range research program of solving the stratigraphic sequence in the Glass Mountains, especially Leonard Mountain near Marathon in west Texas. Last fall they were fortunate in establishing a direct paleontological sequence as well as obtaining evidence to show that the big limestones in the Leonard formation join the basal formation to become a single limestone east of Sullivan Peak. In May they traced this particular key bed across the mountain. An effort was made to collect special material for inclusion in the modernization of an invertebrate paleontological exhibit hall. In November 1957 Dr. Cooper delivered his presidential address before the Paleontological Society in Atlantic City, N.J. He spent several days in Boston the latter part of March examining and studying Silurian, Devonian, and Recent brachiopods at Harvard University and the Massachusetts Institute of Technology.

From July 12 to August 9 Dr. C. L. Gazin, curator of vertebrate paleontology, and exhibits specialist F. L. Pearce prospected for and collected vertebrate fossils in the eastern, central, and western portions of the Bridger Basin around Green River and Lyman, Wyo. Good results were obtained between Smiths Fork and Blacks Fork. A rare skull and skeletal material of the Eocene horse *Orohippus* were recovered. Dr. Gazin spent a week after August 9 at the Los Angeles County Museum studying the Eocene collections recently transferred from the California Institute of Technology. Early in

November 1957 he attended the annual meeting of the Society of Vertebrate Paleontology in Philadelphia, Pa., and the Geological Society of America meetings in Atlantic City, N.J. During the first week of December Dr. Gazin studied Eocene and Oligocene collections at Princeton, N.J., and the American Museum of Natural History. In February 1958 he studied middle Eocene mammalian collections from the Green River beds of northeastern Utah at the Carnegie Museum in Pittsburgh, Pa.

During September 1957 E. P. Henderson, associate curator of mineralogy and petrology, accompanied by photographer Jack Scott, made an extensive trip in order to study the morphology and surface features of meteorites and to photograph large collections. They spent some time going west and also on their return east at the Battelle Memorial Institute in Columbus, Ohio, witnessing the cutting operation of the Grant, N. Mex., meteorite. Meteoritic iron requires much more time to cut than one anticipates. These cut sections will enable the specialist to study the thermal penetration. Henderson and Scott examined and photographed the meteorites at the University of Kansas, Iowa State College and the State University of Iowa, Chicago Natural History Museum, and Wooster and Marietta Colleges in Ohio. These studies are especially important now that manmade satellites are being placed in outer space. Mr. Henderson spent 2 days in May examining the meteorite collection in the Philadelphia Academy of Natural Sciences. He also acquired new material for the Museum's collections.

Dr. D. H. Dunkle, associate curator of vertebrate paleontology, spent 2 days in October 1957 studying various Mesozoic teleostean fishes in the Bayet collection of the Carnegie Museum in Pittsburgh. In March 1958 he devoted 2 days to the study of a restricted group of elopoid fishes from the Cope collection at the American Museum of Natural History.

In the company of two paleontologists of the U.S. Geological Survey, Dr. Richard S. Boardman, associate curator of invertebrate paleontology and paleobotany, spent 6 days in the fall of 1957 collecting bryozoans, brachiopods, and corals from all the stratigraphic zones of middle Devonian rocks along the falls of the Ohio River. Dr. Boardman attended the annual meeting of the Geological Society of America in Atlantic City, and in March 1958 he purchased some well-documented rhomboporoid Bryozoa collected from the middle Devonian Hamilton rocks of the Buffalo, N.Y., area.

Dr. Porter M. Kier, associate curator of invertebrate paleontology and paleobotany, spent several days in October 1957 examining and studying Paleozoic echinoid collections at Yale University and Harvard University. Here he discovered several type specimens never

before recorded and four specimens which represent a new genus. Dr. Kier also attended the meetings of the Geological Society of America in Atlantic City.

In October 1957 Dr. Peter P. Vaughn, associate curator of vertebrate paleontology, spent 3 days collecting tetrapods and the skulls of the rare nectridian *Diploceraspis* from the upper Mississippian formation near Greer, W. Va., and the Dunkard series, lower Permian formation of northern West Virginia and southwestern Pennsylvania. In November 1957 and again in February 1958 he spent several days at the Museum of Comparative Zoology at Harvard University and the American Museum of Natural History examining and studying fossil amphibians, reptiles, and Permian vertebrates. From March 15 to May 17, 1958, Dr. Vaughn, accompanied by exhibits worker John E. Ott of the division of vertebrate paleontology and ranger naturalist R. Donald Widman of the National Park Service, carried forward an extensive paleontological research program in Oklahoma, Texas, New Mexico, and Colorado. Their principal objective was collecting fishes, amphibians, and reptiles in the Permian beds. Several hundred pounds of fossils reached the Museum as a result of their explorations.

The administrative reorganization of July 1, 1957, created two units under the United States National Museum, namely the Museum of Natural History and the Museum of History and Technology. The staff comprising the latter unit found it necessary to visit many of the museums, universities, and private collectors in order to examine, study, purchase, and accept a variety of objects for the new museum. Every effort was made by the many recently employed specialists to acquire outstanding examples to illustrate their subject-matter fields. At the same time every opportunity was taken to perfect their program of exhibition. Only the more important phases of this fieldwork and travel program are here noted:

The Director of the Museum of History and Technology, Frank A. Taylor, made three important trips in connection with the acquisition of objects and the use of modern display methods as well as television facilities for the new museum under construction.

In keeping with the previous program of examining new exhibits and acquiring important apparatus to illustrate the development of the physical sciences, Dr. Robert P. Multhauf, head curator of science and technology, completed extensive field trips. From September 15 to October 21 he visited various museums in Denver, Colo.; San Diego, Los Angeles, San Francisco, Oakland, Nevada City, Calif.; Ames and Iowa City, Iowa; Purdue University, Lafayette, Ind.; and Marietta, Ohio; and participated in a seminar on the history of science at the University of Wisconsin in Madison. In December

1957 he spent 2 days examining old chemical apparatus in the department of chemistry, University of Pennsylvania, with a view to acquiring the objects for the exhibits in the Museum of History and Technology. He also examined some of the rare physics apparatus at West Point and Columbia University. In January 1958 he examined historic astronomical apparatus at Case Institute in Cleveland. Since the College of William and Mary at Williamsburg was one of the first in this country to offer instruction in science, Dr. Multhauf spent 2 days there with Professor Pittman and President A. D. Chandler examining some of the old apparatus used in the teaching of physics. In April he visited Johns Hopkins University with a view to acquiring a balance and gas heating device associated with Ira Remsen. In the department of mineralogy and geology he explored the possibility of obtaining an early polarizing microscope.

As consultant to the department of engineering for locating 19th-century chemical and physical laboratory apparatus to illustrate these disciplines in the new Museum of History and Technology, Dr. Derek J. Price again made numerous trips to museums, colleges, universities, and laboratories. In September 1957 Dr. Price supervised the transfer of three machines pertaining to Henry Fitz, telescope maker, in 1850. These machines, together with his tools, speculum blanks, and many smaller items, should enable the Smithsonian to reconstruct in the Museum of History and Technology a vivid workshop of Henry Fitz. In the department of chemistry at Williams College he was pleased to find a rare cylindrical charcoal-burning chemical furnace made about 1830. This furnace is similar to those used centuries before. In the various colleges and universities visited Dr. Price made several detailed inventories of chemical and physical apparatus which he regarded as worthy of consideration for planned exhibits in the Museum of History and Technology.

The curator of the division of mechanical and civil engineering, Eugene S. Ferguson, attended the annual meeting of the American Society of Tool Engineers, May 5–7, 1958.

From March 24 to April 2 Howard I. Chapelle, curator of transportation, visited museums, collectors, and model-ship builders in Mystic and Essex, Conn.; Providence, R.I.; Nantucket Island; and Salem, Quincy, and Boston, Mass. This trip will prove valuable in connection with the future exhibits of watercraft in the Museum of History and Technology.

William N. Watkins, curator of agriculture and wood products, spent the last week of September and early October studying wood collections and logging dioramas at the College of Forestry, Syracuse University, and the Adirondack Museum at Blue Mountain Lake, N.Y. On February 24, 1958, Mr. Watkins conferred with Prof.

E.S. Harrar at Duke University School of Forestry, Durham, N.C., and studied microscopically many wood sections.

Numerous trips were made by the acting curator of electricity, W. J. King, in an attempt to acquire original examples and models of early electrical equipment for the Museum of History and Technology. In July he visited Great Barrington, Mass., to collect data on George Stanley and his 1886 installation of an AC power system. At Pittsfield he conferred with a descendant of S. F. B. Morse, the inventor of the telegraph. At Philadelphia he examined the Franklin Institute's stored collection of early electrical apparatus. In the fall and winter Mr. King spent some time in Philadelphia, New York City, and Schenectady, as well as at Princeton and Brown Universities. In May 1958 he spent several days in New York and New Jersey, especially at the R.C.A. plants and offices conferring with General Sarnoff and other members of his staff. Much time and study were devoted to identification of original electrical apparatus and going over notebooks of famous inventors such as Langmuir, Elihu Thomson, Morse, and Stanley.

On October 2, 1957, George B. Griffenhagen, curator of medical sciences, accepted for the Smithsonian Institution a collection of rare antique drug jars donated by the Bristol-Myers Co. in New York City. On January 10, while returning from New York, Mr. Griffenhagen examined an early pharmaceutical tablet press which will be donated to the division by Wyeth Laboratories. From March 24 to 27, 1958, he examined pharmaceutical and medical exhibits in Chicago and participated in the dedication of an 1890 drugstore restoration at the Wisconsin State Historical Society in Madison, Wis. In April he attended meetings of the American Institute of the History of Pharmacy and American Pharmaceutical Association Section on Historical Pharmacy in Los Angeles, Calif.

During the past year, E. A. Battison, associate curator of mechanical and civil engineering, made several trips throughout the New England States, as well as New York and Pennsylvania, examining, collecting, and studying numerous private collections of clocks and watches ranging from the early handmade wooden clocks to the most recent electric watch. In addition to this special field, Mr. Battison examined and collected early machine tools, iron planer lathes, and locks.

On May 12 and 13 Kenneth M. Perry, associate curator of transportation, acquired a valuable collection of early marine engines, propellers, models, harpoon heads, tools, and boat drawings assembled by Otis A. Palmer, East Moriches, Long Island, N.Y.

From February 23 to March 1, E. C. Kendall, associate curator of agriculture and wood products, visited Hadley, Mass., Coopers-

town, N.Y., and Kinzers, Pa., to examine and collect early examples of various types of farm machinery.

At the invitation of Dr. J. Stainman, a practicing optometrist, Associate Curator of Medical Sciences Dr. John B. Blake obtained a large collection of refracting instruments for the Smithsonian Institution on August 26, 1957. In September Dr. Blake spent several days in Boston and Salem, Mass., and New York City inspecting and studying collections relating to all phases of medical history. On October 10, 1957, he acquired a 35-year-old General Electric portable X-ray machine in Baltimore, Md. On December 4 and 5 he examined, with a view to acquiring for the Museum of History and Technology, old dental instruments from the School of Dentistry at the University of Pennsylvania. In New York City and Long Island he obtained two cases of anesthesia material from the Wood Museum and Dr. W. H. Archer of Pittsburgh, Pa. From March 16 to 22, 1958, he visited the Cleveland Health Museum and the Dittrich Museum of Natural History examining a large collection of medical instruments; and then proceeded to Chicago where he studied collections at the International College of Surgeons Hall of Fame, the Chicago Historical Society, and other museums.

Robert M. Vogel, assistant curator of mechanical and civil engineering, spent considerable time throughout the year visiting the engineering schools in numerous universities and important engineering plants inventorying and selecting examples of 19th- and early 20th-century material for the planned exhibits in the new Museum of History and Technology.

From October 25 to November 4, 1957, the head curator of arts and manufactures, Dr. P. W. Bishop, was in the vicinity of Pittsburgh, Pa., Chicago, Ill., and Dearborn, Mich., endeavoring to determine the type of engine used by Drake in his 1858–59 oil drilling. In Chicago, Dr. Bishop received excellent cooperation from the Research Plant of Universal Oil Products in planning exhibit models showing various types of catalytic cracking units. In September he spent a day at the Massachusetts Institute of Technology and another at Lakeville, Conn.

The curator of graphic arts, Jacob Kainen, spent September 9 to 13 in Cleveland looking toward the acquisition of early silk-screen stencil printing. He also continued his research on J. B. Jackson, going over references and prints by this artist.

During December 11 to 14, 1957, Miss Grace L. Rogers, acting curator of textiles, studied various phases of the textile collection of the Metropolitan Museum of Art and the exhibit at Amateur Needlework of Today, Inc., in New York City. She also conferred with the donor of an old Jacquard loom now being assembled. After

several conferences Miss Rogers has received the cooperation of several wool, cotton, silk, and manmade-fiber institutes and associations in supplying material for the new textile exhibits planned for the Museum of History and Technology. In the latter part of March 1958 Miss Rogers studied exhibit techniques and storage facilities at Winterthur Museum, Wilmington, Del. From May 4 to 7, 1958, she had the unique experience of examining a 3-story woolen mill just outside Excelsior Springs, north of Kansas City, Mo. This mill, known as the Watkins Woolen Mill, was closed in 1886, yet remained completely undisturbed up to the day of Miss Rogers' visit when the property was auctioned. She therefore had an opportunity to examine a middle 19th-century woolen mill even to the extent of seeing the original machines standing in the same position as they were in 1886, and in many instances the original leather belts were still attached to the main drive shafts.

In September 1957 and again in March 1958 Paul V. Gardner, acting curator of ceramics and glass, visited museums and collector-dealers in New York City. He examined numerous collections of porcelain, glass, and enamels which will assist in identification of objects in his division; studied various methods of exhibition; and visited with philanthropical collectors who may present objects from their collections to the Smithsonian Institution. From May 21 to 27 Mr. Gardner examined European porcelain and china-trade items at the Worcester Art Museum. He also visited collectors in Canton, Norwood, Newbury, Middleton, Sturbridge, and Boston, Mass.

The head curator of civil history, Dr. Anthony N. B. Garvan, spent January 29, 1958, examining the well-documented Edward Andrews collection of Shaker material objects in New Haven, Conn. In February he visited Girard College in Philadelphia where he was given an opportunity to examine the Girard memorabilia. This collection represents an exceptional group of late Colonial and early Republican examples of the history of taste. It depicts Girard's nostalgia for France, pride in American achievements, and his hobbies of music and numismatics. In April Dr. Garvan was in New York City examining collections and consulting with experts on several phases of the new exhibits under his jurisdiction.

On June 3 and 4, 1958, the acting curator of political history, Dr. Wilcomb E. Washburn, together with assistant curators Charles G. Dorman and Mrs. Anne W. Murray and museum aide James Channing, visited the Chester County Historical Society, West Chester, Pa., Brandywine Battlefield State Park, Winterthur Museum, and the Hagley Museum in Delaware. This provided the staff with exceptional opportunities to examine collections, study preservation techniques, and observe methods used in preparing exhibits.

C. Malcolm Watkins, acting curator of cultural history, in collaboration with the head curator of anthropology, F. M. Setzler, and Prof. Oscar Darter of Mary Washington College in Fredericksburg, made considerable progress on the excavation of an 18th-century courthouse and 17th-century documentary research related to Marlborough Town, Va. The archeological excavations revealed the foundations of a T-shaped structure comparable to those well-preserved 18th-century courthouses at Hanover, King William, and Charles City Counties, Va. In September Mr. Watkins spent several days searching documents at the Virginia State Library, Richmond, in connection with the 1956 excavations at Marlborough Town, and a mass of data concerning John Mercer and his mansion and estate at Marlborough. On November 30, 1957, he discovered a 1744–49 ledger of John Mercer at the Bucks County Historical Society, Doylestown, Pa. This important document provides very pertinent information for the interpretation of the Marlborough site. In October Mr. Watkins spent several days visiting various museums in connection with his long-range research program in the documentation of 17th-century pottery. He spent December 4, 1957, at Winterthur, Wilmington, Del., examining room interiors for consideration in plans of exhibition in the Museum of History and Technology.

Throughout the year Francis J. McCall, assistant curator of philately and postal history, made numerous trips to eastern sections of the country attending national and local philatelic meetings, displaying selected postal material from the national collections, and describing present and future programs in the division of philately.

The curator of numismatics, Dr. V. Clain-Stefanelli, traveled extensively in order to acquaint professional and amateur coin collectors with the program, plans, and needs of his division. During the latter part of August and again in December he conferred with Mrs. Rae V. Biester, superintendent of the United States Mint in Philadelphia. During September he interviewed various State bank commissioners in Connecticut. At Yale University he examined the famous Garvan collection of gold coins and conferred with the deputy keeper of coins of the British Museum. In October he attended several numismatic meetings and studied various aspects of ancient coining techniques at the Fogg Art Museum in Boston. From May 20 to 24, 1958, Dr. Stefanelli visited Ottawa where he interviewed officials at the British American Bank Note Co., the Bank of Canada, Canadian Archives, and the Canadian Mint. In the Canadian Archives he examined a rare 1792 Indian Peace Medal. At the mint he examined coins, medals, and special decorations. As a result of his visit, the division will receive a special set of mint coins. In June he visited the headquarters of the Georgia State Bank in Atlanta, as well as Dahloneya, site of the old United States branch mint.

The associate curator of political history, Mrs. Margaret B. Klapthor, visited James Goodin of Reiglesville, Pa., where she inspected authentic costumes of President Madison's family, especially the recently discovered dress, shoes, gloves, and turban of Dolley Madison. In New York City she accepted delivery of Lincoln relics offered to the museum by Lincoln Isham.

Charles G. Dorman, assistant curator of political history, visited Albany Institute of History; the home of Gen. Philip Schuyler in Albany; Fort Crailo in Rensselaer, N.Y.; Bennington Historical Museum; Shelburne Museum near Burlington, Vt.; and other historic houses in New England. In February 1948 he carried forward research at the Historical Society of Pennsylvania in Philadelphia.

From September 23 to 27, 1957, the associate curator of cultural history, G. Carroll Lindsay, examined archives in Richmond, Isle of Wight, and Southampton courthouses in order to document the paneling now on exhibition in the Virginia Room. He established ownership of the property from the time of the original patent in the 17th century. He spent March 30 to April 4, 1958, in Alton, Ill., selecting objects from a large collection of decorative art objects of the Victorian period (1850–1915) which had been willed to the Smithsonian Institution by the late Miss Daisy Templin and donated by her living brother, Roger Pryor Templin. On June 10 Mr. Lindsay acquired at the Parke-Bernet Galleries a life-size cigar-store Indian princess through the generosity of Mrs. Marjorie Merriweather Post May.

Miss Rodris C. Roth, assistant curator of cultural history, spent October 25 to November 4, 1957, in Boston, Salem, Worcester, Newburyport, Mass., and New York City studying period rooms and decorative arts related to American and English interior decorations in the 17th, 18th, and early 19th centuries.

The head curator of armed forces history, Mendel L. Peterson, spent 3 days in September 1957 probing the Pamunkey River, 25 miles northeast of Richmond, to locate a shipwreck believed to have been sunk during General McClellan's drive on Richmond in 1862. Together with a professional diver, Mr. Peterson found the wreck in 15 feet of muddy water. By the use of anchor chains, to prevent injury to themselves, they were able to examine and partially identify the vessel. Thus far no documentation concerning the sinking of such a vessel has been discovered in Civil War archives. The hull measured at least 200 feet in length; it was burned before sinking; the bow section had broken away from the hull probably through an explosion of gunpowder or boiler. A few days in February and again in March Mr. Peterson studied archival records at the New York Public Library and consulted with Edwin A. Link on plans for a continuation of their program of underwater salvage of historic vessels.

In September 1957 E. M. Howell, acting curator of military history, spent 3 days in Chicago and Milwaukee studying collections of arms and armor at various museums. In March 1958 he visited the Metropolitan Museum of Art and New York Historical Society examining collections of powderhorns, Colt revolvers, Revolutionary War British insignia, and colonial-type armor.

Through an exchange the Museum acquired an 1866 model Gatling gun, which was examined and reported upon by Craddock R. Goins, Jr., assistant curator of military history. Late in January 1958 Mr. Goins made an extensive trip to the major firearms manufacturing firms in the vicinity of Bridgeport, New Haven, and Hartford, Conn., and Springfield and Chicopee Falls, Mass.

John E. Anglim, supervisory exhibits specialist, spent 2 days in Williamsburg, Va., inspecting a variety of exhibition cases, panel, grid, and light systems. He also studied the interiors of the restored buildings for ideas that might be included in the hall of 18th- and 19th-century furnishings of the Museum of History and Technology.

In preparation of designing an exhibit to portray hand and photomechanical printing processes, Miss Judith Borgogni, exhibits worker, visited the New York Public Library in February 1958. Together with exhibits worker Robert B. Widder, she critically examined the display methods used in the University of Pennsylvania Museum and the Philadelphia Museum of Art.

Consultant John C. Widener and exhibits worker Thomas G. Baker spent several days in February 1958 visiting chemical and plastics manufacturing companies in order to determine the most feasible method for exhibiting the Museum's large blue whale.

A detailed analysis of the arms and armor exhibition of the Metropolitan Museum of Art was made by exhibits worker William B. Eddy in March 1958. He also scrutinized a variety of exhibits at the Museum of the City of New York and at the American Museum of Natural History.

In connection with the planning of a hall of photographic history in the Museum of History and Technology, Mrs. B. A. W. Karras, exhibits worker, spent 4 days in April 1958 reviewing the highly specialized exhibit at George Eastman House, Rochester, N. Y. Even though technical exhibits comparable to those at Eastman House will be presented, they must be geared simply and graphically to the average visitor both as a source of study and for pure enjoyment.

During February 1958 exhibits specialist Benjamin Lawless, Jr., and exhibits worker Robert B. Widder made extensive examinations of museum displays, new buildings under construction, and architectural offices in New York City.

From March 12 to 15, 1958, Ronald Tavares, exhibits worker, visited the Metropolitan Museum of Art; the Museum of the City of New York; the Peabody Museum of Salem; and the Boston Fine Arts Museum of Massachusetts. He was especially interested in those exhibits illustrating the development and history of watercraft.

William L. Brown, chief zoological exhibits specialist, inspected the tanning of a large elephant hide at Waynesboro, Va., on several days during the month of October 1957.

From October 8 to 11, 1957, Watson M. Perrygo, zoological exhibits worker, visited New York City and Philadelphia where he investigated various plastic-manufacturing companies in order to produce on a large scale museum accessories such as leaves, vines, branches, grass, and other botanical objects. In November 1957 he spent 3 days with George Young, chief of the exhibition department at Kansas University Natural History Museum. Here he had an opportunity to study methods of making plastic exhibition accessories by hydraulic press.

John C. Lingebach, zoological exhibits worker, spent several days in April 1958 collecting a variety of mammals for the exhibits now under construction in the mammal hall. Most of Mr. Lingebach's collecting on this trip and again in May was in the vicinity of Wardensville, Yellow Springs, North Mountain, and Capon Springs, W. Va.

EXHIBITIONS

During the fifth year of the continuing program for the modernization of exhibits at the Smithsonian Institution, $605,000 was made available by congressional appropriation for selected exhibition halls. Construction bids were received in February 1958 for the halls devoted to fossil invertebrates and fossil cold-blooded vertebrates (fishes, amphibians, and reptiles), in June 1958 for North American archeology, and in June 1958 for the hall of agriculture to be located in the east-south range of the Arts and Industries building. Construction work for the textiles hall was commenced in September 1957.

The new hall of health was opened to the public on the evening of November 2, 1957, in ceremonies featuring addresses by Dr. John D. Porterfield, Deputy Surgeon General of the Public Health Service, Dr. Fred L. Soper, Director of the Pan American Sanitary Bureau, and Dr. Leonard Carmichael, Secretary of the Smithsonian Institution. "Through the Ages, Man's Knowledge of His Body" is the theme of this hall, which contrasts old ideas with present-day knowledge of human anatomy and physiology. Emphasis is placed on health rather than disease, and modern exhibit techniques are utilized

to demonstrate the functioning of a the normal, healthy human body. A transparent manikin of a woman shows by electronic devices, light, and sound the location of the major organs of the human body and explains their functions. Among other exhibits are those that illustrate the heart, teeth, endocrine glands, and the brain. Historical displays include reproductions of votive offerings by primitive peoples, ancient manuscripts, and pages from the earliest printed books illustrating embryology, the skeleton, the heart and blood circulation, the brain, and the digestive and respiratory systems.

During the year a pictorial exhibit on the history of surgery, donated by the American Cyanamid Co., was renovated. The National Library of Medicine has lent the following exhibits: Vaccination from Jenner to Salk; Nobel Prize Winners in Medicine; William Harvey and the Circulation; and Women Physicians and Their Hospitals.

On the evening of December 8, 1957, Secretary Carmichael dedicated the hall of North American Indians and Eskimos, and in his address paid tribute to the farsighted men and women who had during the past 150 years saved from possible destruction the ethnological objects displayed therein. Mrs. Mabel A. Byrd, administrative assistant to the Director of the National Museum and herself of Seneca Indian descent, was invited to cut the ribbon at the formal opening. Traditional cultures of the Eskimos and of the Indians of the subarctic region, the eastern woodlands, the great plains, the northwestern plateau, and the north Pacific coast are displayed in this hall. Historically significant objects including the great wampum belt, symbolizing the union of midwestern tribes formed by the Shawnee chief Tecumseh to halt the advance of white settlement, and Sitting Bull's rifle are featured in these display units. A completely furnished tipi of sewn buffalo hides, some 17 feet in height, depicts the home life of an Arapaho Indian family during the past century. Other life-size exhibit units show Polar Eskimos hunting hair seals and the Powhatan Indians trading with Capt. John Smith on the James River in 1607.

The gems and minerals hall planned by curator George S. Switzer was nearing completion at the close of the fiscal year. New exhibition techniques have been utilized in the display of gems, uncut crystals, and minerals with gratifying results, particularly with respect to lighting and reduction of reflection. Installation of the exhibits proceeded so satisfactorily that formal opening of the hall was scheduled for July 1958.

Four new habitat groups portraying the sea-bottom life of the Upper Ordovician, Lower Devonian, Mississippian, and Upper Cretaceous are being prepared for the invertebrate hall by George

Marchand of Ann Arbor, Mich. The removal of adhering matrix and the restoration and mounting of a number of fossil fishes and amphibians for display in the hall of cold-blooded vertebrates were completed. Retirement of a portion of the geology and meteorite collections from hall 6 was undertaken to permit the continued display of the larger Pleistocene mammals.

A group of showy mineral specimens from Arizona and a large mass of uranium ore from Colorado were lent for exhibition in the United States Pavilion at the Brussel's World Fair.

Plans for the modernization of the two halls to be devoted to North American archeology were developed by Dr. Waldo R. Wedel, curator of archeology. In the first hall now scheduled for construction, archeological horizons of the southwestern United States, the Pacific coast, and Arctic America will be featured. Topical exhibits will show native mines and quarries, Indian smoking devices, and trade items found in Indian sites.

At the close of the fiscal year the contractors had almost finished the construction of the walls and display units in the two halls to be devoted to the mammals of the world. Preliminary models of the habitat groups have been prepared for guidance of the exhibits staff, accessories for some of the habitat groups are now ready for installation, and a number of mammals required for the display units have been mounted. During the year the rooms formerly given over to the display of local natural history, other than birds, were more urgently needed for other purposes, and, consequently, these displays were dismantled. When space becomes available, more informative exhibits will be installed.

The formal opening of the hall of military history on the afternoon of June 14, 1958, was presided over by Secretary Leonard Carmichael, who introduced the Honorable Wilber M. Brucker, Secretary of the Army, who in turn introduced Gen. Lyman L. Lemnitzer, Vice Chief of Staff, United States Army, and members of their staffs. Secretary Brucker made reference to the Institution's important role in encouraging patriotism through the exhibits that interpret the Army's long and distinguished role in the history of our country. At the close of these indoor ceremonies, Secretary Brucker was honored by a colorful retreat review by the First Battle Group, Third Infantry Regiment, on the Mall. In the new hall the history and development of the United States Army from the Colonial militia to the modern Pentomic Army are traced through the display of firearms, uniforms, weapons, and other items of military equipment. Unique objects on display include George Washington's sword carried in battle throughout the Revolution and the uniform he wore when

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he resigned his commission in 1783, De Kalb's war saddle, an original Von Steuben drill manual, Rochambeau's sword, and the uniform coat worn by General Jackson at the Battle of New Orleans.

The series of new exhibits illustrating the history and methods of fine printmaking by various hand processes in the graphic arts hall of the Smithsonian Institution Building was completed at the close of the fiscal year. Monthly exhibitions of pictorial photography were continued during the past year, and three special exhibits in graphic arts were shown.

The east side of the inorganic chemistry gallery was rearranged to accommodate the leather and saddlery display removed from the south-central gallery.

Temporary exhibitions during the year included the Sixth International Exhibition of Ceramic Art, August 27 to September 27, 1957, sponsored by the Kiln Club of Washington, and a display of over 700 pieces of ancient glass from the Ray Winfield Smith collection dating from 1500 B.C. to A.D. 1200, shown December 28, 1957, to January 16, 1958.

Existing exhibits were improved during the year by restoration of the Henry electromagnet and the Morse telegraph, the renovation of the collection of antique astrolabes, sundials, and compasses, and the renovation of the Howard tower clock. Ship models in the watercraft hall were repaired and restored.

In the planning for the exhibition series in the Museum of History and Technology, the following hall plans have been furnished to the architect for the detailing of built-in fixtures: Physics and astronomy, chemistry, heavy machinery, medicine, dentistry, pharmacy, electricity, watercraft, ceramics, glass, textiles, graphic arts, and photography.

The south hall of the Arts and Industries Building was closed to the public in July 1957; the former exhibits of textiles were dismantled and the specimens placed in storage. The contractors commenced the renovation of this hall in September 1957, and by the close of the fiscal year some progress had been made in the installation of the new exhibits. Three schematics illustrating various spinning principles have been built and installed, and the renovation of five full-sized machines has been completed. For the gallery of this south hall, plans for renovation were completed, and a contract for the necessary construction was awarded in April 1958. In this gallery, methods of printing fabrics, specimens of needlework, and the history of the sewing machine will be featured.

Plans and designs for four halls in the Museum of History and Technology which will emphasize different aspects of the civil history of our Nation were completed. These halls have been designated as

follows: Historic Americans; Everyday Life in the American Past; Costumes; and First Ladies. Rearrangement and expansion of the White House china collection were effected during the year.

The educational program of volunteer docent guide service conducted with the cooperative assistance of the Junior League of Washington, for the benefit of the school children of the Greater Washington area, was continued with increasing success. The work is under the general direction of Frank M. Setzler, head curator of anthropology, working with Mrs. Peter Macdonald, chairman representing the Junior League.

During the 6-month season 320 tours—an average of 53 a month—were conducted, in which 8,790 elementary school children were escorted through the four exhibit halls included in the docent program—the American Indian Hall, the Hall of Everyday Life in Early America, the First Ladies Hall, and the Hall of Power Machinery. This was an almost threefold increase in this activity over the previous year. In addition to Mrs. Macdonald and her cochairman, Mrs. George Wyeth, Jr., the following members of the Junior League participated in the work of conducting the tours: Mrs. George A. Armstrong, Mrs. John K. Barry, Miss Eleanor Bishop, Mrs. G. Edwin Brown, Jr., Miss Joan Burke, Mrs. Paul Campbell, Mrs. Dean Cowie, Mrs. Charles Donnelly, Mrs. Walter Edwards, Mrs. C. Clarke Gearhart, Mrs. Walter A. Graves, Mrs. H. F. Gregory, Mrs. R. David Herdman, Mrs. Edward M. Lamont, Mrs. John A. Manfuso, Jr., Mrs. William McClure, Mrs. Robert L. McCormick, Mrs. William E. Minshall, Jr., Mrs. John Schoenfeld, Mrs. W. D. Sloan, Jr., Mrs. Walter Slowinski, Mrs. E. Tillman Stirling, Mrs. Richard F. Wallis.

BUILDINGS AND EQUIPMENT

At the close of the fiscal year, the temporary buildings on the site for the new Museum of History and Technology were being torn down to clear the land. The architects, McKim, Mead & White, submitted drawings for the entire building in the tentative stage, made excellent progress on the working drawings, and completed the specifications and drawings for the excavation and foundations. The design of this museum building previously approved by the Board of Regents of the Institution, with the advice of the Joint Congressional Committee, was approved unanimously by the Commission of Fine Arts. The National Capital Planning Commission approved the location of the building on the site.

Senator Clinton P. Anderson, chairman of the Joint Committee on Construction of a Building for the Museum of History and Technology for the Smithsonian Institution, submitted to the United

States Senate a report from the committee which reviews the legislative history of the building and the progress made in its design. This report was printed as Senate No. 1437, 85th Congress, 2d session, April 16, 1958.

Planning for this new building was directed by Frank A. Taylor, Director of the Museum of History and Technology. Designs for most of the exhibition halls requiring special architectural treatment were completed by the Museum staff, and the architects prepared the working drawings. John C. Ewers, administrative officer, directed the Museum staff engaged in the planning of all interior areas. Eugene Kingman, Director of the Josyln Art Museum, Omaha, reviewed many of the plans for exhibition halls and contributed constructive criticism.

Funds for the design and the preparation of working drawings for the construction of additions to the Natural History Building were appropriated by Congress. The architects, Mills, Petticord & Mills, have submitted tentative drawings with a model of the building when completed and have made excellent progress with the working drawings. The Museum committee for the planning of the wings under the chairmanship of Dr. T. Dale Stewart, together with the curators of the natural history divisions, completed a detailed program of requirements which materially advanced the preparation of plans and estimates.

Throughout the year's planning of the two building projects, the Public Buildings Service of the General Services Administration contributed valuable advice and assistance in advancing, coordinating, and approving the plans. Leonard L. Hunter, Assistant Commissioner for Design and Construction, gave helpful advice and professional direction to the progress of the work through the various technical stages and presented the building plans before the approving agencies. Many of his colleagues materially advanced these projects. John E. Cudd, architect of the Public Buildings Service, assigned as liaison to the Smithsonian Institution, contributed greatly to all phases of the two projects, assembling data on requirements, advising the Museum staff on the arrangement of their planned facilities, and assisting the architects in arranging discussions and obtaining decisions on many questions of design and procedure.

Contracts were let for completion of the replacement of the roof covering on the Natural History Building, the first phase of which was completed in the fiscal year of 1957. The work will include covering all skylights with metal and the installation of fluorescent lighting above the laylight glass. Covering of the skylights will permit uniform lighting in the three large halls and eliminate water leakage, which is impossible to control fully in large areas of skylight glass.

The west shipping entrance of the Natural History Building was remodeled to provide a stockroom for the supply division and a more adequate mail room, utilizing space heretofore used to garage Smithsonian trucks. An additional shipping entrance door was provided by remodeling a window between the two existing doors. Supply division offices were moved into the former stockroom after that space was renovated.

Meeting room 43 was completely renovated. The work included an acoustic tile ceiling, additional lighting, relocation of the projection equipment, a new projection screen, tile floor covering, and improved ventilation.

All exterior windows of the Arts and Industries Building were painted, and new glass to provide better illumination was installed in the large windows of the exhibit halls.

New concrete sidewalks were laid along both sides of the west service road, Arts and Industries Building. A new service road was laid along the west side of this building, and the service road along the east side was resurfaced. Completion of this project eliminated service hazards.

CHANGES IN ORGANIZATION AND STAFF

Effective July 1, 1957, the United States National Museum consists of two units, namely, the Museum of Natural History (with its four departments of anthropology, zoology, botany, and geology) and the Museum of History and Technology (with its four departments of science and technology, arts and manufactures, civil history, and Armed Forces history). Under this new organizational setup, the old department of engineering and industries and the department of history were abolished.

Frank A. Taylor was promoted to Director of the Museum of History and Technology on April 16, 1958.

In the department of civil history, Dr. Anthony N. B. Garvan accepted an appointment as head curator on October 9, 1957. Paul V. Gardner, on July 1, 1957, was transferred from the National Collection of Fine Arts to the position of acting curator of ceramics and glass; Mrs. Elvira Clain-Stefanelli was appointed assistant curator of numismatics on September 23, 1957; and Dr. Wilcomb E. Washburn became acting curator of political history on February 3, 1958.

Vacancies in the department of science and technology were filled by the appointment of Dr. John B. Blake as associate curator of medical sciences on July 1, 1957; Robert M. Vogel as assistant curator of mechanical and civil engineering on July 22, 1957; Howard I. Chapelle as curator of transportation on September 3, 1957; and Eugene S. Ferguson as curator of mechanical and civil engineering

on January 30, 1958. Dr. Derek Price, consultant for exhibits of physics and astronomy, completed his assignment on January 3, 1958.

In the department of geology, Dr. Richard S. Boardman transferred from the U.S. Geological Survey to the division of invertebrate paleontology and paleobotany on July 1, 1957; Dr. Peter P. Vaughn accepted an appointment as associate curator of vertebrate paleontology effective July 15, 1957; Paul E. Desautels was appointed associate curator of mineralogy and petrology on August 5, 1957; and Roy S. Clarke, Jr., transferred as chemist to the division of mineralogy and petrology from the U.S. Geological Survey on October 21, 1957. Dr. Porter M. Kier, appointed associate curator of invertebrate paleontology and paleobotany on June 16, 1957, was inadvertently omitted from the list of new appointments during the previous fiscal year.

Dr. Ralph S. Solecki accepted an appointment of associate curator of prehistoric Old World archeology on August 26, 1957, following his return from archeological fieldwork on the Shanidar, Iraq, project.

On March 27, 1958, Bela S. Bory was appointed supervisory exhibits specialist and placed in charge of the production laboratory of the Museum of History and Technology.

J. Russell Sirlouis, assistant curator of military history, retired on June 30, 1957, after 42 years of service with the Institution.

Robert S. Woodbury, curator in charge of the sections of civil and mechanical engineering, resigned July 9, 1957, to return to his former position at the Massachusetts Institute of Technology.

Grace E. Glance, associate curator of entomology, retired July 31, 1957. Miss Glance transferred to the division of entomology from the U.S. Department of Agriculture in 1948 after having been employed in the Bureau of Entomology and Plant Quarantine since 1925.

Franklin R. Bruns, Jr., associate curator of philately and postal history, by lateral transfer on November 18, 1957, became director of the division of philately of the Post Office Department.

Herbert W. Krieger, curator of ethnology, retired November 30, 1957, after having served 33 years in the department of anthropology. Mr. Krieger had participated in fieldwork sponsored by the Institution in southeast Alaska, Santo Domingo, Haiti, Cuba, the Bahama Islands, and the Virgin Islands.

After having served more than 43 years as taxidermist on the exhibits staff, Charles R. Aschemeier retired May 31, 1958. He represented the Smithsonian Institution on the Collins-Garner Expedition to the Fornan Vaz District of Belgian Congo, where fieldwork was

continued for more than 2 years as a result of transportation difficulties during World War I.

Lee L. Buchanan, research associate in entomology, died in Washington, D.C., on February 15, 1958. Buchanan, an authority on weevils, had served as assistant biologist in the Bureau of Biological Survey from 1917 to 1929, and remained in the U.S. Department of Agriculture Bureau of Entomology and Plant Quarantine from 1929 to 1949 when he retired for health reasons. He was appointed a specialist for the Casey Collection of Coleoptera on April 1, 1926.

Dr. Harriet Richardson Searle, collaborator since January 11, 1901, and research associate in zoology since December 27, 1956, died in Washington, D.C., on March 28, 1958. Dr. Richardson was a world authority on the isopod crustaceans and published more than 80 papers, including the monograph of the isopods of North America which appeared in 1905 and which is still a standard reference work on the group.

Respectfully submitted.

REMINGTON KELLOGG, *Director.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Bureau of American Ethnology

SIR: I have the honor to submit the following report on the field researches, office work, and other operations of the Bureau of American Ethnology during the fiscal year ended June 30, 1958, conducted in accordance with the act of Congress of April 10, 1928, as amended August 22, 1949, which directs the Bureau "to continue independently or in cooperation anthropological researches among the American Indians and the natives of lands under the jurisdiction or protection of the United States and the excavation and preservation of archeologic remains."

SYSTEMATIC RESEARCHES

(Prepared from data submitted by staff members.)

Dr. M. W. Stirling, Chief of the Bureau of American Ethnology from 1928 to 1947 and Director since 1947, retired on December 31, 1957. At that time he was appointed a research associate. During the period from July 1 to December 31, 1957, Dr. Stirling devoted most of his time to administrative duties and the preparation of a manuscript pertaining to previous fieldwork in Panama and Ecuador. Effective January 1, 1958, Dr. Frank H. H. Roberts, Jr., Associate Director, was appointed Director. He also continued to be in charge of the River Basin Surveys.

During the fiscal year Dr. Roberts devoted most of his time to the management of the River Basin Surveys and subsequently to the duties of the main Bureau office. In July and early August he made an inspection trip to the Missouri Basin where he visited all the excavation parties of the River Basin Surveys and also several of those from cooperating institutions. He was accompanied by Dr. Robert L. Stephenson, chief of the Missouri Basin Project, Dr. John M. Corbett, National Park Service archeologist, and Paul L. Beaubien, regional archeologist for Region Two of the Service. Late in April Dr. Roberts went to the field headquarters at Lincoln, Nebr., to assist in preparing plans for the field season in the Missouri Basin. From Lincoln, in company with several members of the Missouri Basin Project staff, he went to Norman, Okla., to attend and participate in the annual meeting of the Society for American Archeology. From here the group proceeded to Russellville, Ark., where it inspected the

excavations being carried on by a River Basin Surveys party in the Dardanelle Reservoir area. En route back to Lincoln a stop was made at the University of Arkansas at Fayetteville, and a number of collections of archeological material in the museum there were examined. After spending several additional days at Lincoln studying the operations of the office and laboratory, Dr. Roberts returned to Washington and was in the office at the close of the year. During the fall and winter months Dr. Roberts reviewed and suggested changes in the manuscripts of several detailed, technical reports on the results of excavations at sites in the Missouri Basin and other areas.

Dr. Henry B. Collins, anthropologist, continued his Eskimo studies and other Arctic activities. He prepared an article on Eskimo art for the *Enciclopedia Universale Dell'Arte*, a 14-volume work to be published in Italian and English by the Istituto per la Collaborazione Culturale, Rome. His paper "Present Status of the Dorset Problem," which he presented at the 32d International Congress of Americanists in Copenhagen, was published in the Proceedings of the Congress.

In May Dr. Collins participated in an international conference on Arctic anthropology held at the Danish National Museum in Copenhagen. Also attending were five anthropologists from the United States, one from Canada, four each from Denmark and the U.S.S.R., and two each from Norway, Sweden, and Finland. The purpose of the meeting was to discuss plans for closer international cooperation in Arctic anthropology. Following the conference Dr. Collins visited a large Mesolithic site, Kongemosen, representing the formative stage of the Ertebölle culture, and two other Mesolithic sites at Eriksholm and Langtved, near Holbaek.

Dr. Collins continued to serve on the publications and research committees of the Arctic Institute of North America, as well as on the committee which plans the research program of the Arctic Research Laboratory at Point Barrow, operated by the Office of Naval Research. He also continued as chairman of the Directing Committee which plans and supervises the work of the *Arctic Bibliography*, a comprehensive annotated and indexed bibliography of publications in all fields of science relating to the Arctic and sub-Arctic regions of America and Eurasia. The work is being prepared by the Arctic Institute of North America for the Department of Defense. Volume 8 of the Bibliography, which abstracts and indexes the contents of 5,623 publications in English, Russian, German, and the Scandinavian and 17 other languages, was delivered to the Government Printing Office in June. This makes a total of 49,087 publications that have been abstracted thus far in *Arctic Bibliography*.

Dr. William C. Sturtevant, ethnologist, spent the week of July 29–August 4, 1957, in South Carolina working with the last living speaker of any of the Siouan languages of the east—a Catawba man 85 years old. The informant proved somewhat less than satisfactory, owing to his age and rather poor recall of a language he has not spoken for some years. However, a vocabulary file of a few hundred entries was built up, and several short texts and songs were collected. In addition to transcription in a phonetic orthography, all materials were recorded with a tape recorder, to form a permanent record of a different nature than the Catawba linguistic materials collected by others before the advent of convenient mechanical recording devices with good fidelity. The language has not yet been adequately analyzed, nor has its precise relationship to other Siouan languages been established; the tape recording will be invaluable when these tasks are eventually undertaken.

Dr. Sturtevant spent 7 weeks continuing his field research among the New York State Seneca, during four separate trips. In September he devoted 10 days to close observation of the work of a skilled Seneca mask carver on the Allegany Reservation, making detailed notes on his construction techniques and taking numerous photographs to document the various steps in the process. For a few days of this period Dr. Sturtevant received valuable assistance from Dr. William H. Davenport of Yale University, a specialist on primitive art. It became evident during this fieldwork that observation of construction is an essential preliminary to the structural analysis of the forms of these Seneca masks and will be of considerable assistance in the ethnoesthetic study initiated during the previous fiscal year. During January and February, Dr. Sturtevant spent about 2 weeks on the Cattaraugus Reservation attending the annual midwinter ceremony of this Seneca group and discussing it with participants. The data obtained form part of a continuing study of the religion of this community, which has previously received little attention from ethnologists, in contrast to most other Iroquois non-Christian communities.

In April 1958, Dr. Sturtevant visited Gainesville, Fla., for consultations on Florida anthropology with Dr. John M. Goggin. From there he traveled to Oklahoma via Montgomery, Ala. (where he examined the collections of the Alabama Department of Archives and History), and the region around Philadelphia, Miss. (where he spent three days surveying the possibilities for research among the Mississippi Choctaw). In Oklahoma he examined the photograph and specimen collections of the Oklahoma Historical Society, attended the joint annual meetings of the Society for American Archeology and the Central States Anthropological Society, and had brief contacts with members of several Oklahoma tribes. Dr. Sturtevant also

attended the 11th Conference on Iroquois Research at Red House, N.Y., in October 1957. At these latter two professional meetings he delivered three papers. In December 1957 he attended the American Anthropological Association meetings in Chicago (where he also examined an important collection of Seminole artifacts and a large newly discovered collection of early photographs of the Seminole).

In May and June 1958, Dr. Sturtevant returned for three weeks to the Allegany Reservation, where he concentrated on study of social organization, particularly residence patterns. These data should prove valuable for comparison with similar information, as yet unpublished, collected some 25 years ago on this reservation by Dr. William N. Fenton. Furthermore, the community studied is threatened with removal to make way for flooding of a large part of the reservation by the proposed Kinzua dam. If the dam is built, present residence patterns can then be compared with residence after relocation of the community. The nearly unanimous opposition of the Indians to relocation makes research of this sort rather difficult.

Dr. Sturtevant's office work included continuation of his research on the Florida Seminole, on which a paper was published in Publication No. 5 of the Florida Anthropological Society, and work on a paper on the historical ethnobotany of the cycad *Zamia*.

At the beginning of the fiscal year Carl F. Miller was continuing the excavations by the Smithsonian Institution–National Geographic Society Expedition at Russell Cave in Alabama. The work continued until the end of August, and during that period a section of the cave floor was excavated to a depth of 32 feet, where a water table was encountered and it was necessary to stop the digging. During the course of the work the skeletal remains of a very young infant were found at a depth of approximately 4 feet. On the basis of a carbon-14 date obtained during the previous season's investigations at the cave, it is estimated that the burial was approximately 5,000 years old. There were no accompanying mortuary offerings, but the deposits where the remains were interred indicated that the Early Woodland Period was represented. The partially flexed remains of an adult male were found 8½ feet below the floor level and it also lacked any accompanying offerings. The burial probably was made about 7,000 years ago. The material from the deposits indicates that potterymaking began in that area at about 3500 B.C. Prior to that time the people apparently had a completely hunting-fishing economy. A large series of implements, discarded animal bones, and other materials was obtained from the lower deposits, and at a depth of 23 feet the remains of a hearth were uncovered. Charcoal from that hearth was recently dated by Dr. H. R. Crane at the University of Michigan as being 9,020±350 years old. The Russell Cave Expedi-

tion brought back to the Smithsonian Institution somewhat more than a ton and a half of material for study and exhibit purposes.

RIVER BASIN SURVEYS

The River Basin Surveys, in cooperation with the National Park Service and the Bureau of Reclamation of the Department of the Interior, the Corps of Engineers of the Department of the Army, and various State and local institutions, continued its program for salvage archeology in areas to be flooded or otherwise destroyed by the construction of large dams. During the fiscal year 1957–58 the program was financed by a transfer of $175,624 from the National Park Service to the Smithsonian Institution. Of that amount $157,624 was for use in the Missouri Basin and the remainder covered operations in other areas. A carryover of $15,902 from the Missouri Basin funds for the preceding fiscal year made the total available for the Missouri Basin $173,526. The over-all total for the year was $191,526. The amount of available money was somewhat larger than during the previous fiscal year, and the increase was reflected in the work accomplished.

Field investigation during the year consisted mainly of excavations, although some surveys were carried on in several areas. On June 1, 1957, nine parties were in the field. Four were doing intensive digging in the Great Bend Reservoir area and four were making excavations in the Oahe Reservoir area, both projects being located in South Dakota. A survey party covered portions of the Big Bend area, which had not been visited during the previous summer's work, and carried on test operations in 14 sites. In September that party moved to the Oahe Reservoir basin where it started similar operations. Most of the field parties had returned to their headquarters by the end of September. Early in the spring a party conducted excavations in the Dardanelle Reservoir area on the Arkansas River in Arkansas. During the period February–June, a survey party worked in three reservoir areas along the lower Chattahoochee River in Alabama and Georgia, and in April–June another party excavated in two sites in the Hartwell Reservoir area in South Carolina-Georgia. At the end of the fiscal year nine parties were conducting excavations along the Missouri River in South Dakota. Five were working in the Great Bend Reservoir area and four in the Oahe Reservoir Basin.

By June 30, 1958, reservoir areas where archeological surveys and excavations had been made since the salvage program got under way in 1946 totaled 254 in 29 States. The survey parties have located and recorded 4,889 archeological sites, and of that number 997 have been recommended for excavation or limited testing. In general

the term "excavation" does not indicate the complete investigation of a site, but usually means that only about 10 percent of it has been uncovered. There are some cases, however, where the locality is of sufficient significance to warrant extensive digging. Preliminary appraisal reports have been issued for all the reservoir areas surveyed, with the exception of the Big Bend in South Dakota and the group of three in Chattahoochee Basin. The report for the Big Bend has been completed, however, and will be processed early in the coming fiscal year. One preliminary report covering the survey of the Dardanelle Reservoir area in Arkansas was mimeographed and distributed during the year. Since the beginning of the Inter-Agency Archeological Salvage Program, 184 appraisal reports have been issued. The discrepancy between that number and the total of the reservoir areas examined is due to the fact that in several cases information obtained from a number of reservoir projects located in a single basin or subbasin have been combined in a single report.

By the end of the fiscal year 388 sites in 52 reservoir basins located in 19 different States had been either partially or extensively dug. Only a single site was excavated in some of the reservoir areas, while in others a whole series was investigated. At least one example of each type of site recommended by the preliminary surveys had been excavated. In some cases it has been necessary to dig a number of somewhat similar sites because the complexity of such remains makes it essential to have considerable comparative material in order to obtain full information about that particular phase of aboriginal culture. In brief it may be said that the cultural stages represented cover the range from the early hunting peoples of about 10,000 years ago to the frontier trading and Army posts of the latter part of the 19th century. Reports of the results obtained from some of the excavations have been published in Bulletins of the Bureau of American Ethnology, in the Smithsonian Miscellaneous Collections, and in various scientific journals. During the year River Basin Surveys Paper No. 8, Bulletin 166 of the Bureau of American Ethnology, was distributed. It was written by Dr. Douglas Osborne and pertains to excavations in the McNary Reservoir Basin near Umatilla, Oreg. Accompanying the archeological report are appendices on the skeletal material, trade goods, and composition of the copper objects found during the excavations. River Basin Surveys Papers 9–14, which will constitute Bulletin 169 of the Bureau of American Ethnology, were in page proof at the end of the year, and the volume should be ready for distribution early in the next fiscal year. Three of the papers pertain to investigations in the Missouri Basin, two to work done in the Jim Woodruff Reservoir area, Georgia-Florida, and one to a site in the Alatoona Reservoir

area in Georgia. Twelve detailed technical reports on the results of work done during previous years were completed during 1957–58 and are ready to submit to the editors for publication as soon as funds sufficient to cover their cost are available.

As of June 30, 1958, the distribution of reservoir projects that have been surveyed for archeological remains was as follows: Alabama, 3; Arkansas, 1; California, 20; Colorado, 24; Georgia, 8; Idaho, 11; Illinois, 2; Iowa, 3; Kansas, 10; Kentucky, 2; Louisiana, 2; Minnesota, 1; Mississippi, 1; Montana, 15; Nebraska, 28; New Mexico, 1; North Dakota, 13; Ohio, 2; Oklahoma, 7; Oregon, 27; Pennsylvania, 2; South Carolina, 1; South Dakota, 10; Tennessee, 4; Texas, 19; Virginia, 2; Washington, 11; West Virginia, 2; Wyoming, 22. Excavations have been made or were under way in reservoir basins in Arkansas, 1; California, 5; Colorado, 1; Iowa, 1; Georgia, 5; Kansas, 5; Montana, 1; Nebraska, 1; New Mexico, 1; North Dakota, 4; Oklahoma, 2; Oregon, 4; South Carolina, 2; South Dakota, 4; Texas, 7; Virginia, 1; Washington, 4; West Virginia, 1; Wyoming, 2. The preceding figures include only the work of the River Basin Surveys or that which was in direct cooperation between local institutions and the Surveys. The investigations made by State and local institutions working under agreements with the National Park Service have not been included because complete information about them is not available.

The River Basin Surveys, as in previous years, received helpful cooperation from the National Park Service, the Bureau of Reclamation, and the Corps of Engineers, and various State and local institutions. The Corps of Engineers provided transportation and guides for work in one of the reservoir areas and provided temporary field headquarters for a party in another area. In several instances mechanical equipment to assist in heavy excavations was made available by the construction agency. Field personnel of all the agencies was particularly helpful to the various party leaders from the River Basin Surveys and expedited their activities in numerous ways. The National Park Service continued to serve as the liaison between the various agencies, both in Washington and in the field. The Park Service also prepared the estimates and justifications for the funds needed to carry on the salvage program. In the several Park Service regions the regional directors and members of their staffs cooperated wholeheartedly in the program and greatly aided all phases of the operations.

The main office in Washington continued general supervision of the program. The field headquarters and laboratory at Lincoln, Nebr., was responsible for the activities in the Missouri Basin and also provided a base of operations for the party which worked at the

Dardanelle Reservation in Arkansas. The materials collected by the excavating parties in the Missouri River Basin, as well as the one in Arkansas and those from the Toronto Reservoir area on the Verdigris River in Kansas, which were obtained the previous year, were processed at the Lincoln laboratory. During the first two months of the fiscal year, Dr. James H. Howard, who supervised the project at the Kansas Reservoir, worked in the Lincoln office studying the specimens which he had recovered and preparing his report.

Washington office.—The main headquarters of the River Basin Surveys at the Bureau of American Ethnology continued under the direction of Dr. Frank H. H. Roberts, Jr. Carl F. Miller, archeologist, was detailed to the regular Bureau staff for the period from July 1 to December 29, in order to continue excavations at Russell Cave, Alabama, and to work up the material obtained from the cave. On December 30 he returned to the River Basin Surveys staff and from then until April 22 devoted his time to the completion of his report on previous excavations at the James H. Kerr (Buggs Island) Reservoir on the Roanoke River in southern Virginia. During the winter months he spoke before several local societies, completed an article on the Russell Cave work for the National Geographic Magazine and gave a lecture on the cave before the National Geographic Society in Washington. On April 22 he proceeded to South Carolina where he conducted excavations in the Hartwell Reservoir area. While engaged in those investigations he spoke before several local Rotary and Lions Clubs, several groups of Boy Scouts, and a Naval Research group at Clemson College. On May 23 he participated in a conference held at the University of Georgia at Athens, at which time representatives of the National Park Service, the University of Georgia, and the River Basin Surveys discussed future work for the Hartwell Reservoir area. Mr. Miller returned to Washington on June 26 and on June 29 was again transferred to the Bureau of American Ethnology to resume the activities at Russell Cave. The latter work, which is a cooperative project between the Smithsonian Institution and the National Geographic Society, was to continue through the early months of the following fiscal year.

William M. Bass III, temporary physical anthropologist, was on duty in Washington at the beginning of the year. He devoted the month of July and the first week in August to a study of human skeletal material from various sites in the Missouri Basin and prepared reports on his findings. On August 9 he left Washington for Pierre, S. Dak., and spent the ensuing 3 weeks assisting in the removal of Indian burials at the Sully site in the Oahe Reservoir area. Mr. Bass returned to Washington August 29 and resigned from the Surveys in order to resume his studies toward an advanced degree. On

June 2 Mr. Bass again reported for duty in Washington and spent 3 weeks classifying human skeletal material from the James H. Kerr Reservoir in southern Virginia. He then proceeded to Pierre, S. Dak., and took charge of a party conducting excavations in the burial area at the Sully site. Mr. Bass was engaged in those activities at the close of the year.

Harold A. Huscher, archeologist on the staff of the Missouri Basin Project, was detailed to the Washington office beginning February 2, 1958, and on February 7 left for Georgia and Alabama, where he carried on preliminary surveys in three reservoir areas in the lower Chattahoochee River Basin. Mr. Huscher continued those activities until June 23 when he went to Athens, Ga., to participate in the conference at which Mr. Miller was also in attendance. Following the conference Mr. Huscher returned to Washington, and at the close of the fiscal year was preparing a summary report on the results of his explorations along the Chattahoochee.

Alabama-Georgia.—During the period February 10 to June 21 preliminary surveys were made in the areas to be flooded by the Columbia Dam and Lock, the Walter F. George Dam and Lock, and the Oliver Dam on the lower Chattahoochee River. The Columbia Dam and Lock and the Walter F. George Dam and Lock are projects of the Corps of Engineers, Department of the Army, while the Oliver Dam is being constructed by the Georgia Power Co. The Columbia Dam is to be located a short distance below the bridge across the Chattahoochee River at Columbia, Ala. The Walter F. George Dam is to be built at Fort Gaines, Ga., and the Oliver Dam is located a short distance above Columbus, Ga. These three projects together will flood out 120 contiguous miles of the Chattahoochee bottoms. Since the area to be affected by the Walter F. George project will be the first to be inundated, most of the period was spent in that area, although some reconnaissance was made in both of the other basins.

During the course of the survey in the Walter F. George basin, 117 archeological sites were located and recorded on the Georgia side of the river and 90 sites on the Alabama side. They range from simple village locations to areas containing the remains of several different cultures, and from single to multiple mound groups. In addition there are two historical sites of considerable importance. One is that of the Spanish Fort of Apalachicola, dating from 1689 to 1691, and the other the historic Creek town of Roanoke which was occupied by the whites and then attacked and burned by the Indians in 1736. Because the exact dates of occupancy of the Fort are known, it should provide an important check point in working out the chronology of the area. Also, since the Roanoke village was burned it should be quite productive archeologically. The aboriginal sites range from Early

Woodland to relatively late Creek villages dating from the period 1675–1836. The latter present the possibility of a specific identification of sites from ethnohistorical evidence, as well as an unusual opportunity to use the direct-historical approach in establishing a regional chronology.

The manifestations in the Columbia Dam and Lock and Oliver Dam basins are an integral part of the entire picture in the Lower Chattahoochee Valley and must be studied in conjunction with those in the Walter F. George section. Complete coverage of those two projects was not possible in the time devoted to the reconnaissance, but it was determined that there are at least 14 sites in the immediate area of the Columbia Dam which will be affected by construction activities. One is a major mound site probably dating about A.D. 1200, already half destroyed by the river, which calls for immediate investigation. Three others are major village sites attributable to the Weeden Island cultural pattern. In the Oliver Dam district there are at least 15 known sites including mounds, early village locations, and caves giving evidence of Indian occupation. The series encompasses a period of at least 3,000 years.

The entire history of aboriginal development in that portion of the Chattahoochee Valley is contained in the river bottoms and low terraces which will be flooded by the three reservoirs. Very little archeological work has been done there and an extensive program of excavation is indicated. In addition, further surveys should be made in districts not covered during the recent investigations.

Arkansas.—In the Dardanelle Reservoir Basin on the Arkansas River in west-central Arkansas, excavations were made in five sites, and two new sites were located and recorded during the period from March 18 to May 7. All seven of the sites involved were in the lower portion of the reservoir area. One rock shelter was almost completely excavated and four open sites were extensively tested. Little was found at the excavated sites to indicate the type of dwelling or structures erected by the people. However, a considerable collection of artifact material was recovered which shows that the sites primarily represent the Archaic Period and that their ceramics were related to the Lower Mississippi Valley sequences. Only slight influences were noted from the Caddoan area to the west and southwest. The two new sites found by the field party represent a mound-village complex and a historic Cherokee location. Because of adverse weather and unusually heavy rains during the period the party was in the Dardanelle area, not so much work was accomplished as had been contemplated, and it was recommended that similar excavations be made during the following fiscal year in upper portions of the reservoir basin.

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The proposed survey of the Greer's Ferry Reservoir area, which was postponed the previous year because of high waters, was not made during the current year by a River Basin Surveys party as contemplated. Instead the University of Arkansas, working under an agreement with the National Park Service, carried out the preliminary investigations at Greer's Ferry. The situation there was somewhat comparable to that in the Dardanelle area in that weather conditions hampered the work to a considerable degree. It was planned that another party from the University would return to the Greer's Ferry area shortly after the beginning of the new fiscal year.

Iowa.—No fieldwork was carried on in Iowa during the fiscal year ended June 30, 1958. However, the detailed technical report "Archeological Salvage Investigations in the Coralville Reservoir, Iowa" was completed during the year and will be available for publication as soon as funds for that purpose are available. The report consists of 100 typed pages, 12 plates, and 15 text figures.

Kansas.—The only activity on the part of the River Basin Surveys during the fiscal year pertaining to Kansas was that of the completion of the detailed technical report on the excavation in eight sites in the Toronto Reservoir Basin during the spring months of 1957. A typed manuscript of 90 pages with 12 plates and 15 text figures is now ready to submit to the editors.

Missouri Basin.—As in previous years, the Missouri Basin Project continued to operate from the field headquarters and laboratory at 1517 "O" Street, Lincoln, Nebr. Dr. Robert L. Stephenson served as chief of the Project throughout the year. Activities included work on all four phases of the salvage program: (1) Survey, (2) excavation, (3) analysis, and (4) reporting. The first two phases received major attention in the summer months, and the second two during the fall and winter. In addition to the four regular phases of the program, a special chronology program was initiated during the year.

At the beginning of the fiscal year the staff, in addition to the chief, consisted of 4 permanent archeologists, 1 archeologist detailed to the Project from the Washington office, 5 temporary field assistants, 1 field assistant detailed to the project from the Washington office, 1 temporary physical anthropologist on duty in the Washington office, 1 field and laboratory assistant, 1 administrative assistant, 1 museum aide, 1 clerk-stenographer, 1 file clerk (half time), 1 photographer, 1 clerk-typist, 2 temporary laboratory assistants, 1 temporary (part time) draftsman, and 79 temporary field crewmen. At the end of the 1957 summer field season, all temporary field crewmen were terminated, with the exception of one who was assigned laboratory assistant's duties in the Lincoln office. The physical anthropologist subsequently was on duty in the Missouri Basin for 3

weeks in August. The archeologist and field assistant detailed from the Washington office returned to their regular assignments in August. Two temporary field assistants were terminated in August. Two other temporary field assistants were appointed as archeologists on the permanent staff. One temporary field assistant was transferred to duty outside the Missouri Basin in January. One illustrator was added to the permanent staff in November. All other temporary employees were terminated in December and January. Four museum aides were added to the permanent staff during the year. One temporary archeologist and two temporary field assistants were added at the beginning of the 1958 field season. At the end of the fiscal year there were 6 archeologists in addition to the chief, 1 administrative assistant, 1 clerk-stenographer, 1 file clerk (three-quarters time), 1 clerk-typist, 1 photographer, 1 illustrator, and 4 museum aides on the permanent staff. Temporary employees included 1 archeologist, 1 physical anthropologist, 2 field assistants, 3 cooks, and 90 crewmen.

During the year there were 19 Smithsonian Institution River Basin Surveys field parties at work within the Missouri Basin, while another, working outside the Basin, also operated from the Project office in Lincoln. Of the 19 Missouri Basin parties, 5 were at work in July, August, and September in the Big Bend Reservoir area in South Dakota, and 5 additional parties were at work there in June. Five parties worked in the Oahe Reservoir area in July, August, and September, and four other parties were at work there in June. The party outside the Missouri Basin was that in the Dardanelle Reservoir area in Arkansas.

Other fieldwork in the Missouri Basin during the year included 11 field parties from State institutions working under agreements with the National Park Service and in cooperation with the salvage research program of the Smithsonian Institution. Parties from the Universities of South Dakota, Idaho, Wyoming, Kansas, and Missouri and from the North Dakota State Historical Society were in the field during July to October. Parties from the Universities of South Dakota, Idaho, Wyoming, and Missouri were conducting excavations in June, as was a joint party from the North Dakota State Historical Society and the University of North Dakota.

At the beginning of the year in the Big Bend Reservoir area, G. Hubert Smith and a party of 10 were engaged in excavations on the right bank of the Missouri River near the mouth of Medicine Creek, in Lyman County, S. Dak., at site 39LM241. This site was believed to be that of Fort Defiance (or Bouis), a small, short-lived trading post of the 1840's. It was one of a number of such establishments organized from time to time in competition with the American Fur Co. (P. Chouteau, Jr., & Co., after 1834). It was hoped that

work there would provide information on such lesser establishments of the fur and Indian trade, of which little was ever recorded at the time they were in use. Excavations at 39LM241 proved that it was not the site of Fort Defiance (or Bouis) but that it was of a later period of permanent settlement, dating after 1880. Further search for the Fort Defiance site proved fruitless. While somewhat scanty, the data and specimens from 39LM241 provide materials that should be very useful for comparative studies relating to this later period of white occupation. The Smith party completed 6 weeks of fieldwork and returned to the Lincoln office early in August.

The second River Basin Surveys field party in the Big Bend Reservoir area at the beginning of the year was directed by Dr. Warren W. Caldwell and consisted of a crew of nine. The group was at work on the right bank of the Missouri River in Lyman County, S. Dak., some 7 miles above the Lower Brule Agency, excavating in the Black Partizan site (39LM218). The latter consists of the remains of a prehistoric earth-lodge village of at least 2 component occupations and perhaps 3. The party completely excavated 1 circular earth-lodge ruin and a large portion of a second, cross-sectioned a defensive fortification ditch, excavated 1 complete bastion of the stockade, and tested a number of midden areas and cache pits. The circular houses were situated well outside the fortification ditch and were of the late occupation of about the end of the 17th century. The ditch and bastion represent two earlier occupation periods, with the ditch being dug during the earlier one, later filled in and, still later, redug. Tests indicated a rectangular house inside the fortification ditch and, together with midden areas and cache pits in that area, provided both simple-stamped and cord-roughened pottery that predates the material recovered from the circular houses outside the stockade. Among the finds made in the cache pits, one of particular interest was the burial of two very large, adult dogs, together with a pup. After 12 weeks of excavation, the party disbanded and returned to the Lincoln office on September 7. The Caldwell and Smith parties shared a joint field camp near the mouth of Medicine Creek.

The third River Basin Surveys field party in the Big Bend Reservoir area at the beginning of the year was under the direction of Robert W. Neuman and had a crew of 10. That party conducted excavations in four sites in the vicinity of Old Fort Thompson, the Indian Agency, on the left bank of the Missouri River in Buffalo County, S. Dak. Two of them were prehistoric village sites on the low terrace bottoms, and two were burial mounds situated on the higher terrace of the Missouri River. The Pretty Bull site (39BF12) was found to have had three separate occupations. The earliest and deepest remains were recovered from two test excavations that un-

covered two basin-shaped pits with burned, bright orange-colored walls. One of these pits was associated with a few scattered post molds. The recovered artifacts suggest a Middle Woodland occupation and include cord-marked pottery, crude triangular projectile points, stone end scrapers, elk or deer bone and antler tools, small shell disk beads, and concentrations of hematite. The middle occupation was apparent in a large strata trench, where six cache pits with slightly convex bottoms and undercut walls were excavated. Fill within the pits included an abundance of Monroe, Anderson, and Foreman pottery that relates to an early, rectangular-house occupation. Bone and stone implements were also numerous, but no architectural features were found. The late occupation was represented in the excavations by the remains of a large, circular earth lodge. A central fire hearth, basin- and bell-shaped cache pits, and secondary fire hearths were excavated within the house. The ceramic collections from the house fill consist of at least nine pottery types, suggesting a long and varied occupation. The post-mold pattern of the house was poorly defined in some places, but the general pattern was unmistakable.

The second village location excavated by the Neuman party was the Akichita site (39BF221). There, three midden areas were sampled extensively, and an abundance of artifacts and refuse was recovered, but no houses were located. One bell-shaped cache pit was dug. Artifacts collected suggest close affiliation with the older levels at the Dodd site (39ST30) near Pierre, S. Dak. It was felt at the end of the season that additional work was needed there, particularly an effort to determine the architectural pattern of the houses. A third site excavated was the Olson Mound (39BF223). It was a low, circular earth mound 1.5 feet high and 40 feet in diameter. No pottery and very few bone or stone artifacts were recovered from the fill. In the center, and on the base of the mound, there was a concentration of badly decomposed human bones, suggesting the secondary burial of an undetermined number of individuals. The cultural affiliation of the complex has not yet been determined. The final site excavations by the Neuman party were at the Truman Mound site (39BF224). The latter consisted of a group of four low, circular mounds in a line along the terrace edge, each measuring about 2 feet in height and 50 feet in diameter. Three of the mounds contained primary and/or secondary burials. One mound contained a deep, oval pit extending 6 feet below its top surface. A flexed burial, shell pendants, pottery sherds, and bone and shell tools were recovered from both the pit and the mound fill. Another of the mounds had a rectangular design of small rocks on its top surface and contained secondary burials. One skull displayed a large cut hole in the left

temporal region. This mound lacked pottery, but in all other respects resembled the other three excavated mounds. The pottery from this mound group, including one restored vessel, was simple stamped, but had a typical Middle Woodland conoidal vessel shape and no decoration. This party disbanded and returned to the Lincoln headquarters on October 3, after 14 weeks of fieldwork.

The fourth River Basin Surveys field party in the Big Bend Reservoir area was directed by William N. Irving and consisted of a crew of eight. At the beginning of the year the party was at work on the left bank of the Missouri River in the vicinity of Old Fort Thompson in Buffalo County, S. Dak. Efforts were concentrated on the Medicine Crow site (39BF2), and excavations were made in three separate areas. In area A the men uncovered a circular earth lodge and several cache pits of the late occupation of about the early 18th century. In area C another circular earth lodge and several cache pits were excavated, and the recovered material suggests an occupation date a few decades earlier than that of area A. One cache-pit burial was recovered there. The main work of the season was in area B, where a large series of extensive test excavations revealed deeply buried evidence of at least three separate occupations, antedating the appearance of ceramics in the area. Some 25 projectile points and a large collection of camp refuse were obtained. The types of the artifacts and the stratigraphic situation, terminating in a coarse sand at the bottom, suggest an early Archaic occupation of perhaps as much as 5,000 or more years ago. One skull, recovered from the site, compares physically with the "Minnesota Man" remains, which generally are believed to be late Pleistocene in age. This is the best early-period site thus far noted in the immediate valley of the Missouri River. It has a strong potential for producing evidence for a good sequence of occupations from very early preceramic times to late ceramic times. The geology of the terrace formations there, and pollen analyses, promise good interpretative possibilities. The party ended the season's work on October 3, after 14 weeks of excavation. The Neuman and Irving parties shared a joint camp at Old Fort Thompson.

The fifth River Basin Surveys field party in the Big Bend Reservoir area at the beginning of the fiscal year was directed by Harold A. Huscher. He was assisted by a crew of three. This was a mobile party and constituted an extension of the previous summer's survey work in that area. During the season's work the group conducted extensive test excavations in 14 sites on both sides of the river in Buffalo, Hyde, Hughes, Lyman, and Stanley Counties; made surface collections from 14 other sites in Buffalo and Hyde Counties; and located 16 previously unrecorded sites. Of the sites tested, 12 were

recommended for excavation and 2 were written off as meriting no further attention. The 12 comprised either single- or multi-occupation sites, ranging in time from Middle Woodland through the early ceramic periods of rectangular houses to and including the late ceramic periods of circular earth lodges. One suggests a preceramic horizon somewhat similar to that at the Medicine Crow site (39BF2). Of the sites visited and not tested, nine were recommended for further investigation, and five were written off. One of the latter five, 39HU215, was first thought to be an early 19th-century trading post, but tests indicated that it was a late 19th-century homestead allotment, probably of Dakota occupancy. On September 3 this party terminated its work in the Big Bend area after 8 weeks in the field, and moved to the Oahe Reservoir area to continue similar survey and testing activities.

In the Oahe Reservoir area there were four River Basin Survey parties in the field at the beginning of the fiscal year, and a fifth party began work there early in September. Dr. Robert L. Stephenson with a crew of 23 was excavating, at the beginning of the year, in the vicinity of Fort Sully on the left bank of the Missouri River in Sully County, S. Dak. That party conducted intensive excavations in the Sully site (39SL4), the remains of the largest of the prehistoric earth-lodge villages known in the Missouri Basin. It also completely excavated a small rock-cairn burial site (39SL38) nearby. The latter consisted of a deep burial beneath a rock pile and produced a skeleton in poor condition, with no associated artifacts. The Sully site excavations included 13 circular earth lodges of the nearly 400 presumed to be present in the site, and 1½ of the 4 ceremonial lodges. The house floors ranged in depth, below the surface, from 2 to 4 feet; entrances were to the southwest; and two distinct architectural patterns were observed. One was composed of closely set double rows of small outer wall posts, the other was composed of widely spaced single rows of large outer posts with leaner posts outside them. Apparently there were two closely related, yet somewhat different, occupational patterns, and the artifact inventory tends to support this distinction. The ceremonial lodges were 12-sided structures of 75- to 80-foot diameters and had long entrance passages. The other houses all had very short entrances. The ceramic inventory suggests that there may have been an earlier occupation featuring rectangular houses, but no such houses were found in the areas excavated. Other features excavated include burial areas where 63 burials were recovered, midden heaps, a large rectangular "plaza" area of unknown usage, a large I-shaped depression of unknown usage, a strata trench across the center of the site, and 91 cache pits. The major occupation of the site appears to have been by the immediate ancestors of the

Arikara during the period 1600–1750. The other occupation or occupations were somewhat earlier. Among the unusual materials recovered were several catlinite pipes, an ornament of turquoise, a piece of obsidian, and several ornaments made from marine shells. The burials will provide a good series for study, and the field party was particularly fortunate to have William M. Bass III, physical anthropologist of the River Basin Surveys staff, present to assist in the excavation of the burial areas. This party returned to the Lincoln headquarters on September 14, after 13 weeks in the field.

The second River Basin Surveys party in the Oahe Reservoir area, comprising a crew of seven, was directed by Charles H. McNutt. At the beginning of the year they were camped with Dr. Stephenson's party near Fort Sully and were excavating in the nearby C. B. Smith site (39SL29) on the left bank of the Missouri River in Sully County, S. Dak. They uncovered major sections of 2 large circular earth lodges, 10 cache pits, and 17 other features, and tested 2 extensive midden areas. This proved to be a moderately large earth-lodge village site of about the early 17th century. After the completion of work there, the party moved to the nearby Sully School site (39SL7) and excavated 2 houses, 12 cache pits, and 9 other features, tested one midden area, and trenched a portion of the fortification ditch and palisade. One of the houses had been a long, rectangular structure with an entry ramp to the south, while the other was a large circular structure. The two occupations thus indicated suggest that one belonged to a period approximating that of the C. B. Smith site, while the other was considerably earlier—perhaps between A.D. 1200 and 1400. The fortification ditch and palisade apparently surrounded the later period occupation. In addition to the excavations at those two sites, the McNutt party investigated two lesser sites in the vicinity. One, 39SL9, was a small occupation area with a few surface remains. Testing there gave no promise of significant returns for intensive digging and no further work was attempted. The other, 39SL10, was a burial site along the edge of the present river bank. Stream cutting had destroyed all but the last vestiges of it, and there was little to salvage. The party disbanded and returned to the Lincoln headquarters on September 14, after 13 weeks of work.

The third River Basin Surveys party in the Oahe Reservoir area was directed by Dr. Waldo R. Wedel, who was detailed to the River Basin Surveys for the summer by the department of anthropology of the U.S. National Museum. Dr. Wedel and a crew of nine worked near the Old Fort Bennett area on the right bank of the Missouri River in Stanley County, S. Dak. The party conducted intensive excavations in site 39ST203, where it uncovered two large circular earth lodges dating around the 17th century and two large long-rectangular houses of a much earlier period, perhaps the 14th or 15th centuries. The

floors of the circular houses were 1½ to 2½ feet below the surface, while those of the rectangular structures were 3½ to 4 feet. Other features excavated in this site include a burial pit with the remains of five individuals, and evidence of burning over the top of the corpses. The party also excavated a circular house and a large portion of the stockade line at the nearby site, 39ST50. This small fortified village of the late 18th or early 19th century may possibly be the Truteau village of the mid-1790's. Glass bottles and considerable metal were found in the site. Dr. Wedel's party disbanded on August 19, after 8 weeks of excavation.

The fourth River Basin Surveys party in the Oahe Reservoir area was directed by Donald D. Hartle. It consisted of a crew of seven and shared a joint field camp with the Wedel party. This party dug test excavations in three sites during the season. At 39ST11, two houses, nine cache pits, and several other features were excavated. The houses were small rectangular structures with single end posts, evenly spaced side-wall posts, and entrance ramps. Of especial interest was the small size and short-rectangular shape of these houses, distinguishing them from the long-rectangular structures of more usual occurrence. Architecture and artifact collections suggest affiliation with the early sedentary Anderson Focus of the 14th or 15th centuries. Another interesting feature was the remains of three people who had died within a corner of one of the houses. With them were a whole pottery vessel and some fragments of basketry. In 39ST23, a dwelling house, a ceremonial lodge, several cache pits, a palisade and fortification ditch, and several other features were excavated. The pottery and circular houses suggest an Arikara occupation of perhaps the 17th or 18th century. The ceremonial house contained an altar, and the wall posts were set in a trench around the base of the wall. At 39ST45, three houses, several cache pits, two palisade bastions, and several other features were excavated. This site was occupied at two different times at least, since one house was rectangular and two were circular. The rectangular house was short and small and represents an occupation very closely related to that of site 39ST11. The circular house occupation was not entirely clear, but appears to have been representative of a culture pattern somewhat earlier than that of site 39ST23. The two palisade bastions were oval in pattern and extended laterally from a fortification palisade. This field party ended its work on August 24, after 9 weeks in the field.

The River Basin Surveys' mobile survey and testing crew of three, under the direction of Harold A. Huscher, moved from the Big Bend Reservoir area on September 3 and began a site survey and testing operation in the Oahe Reservoir area between the mouth of the Cheyenne River and Whitlocks Crossing on the right bank of the Missouri River. Heavy vegetation growth and much rain during

the season prevented the party from doing extensive site mapping or reconnaissance in the area, but several of the larger sites were visited and surface collections were made. A site map and exploratory tests were made at 39AR8, which appears to be related to the Huff site in North Dakota. Six other large sites were located and recorded for the first time in this area. The party disbanded on September 16, after 2 weeks in the Oahe Reservoir area.

The 1958 field season in the Missouri Basin began in the Big Bend Reservoir area on May 11 with a small party exploring in the vicinity of the Medicine Crow site (39BF2). William N. Irving with a crew of three and Mrs. Kathryn H. Clisby, pollen specialist from Oberlin College, Ohio, collected samples of fossil pollen from various localities in the area. Upon Mrs. Clisby's departure, Irving and his crew prepared a detailed map of the Medicine Crow site. On June 10 he increased his party to eight crewmen and added an assistant trained in geology to work with him on stratigraphic terrace sequences relating to the geology of the site and its immediate vicinity. They located one new site containing a large mammalian fossil in a terrace fill deposit and another site with columnar fire hearths exposed in a cut bank of the river. Intensive excavations continued in area B at the Medicine Crow site, and by the end of the year were progressing through the upper 3 feet of the preceramic zones.

On May 19, the second River Basin Surveys field party began operations in the Big Bend Reservoir area. This was a party of 10 under the direction of Robert W. Neuman excavating at two sites near Old Fort Thompson on the left bank of the Missouri River. Part of this crew continued work begun last season in the Akichita site (39BF221) in an attempt to learn details of architectural features. Extensive trenching had failed to find any traces of a house structure by the end of the year, although much midden refuse added significantly to the specimen inventory. The second section of the crew continued work begun last season at the Truman Mound site (39BF224). In that mound group, Mounds 5 and 6 were excavated during June, thus completing work at the site. In both mounds secondary burials accompanied by shell, disk, and bone beads were found. Beneath Mound 6, several projectile points, bone beads, and other artifacts were found. This party planned to concentrate the remainder of the field season on the several other mound sites in the immediate vicinity.

The third River Basin Surveys party in the Big Bend Reservoir area in June consisted of a crew of seven led by James J. F. Deetz. It began work on June 10 and spent the remainder of the month in excavations in areas A and C of the Medicine Crow site (39BF2). Midden areas were trenched, and one circular earth lodge was excavated. This lodge was actually two closely superimposed structures.

Work was continuing at this site at the end of the year. The field parties of Irving, Neuman, and Deetz shared a joint field camp near the Medicine Crow site.

The fourth River Basin Surveys field party in the Big Bend Reservoir area in June was composed of a crew of 13 directed by Dr. Warren W. Caldwell. It began work on June 10 at the Black Partizan site in an effort to complete excavations started last season. By the end of the year a circular (or more exactly an octagonal) earth lodge had been completely excavated and a midden area trenched.

The fifth River Basin Surveys party in the Big Bend Reservoir area consisted of a crew of seven led by Bernard Golden. It began work on June 10 at the Hickey Brothers site (39LM4) and spent the remainder of the year excavating midden deposits and one circular depression that appeared to be an earth-lodge ruin. Artifact inventory was small as of the end of the year. The Caldwell and Golden parties shared a joint camp at the Black Partizan site.

In the Oahe Reservoir area, four River Basin Surveys parties were in the field during the month of June and a fifth party was scheduled to begin work early in the next fiscal year. The first party in the area had a crew of 10 under the direction of Charles H. McNutt. This group began on June 16, and spent the rest of the month continuing excavations begun last season at the Sully School site (39SL7). There, a long expanse of the fortification stockade was uncovered, and work was well under way toward excavation of circular earth-lodge structures.

The second River Basin Surveys party in the Oahe Reservoir area in June consisted of a crew of 23 under the direction of Dr. Robert L. Stephenson, with Lee G. Madison as assistant. They began work on June 16 on the Sully site (39SL4) and by the end of the year had exposed the floors and other features of three circular earth-lodge structures. Artifact inventories were abundant in all 3, and an area surrounding 3 sides of each of 2 of the houses was being exposed in order to learn the nature of materials outside the houses.

The third River Basin Surveys party at work in the Oahe Reservoir area by the end of the year was that of Richard P. Wheeler. It consisted of a crew of eight and was working on the Fort Bennett site (39ST12), on the right bank of the Missouri River near Old Fort Bennett in Stanley County, S. Dak. That party began work on June 19, and by the end of the year had started the clearing of three circular earth-lodge structures.

On the last day of the year, a fourth River Basin Surveys party started work in the Oahe Reservoir area. It was comprised of a crew of six, under the direction of William M. Bass III, and was to excavate the extensive burial area at the Sully site (39SL4).

The McNutt, Stephenson, and Bass parties shared a joint field camp in the vicinity of the Sully site. Such 2- and 3-party field camps were proving to be efficient and economical, as many of the activities and expenses of several parties could be combined. The necessary field equipment, vehicles, number of cooks, and other expenses were proportionately reduced. The consultative advantage of having two or three archeologists in a single camp was proving to be of great help in discussions pertaining to excavation methods and general archeological interpretations.

Cooperating institutions in the Oahe Reservoir area at the beginning of the fiscal year included a party from the University of South Dakota directed by Dr. Wesley R. Hurt, Jr.; a party from the University of Idaho under the direction of Dr. Alfred Bowers; and a party from the State Historical Society of North Dakota, directed by Daniel J. Scheans. At the end of the fiscal year cooperating institutions in the Oahe Reservoir included a party from the University of South Dakota directed by Eugene Fugle; a party from the University of Idaho directed by Dr. Alfred Bowers; a party from the State Historical Society of North Dakota and the University of North Dakota combined, directed by Dr. James H. Howard. In other reservoirs in the Missouri Basin cooperating institutions had parties in the field at the beginning of the year as follows: The University of Wyoming, with a party directed by Dr. William Mulloy in the Glendo Reservoir of southeastern Wyoming; the University of Kansas, with a party directed by Dr. Carlyle S. Smith in the Tuttle Creek Reservoir of northeastern Kansas; and the University of Missouri with a party directed by Carl Chapman in the Pomme de Terre Reservoir of west-central Missouri. At the end of the fiscal year cooperating institutions were: The University of Wyoming with a party directed by Dr. William Mulloy in the Glendo Reservoir area and the University of Missouri with a party directed by Carl Chapman in the Pomme de Terre Reservoir area. All these parties were operating through agreements with the National Park Service and were cooperating in the Smithsonian Institution research program.

During the time that the archeologists were not in the field, they were engaged in analyses of their materials and in laboratory and library research. They also prepared manuscripts of technical, scientific reports and wrote articles and papers of a more popular nature.

During January the first steps were taken by the staff archeologists of the Missouri Basin Project toward a long-range Missouri Basin Chronology Program. This program is a new departure in the field of salvage archeology and is directed toward a more precise understanding of the time sequences of the prehistoric cultures represented in the sites being excavated in the Missouri Basin. One primary objective of the program is to be able to plan future salvage excavations

with increased efficiency. The program includes intensive research in dendrochronology, radiocarbon-14 dating, pollen analysis, geologic-climatic dating, typological analyses of artifact materials, historical documentation, and the several subsidiary techniques applicable to chronology. Ultimately the program should provide a specific time scale into which each of the culture complexes represented in the excavated sites can be fitted with pinpoint accuracy. In the second half of the fiscal year the Missouri Basin Chronology Program made several significant accomplishments. A large wall chart and map were prepared, showing temporal position and geographic location of all of the archeologically pertinent carbon-14 dates so far available. A series of 11 radiocarbon-14 specimens were submitted to the University of Michigan for dating. The available dendrochronological materials on hand in the Missouri Basin were analyzed, and a determination was made of what further material is needed. Plans were also made for procuring additional dendrochronological specimens upon which a series of local master plots can be built. Pollen samples from ancient bog areas were collected and submitted to Oberlin College for analyses, and plans were made for further collecting of fossil pollens. A man with geological training was temporarily added to the staff to work out a terrace-system sequence along a portion of the Missouri River, and a series of specimens was submitted to the University of Michigan proportional counter laboratory for analyses. Representatives from several State institutions are also cooperating in the program.

The laboratory and office staff devoted its time to processing specimen materials for study, photographing specimens, preparing specimen records, and typing and filing of records and manuscript materials. The accomplishments of the laboratory and office staff are listed in the following tables.

TABLE 1.—*Specimens processed July 1, 1957–June 30, 1958*

Reservoir	Number of sites	Catalog numbers assigned	Number of specimens processed
Big Bend	34	8,290	52,718
Oahe	13	5,417	38,864
Toronto	29	901	1,304
Sites not in reservoirs	5	23	212
	81	14,631	93,098
Collections not assigned site numbers	2	9	9
Total	83	14,640	93,107

TABLE 2.—*Record materials processed July 1, 1957–June 30, 1958*

Reflex copies of records	9, 240
Photographic negatives made	2, 946
Photographic prints made	11, 521
Photographic prints mounted and filed	5, 182
Transparencies mounted in glass	1, 122
Color pictures taken in the laboratory	368
Plate layouts made for manuscripts	92
Cartographic tracings and revisions	220
Plates lettered	37
Artifacts sketched	58
Profiles drawn	16

As of June 30, 1958, the Missouri Basin Project had cataloged 917,370 specimens from 1,762 numbered sites and 52 collections not assigned site numbers. During the current fiscal year, 8 pottery vessels and 37 pottery vessel sections were restored, and 104 nonpottery artifacts were repaired. Archeological specimens from 236 sites in 5 reservoirs were transferred to the United States National Museum, as were selected specimens of dog, bird, and fish bones, and of shell. Pottery specimens and stone projectile points were transferred to Region Two of the National Park Service for use as display material at Wind Cave National Monument in South Dakota. The Missouri Basin Project received, by transfer from the Nebraska State Historical Society, through the courtesy of Marvin F. Kivett, sample pottery specimens from four prototypical Nebraska sites. Cultural units and sites of these type specimens are: Dismal River, the Lovett site (25CH1); Lower Loup, the Burkett site (25NC1); Oneota, the Leary site (25RH1); and Valley Woodland, the Schultz site (25VY1). These specimens are now a part of the Missouri Basin Project comparative collection. The Missouri Basin Project also received by transfer from the University of Kansas Museum of Natural History, through the courtesy of Dr. Carlyle S. Smith, archeological collections from two sites in the Fort Randall Reservoir area. This was a permanent transfer of excavated materials which increased materially the research value of Missouri Basin Project collections.

During the Thanksgiving weekend, members of the staff participated in the 15th Plains Conference for Archeology, held in Lincoln. On April 19, members of the staff presented papers at the annual meeting of the Nebraska Academy of Sciences, also held in Lincoln. On April 30 and May 1 and 2, members of the staff attended and participated in the annual meeting of the Society for American Archeology held in Norman, Okla.

Dr. Robert L. Stephenson, chief, when not in charge of field parties, devoted most of his time to managing the office and laboratory in Lincoln and preparing plans for the 1958 summer field season. He spent

some time working on a summary report of the Missouri Basin Salvage Program for the calendar years 1952–56 and wrote several short papers for presentation before scientific groups. He also worked on a manuscript on the "Archeological Investigations in the Whitney Reservoir, Texas," and prepared text, pictures, and captions for a photographic booklet, "The Inter-Agency Archeological Salvage Program, After Twelve Years." During the second half of the year, he served as chairman of the Missouri Basin Chronology Program. In August he addressed the Pierre, S. Dak., Rotary Club on "Archeological Salvage in South Dakota." In October he addressed the Fidelia Lyceum in Lincoln, Nebr., on "Prehistoric America in Missouri Basin." In January he attended and participated in the annual meeting of the Committee for the Recovery of Archeological Remains, held in Washington, D.C. On April 19 he attended the annual meeting of the Nebraska Academy of Sciences, held in Lincoln, and presented a paper on "The Missouri Basin Chronology Program." On April 30 and May 1 and 2, at Norman, Okla., he attended the annual meeting of the Society for American Archeology and participated as a discussant of a paper presented by Robert Bell, entitled "Caddoan Relationships to the Plains."

Dr. Warren W. Caldwell, archeologist, during the fall and winter months devoted most of his time to analyses of specimen materials recovered from sites he had excavated over the past year. He completed all plates, figures, and manuscript text for the final report "Archeological Investigations in the Coralville Reservoir, Iowa." He also completed all plates, figures, and manuscript text for the final report, "Archeological Salvage Investigations in the Hell's Canyon Area, Snake River, Oregon and Idaho." He prepared a brief technical manuscript, "Firearms and Connotive Materials from Fort Pierre II (39ST217), Oahe Reservoir, South Dakota," and a brief popular article, "The Smithsonian Institution in Arkansas." The latter was published in the June issue of *The Ozark Mountaineer*. Dr. Caldwell also submitted a short note for publication in the *Davidson Journal of Anthropology* entitled "Pacific Coast Clay Figurines: A Contraview." He submitted a book review of "Northwest Archeology," *Research Studies of the State College of Washington*, vol. 24, No. 1, that was published in *American Antiquity*, vol. 23, No. 2, 1957. During the second half of the year he served as dendrochronology chairman of the Missouri Basin Chronology Program.

Donald D. Hartle, temporary archeologist, on the staff at the beginning of the year, left the project on August 26 to resume his graduate studies. Mr. Hartle was formerly a regular member of the staff at Lincoln and is still working on reports of work done at that time. He also is preparing a report on the results of his investigations during the 1957 field season in the Oahe Reservoir area.

Harold A. Huscher, temporary archeologist, on the staff at the beginning of the year, was transferred to the Washington office on January 27 to carry on the explorations in Alabama-Georgia previously discussed. Between his return from the field on September 16 and his departure for the Southeast, Mr. Huscher wrote a rough draft of a manuscript covering his work in the Missouri Basin in the summers of 1956 and 1957—"Appraisal of the Archeological Resources of the Big Bend Reservoir, South Dakota." He also prepared the preliminary draft of a brief technical manuscript on earth-lodge village fortifications in the Missouri Basin, and presented it as an oral report at the 15th Plains Conference for Archeology in Lincoln on November 28. He participated in the initial stages of the Missouri Basin Chronology Program.

William M. Bass III, temporary physical anthropologist, left the staff on August 28. He rejoined the staff in the same capacity on June 2 and remained in the Washington office until June 20, when he proceeded to the Lincoln office where he spent five days working on a comparative human skeleton. He left for the field in the Oahe Reservoir area on June 28.

William N. Irving, temporary archeologist, was appointed to the permanent staff on May 18. When not in the field directing excavations, he was in the Lincoln office analyzing materials he excavated during the preceding summer and investigating the geological possibilities of the Medicine Crow site (39BF2). He presented a preliminary report on the archeology of the Medicine Crow site at the 15th Plains Conference for Archeology on November 28, and a report on the chronology of the Medicine Crow site at the annual meeting of the Nebraska Academy of Sciences on April 19. On May 1 he went to Norman, Okla., and presented a paper on the chronological relationships of the early part of the Medicine Crow site at the annual meeting of the Society for American Archeology. During the second half of the year he served as geology chairman of the Missouri Basin Chronology Program.

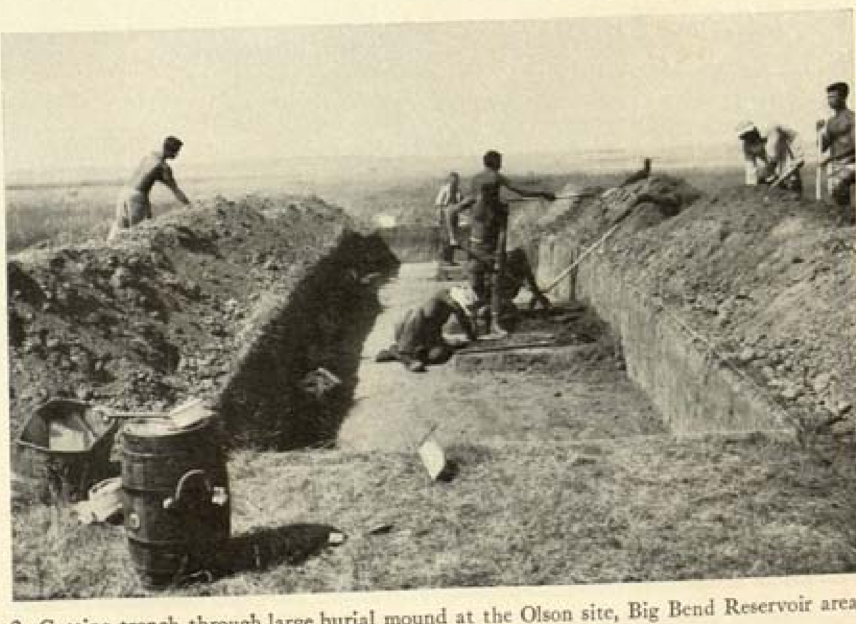
James J. F. Deetz, temporary archeologist, joined the staff on June 2, and on June 10 left Lincoln for South Dakota to excavate a series of sites in the Big Bend Reservoir area.

Alan H. Coogan, temporary field assistant, joined the staff on June 2, and on June 10 left Lincoln for the field to serve as assistant to William N. Irving in the geological-archeological work in the vicinity of Old Fort Thompson in the Big Bend Reservoir area.

Bernard Golden, temporary archeologist, joined the staff on May 19 and on June 10 left Lincoln to begin excavations in an earth-lodge village site in the Big Bend Reservoir area.

Charles H. McNutt, archeologist, when he was not in the field, devoted most of his time to analyses and the preparation of reports. He

1. Excavating a dwelling site of the period of permanent White settlement in the Big Bend Reservoir area, South Dakota. River Basin Surveys.



2. Cutting trench through large burial mound at the Olson site, Big Bend Reservoir area, South Dakota. River Basin Surveys.

1. Floor of large circular earth lodge dating about the 17th century. Holes around periphery indicate location of wall poles; four larger holes in floor area show position of main supports. Entrance passage at rear with the Missouri River in background. Oahe Reservoir area, South Dakota. River Basin Surveys.

2. Excavating house floor and cache pits at the Sully site, Oahe Reservoir area, South Dakota. River Basin Surveys.

Four stages in the carving of a Seneca mask. Allegany Reservation, New York. September 1957.

1. Bike Williamson, Mississippi Choctaw, with drum used in stick-ball game. April 1958.

2. Samuel Taylor Blue, last living speaker of the Catawba language, South Carolina. August 1957.

served as carbon-14 chairman, during the second half of the year, in the Missouri Basin Chronology Program. He completed the final draft of a major technical manuscript covering part of his previous summer's work, entitled "Archeological Investigations in the C. B. Smith Site (39SL29), Oahe Reservoir, South Dakota." He also completed the final draft of an unfinished manuscript begun by Harold A. Huscher, entitled "Appraisal of the Archeological Resources in the Big Bend Reservoir Area, South Dakota." On November 28, he presented a paper, "Excavations at Two Sites in the Oahe Reservoir, Sully County, South Dakota," at the 15th Plains Conference for Archeology in Lincoln. On April 18 he presented a paper entitled "La Roche Ware and Relative Chronology" at the annual meeting of the Nebraska Academy of Sciences in Lincoln. From April 30 to May 3 he attended the annual meeting of the Society for American Archeology in Norman, Okla. He was senior author, with Richard P. Wheeler, of a brief article entitled "Bibliography of Primary Sources for Radiocarbon Dates," which was submitted in June for publication in the Notes and News section of *American Antiquity*.

Robert W. Neuman, temporary archeologist, was appointed to the permanent staff on July 29. During the time he was not directing field activities he was busy completing the analyses of the data and materials he had collected and preparing reports on his previous seasons' work. He completed the final draft of a major technical manuscript entitled "Archeological Investigations in the Lovewell Reservoir Area, Kansas." On November 28, he presented a paper, "Excavations in Four Sites in the Big Bend Reservoir Area, South Dakota." On April 19 he attended the annual meeting of the Nebraska Academy of Sciences in Lincoln, and from April 30 to May 3 attended the annual meeting of the Society for American Archeology in Norman, Okla.

G. Hubert Smith, archeologist, during the periods he was not in the field, devoted his time to completion of final drafts of two major technical reports and one minor report. One major technical report was "Archeological Investigations at the Site of Fort Berthold II (32ML2), Garrison Reservoir, North Dakota"; the second was "Archeological Investigations at the Site of Fort Pierre II (39ST217), Oahe Reservoir, South Dakota." A brief report on excavations at site 39LM241 was also completed. On November 29, he served as chairman for a section of the Plains Conference for Archeology, devoted to historic sites archeology, and summarized the reports of the seven speakers. He submitted a book review of "New Discoveries at Jamestown" by John L. Cotter and J. Paul Hudson, which was published in the Autumn 1957 issue of *Archeology*. On January 2, Mr. Smith was detailed, on a reimbursable basis, to the

National Park Service to conduct archeological excavations at the site of Fort McHenry in Baltimore, Md.

Richard P. Wheeler, archeologist, was at the Lincoln headquarters throughout the year until June 20. During this period he spent his time preparing technical reports on work completed in previous years. He completed the final section of a draft of a lengthy, detailed report on excavations conducted during 1949–51 in the Angostura Reservoir area in South Dakota and the Boyson and Keyhole Reservoir areas in Wyoming. He also completed the draft of a technical report on excavations in the Jamestown Reservoir area in North Dakota. At the 15th Plains Conference for Archeology, in Lincoln, he presented a preliminary statement on the Stutsman Focus, and a paper, jointly with Harry E. Weakly, dealing with the cultural and chronological sequences at Birdshead Cave, Wyo. A third paper presented at that meeting dealt with radiocarbon dates and prehistory in the central and northern Plains. As previously mentioned, he collaborated with Charles H. McNutt in preparing a paper for submission to *American Antiquity*. From April 30 to May 3 he attended the annual meeting of the Society for American Archeology in Norman, Okla.

Snake River Basin.—No field explorations were carried on in the Snake River Basin during the fiscal year. However, one report on the investigations made there during the previous year was completed. It is called "Archeological Salvage Investigations in the Hell's Canyon Area, Snake River, Oregon and Idaho." The manuscript consists of 95 typed pages and has 8 plates and 6 text figures. The material and information upon which the report is based were mainly from two sites in the vicinity of Robinette, Oreg. Another report pertaining to the excavations on the Idaho side of the river at Big Bar has not yet been completed, but it is well under way.

South Carolina-Georgia.—Excavations were made at two sites in the Hartwell Reservoir Basin during the period from April 22 to June 21. One of them was located in South Carolina and the other in Georgia. In addition, three other sites in the South Carolina area were inspected and an extensive surface collection of artifacts was made at one of them. Owing to the refusal of the owner to permit digging, no attempt was made at the latter site to determine its depth or the extent of its deposits.

One of the sites where digging was carried on is located in the fork created by the juncture of the Tugaloo and Chauga Rivers. The site originally consisted of one large mound flanked on either side by a low mound. During the last 10 to 12 years the large mound was intentionally reduced in height in order to facilitate cultivation of the field where it is situated. Consequently its present height of 12 feet above the level of the bottom lands does not represent its

original height and its contour has also been modified. Four test areas were dug in the vicinity of the present apex of the mound to determine if possible where the original apex had been, and also to discover the physical makeup of the feature and the possible purpose for its construction. One of the test areas exposed the outline of a rectangular structure with rounded corners and a subterranean floor. The posts which had formed the walls had been placed at 2-foot intervals. Because of lack of time the house remains were not completely excavated. Enough was done, however, to determine its general characteristics. Two of the other test areas showed that the mound had been erected in several stages over a period of years. In each case the exterior mantle consisted of a hard-packed bluish-gray sandy clay which varied from 3 to 6 inches in thickness. Each mantle in turn had been spread over a layer of clean river sand averaging 1 foot 3 inches in thickness. There had been at least four such features, and additional digging may reveal still earlier ones. Not much artifact material was recovered, but such as was found indicates that the latest culture represented probably was Cherokee with an earlier underlying Etowah horizon. The site may well have been that of the Cherokee village and mound known as Chauga.

On the Georgia side of the Tugaloo River approximately 2 miles downriver from the Yonah Dam of the Georgia Power Co. is a village and mound site which also has Cherokee affinities. This is the largest site in the Hartwell Basin and lies on a sandy ridge 1,000 feet long and 150 feet wide which parallels the river. There was a small mound 150 feet from the northern limits of the ridge which upon excavation proved to be quite unusual. The top layer or mantle consisted of a sandy humus. This covered a small mound of river cobblestones of various weights and diameters which was approximately 2 feet in height and 18 feet in diameter. Directly underneath the base of the rock mound was a series of seven heavy-packed ash and calcined bone-filled basin-shaped hearths. Each of the hearths was circular in outline and averaged slightly over 5 feet in diameter and from 1 foot to 18 inches in depth. Because of the presence of the fragmentary calcined bones it was thought that the basins served as crematory areas over a long period of time. After the last or uppermost hearth had served its purpose, the cobblestone mound was erected over the crematory area, perhaps to indicate that it was a place of particular significance or to protect the features lying beneath it. Thus far such a manifestation is unique in southeast archeology and it may indicate a local cult which has previously passed unnoticed or has not been reported.

Adjacent to and south of the mound were the remains of three houses representing different types of structure. The uppermost was approximately square and the walls had been constructed by placing

individual posts in prepared post holes. Directly beneath those remains was evidence for a large rectangular "town-house" type of structure measuring 44 feet in length and 26 to 27 feet in width, with the doorway opening toward the south. The individual post form of construction had also been used in erecting that structure. Immediately beneath it and resting upon sterile red clay were the fragmentary remains of two small circular trench-type houses, the earliest form of house found throughout the Southeast. Additional work at this location would undoubtedly yield further evidence pertaining to the sequence of house forms and might also give a clue to their significance.

Two unusual ceremonial burials were found in a test area some 40 feet from the house remains. Tubular-shaped pits with saucer-shaped bottoms had been dug in the clean sterile sand of the ridge. The pits were approximately 2 feet in diameter and the walls of one had been lined with small cobblestones, while those in the other were left in their natural state. At the bottom of each pit, 5 feet 5 inches below the surface, were the fragmentary remains of a human cranium. Other bones may originally have been present, but they had long since disintegrated. The rock-lined pit was filled with a dark humic soil intermixed with some stones, while the other was filled with clean river sand. These burials may represent a new trait for that section of South Carolina, Georgia, and the Southeast. The specimens collected during the course of the work suggest that it was of Cherokee origin. The site has been identified, tentatively, as that of the Cherokee Lower Settlements town of Estatoee by some. Others think further evidence is needed to demonstrate that such was the case, since historically it supposedly was on the South Carolina side of the river. Additional excavations are certainly warranted at that location.

Cooperating institutions.—In addition to the several State and local institutions cooperating in the Missouri Basin, others participated in the Inter-Agency Salvage Program in a number of areas. The University of Arizona carried on investigations in the Painted Rocks Reservoir basin on the Gila River in Arizona. The Museum of Northern Arizona continued its explorations in the Glen Canyon Reservoir area on the Colorado River. The University of Utah also cooperated in the Glen Canyon project, working the upper end of the basin. The University of California made surveys and conducted excavations in the Trinity Reservoir area on the Trinity River, the Terminus Reservoir on the Kaweah River, in the Coyote Valley Reservoir area on the Russian River, and in the Washoe Reservoir basin on the Truckee River. The University of Southern California

worked in the Buena Vista watershed project and the Arroyo Grande Creed watershed project in California. Idaho State College made surveys along the Upper Snake, the Salmon, and Middle Fork Rivers in Idaho. The University of Southern Illinois carried on surveys and excavations in the Carlyle Dam area on the Kaskaskia River in south-central Illinois. In New Mexico the School of American Research excavated in the Abiquiu Reservoir area along the Chama River and made surveys in the Navajo Reservoir area along the San Juan River in northern New Mexico and southwestern Colorado. The University of Oklahoma participated in three projects. One consisted of a reexamination of the Fort Gibson Reservoir basin on the Grand or Neosho River. Surveys and excavations were made there a number of years ago before the dam was completed and the area flooded. Because of a greatly lowered pool level last year it was possible to return to the area and examine a number of sites which had been under water for some time. The other two projects of the University of Oklahoma were in the Sandy Creek Reservoir area along the Blue River and Waurika Reservoir basin along Beaver Creek, a tributary of the Red River. The University of Oregon surveyed and excavated in two reservoir basins. One was the Immigrant on Beaver Creek, a tributary of the Rogue River, and the other was the John Day along the Columbia River. The University of Texas continued its excavation project at the Ferrell's Bridge Reservoir along Cypress Creek, a tributary of the Red River in eastern Texas. The State College of Washington continued excavations in the Ice Harbor Reservoir area along the Lower Snake River in southeastern Washington. In the New England area surveys were made on a personal contract basis by one member of the Department of Anthropology at Harvard University and by a member of the faculty from Temple University at Philadelphia. All these projects were carried on under agreements with the National Park Service. In several areas local groups continued to assist on a voluntary basis. These activities were mainly in Ohio, Indiana, and southern California.

ARCHIVES

The Bureau archives continued during the year under the custody of Mrs. Margaret C. Blaker. From June 1 to 6 Mrs. Blaker examined pictorial and manuscript collections relating to the American Indian in the University of Pennsylvania Museum in Philadelphia, and in the American Museum of Natural History, the Museum of the American Indian, the New York Historical Society, the New York Public Library, and the Frick Art Reference Library in New York. On June 13 Miss Barbara Hemphill entered on duty as a summer interne, detailed to the archives.

Photographic collections.—Anthropologists, historians, publishers, and interested members of the public continued in increasing numbers to draw upon the extensive photographic collections of the Bureau as a source of documentation and illustration. The year's total of 534 orders and written and personal inquiries concerning photographs represents a 20-percent increase over the previous year's figure of 444, and is almost double the 1956 total of 294. The 1,231 prints distributed is also an appreciable increase over the 1,019 of last year and 978 in 1956. The preparation and distribution, during the past 2 years, of descriptive lists of specific portions of the photographic collections have undoubtedly made more searchers aware of the photographic resources of the Bureau, the result being an increased number of purchase requests. Lists describing photographs relating to 86 tribes or subjects are now available; 21 such lists were prepared during the past year.

There were 22 new photographic collections received during the year, some of which are described below:

A very important collection relating to North American Indians was received by transfer from the Library of Congress. It consists of some 7,200 photographs pertaining to over 120 tribal units of the United States, Alaska, and Canada; the Southwest, the Northwest Coast, the Plains, and the Great Lakes areas are particularly well covered. The photographs were made by professional photographers from approximately 1890 to 1920, and are of excellent photographic quality. Over two-thirds of them are outdoor views; the remainder are portraits, most of which are accompanied by the name of the individual. At year's end only a preliminary examination of the collection had been made. The arrangement and cataloging of the photographs by tribe and area will be a major project for the coming year.

An album of 60 photographs relating to the several Indian tribes residing on the Muckleshoot Reservation, Wash., in the period 1902–36 was received as a transfer from the Indian Claims Commission, through the courtesy of Arthur C. Ballard, who made and collected the photographs. The collection, with detailed captions, includes portraits of Indian informants and views of native activities and equipment such as fishing gear, firemaking equipment, ceremonial objects, houses, and tools.

A collection of about 40 photographs of Plains Indians made by commercial photographers of the late 19th century was received as a gift from the Pennsylvania Historical and Museum Commission, through John Witthoft, chief curator. Another group of 26 such photographs, including a number of Indian portraits by D. F. Barry, was lent for copying through the courtesy of Mr. Witthoft.

A series of about 35 negatives relating to the Acoma, Laguna, and Taos pueblos and to the Navaho and Paiute tribes, made by Vernon Bailey during the first decade of the 20th century, was received as a transfer from the Smithsonian library, where they had been deposited as a gift from Mrs. Vernon Bailey in 1945.

Thirteen photographs of Chiricahua and Mescalero Apache Indians, including recent portraits of some descendants of prominent Apache personalities of the 19th century, were received from Mrs. Eve Ball, of Hollywood, N. Mex. With the assistance of Apache informants, Mrs. Ball also provided identifications and notes on several photographs in the Bureau collections.

Copy prints of 24 portraits and views of activities at Carlisle Indian School, collected by O. H. Bakeless, ca. 1892–1902, were forwarded by Dr. Archibald Hanna as a gift from the Yale University Library, through the courtesy of John Bakeless, who owns the original prints.

Eight copy photographs relating to Indians of Michigan in the period 1865–ca. 1900, collected from various sources by the Michigan Historical Commission, were received as a gift from the Commission, through the courtesy of Dr. Philip P. Mason.

Mrs. Marion Vincent, of Sequim, Wash., lent for copying eight photographs of elderly Clallam Indians taken at various dates in the first half of the 20th century, including a portrait of old Doctor Hall, the boatmaker.

Richard Pohrt, of Flint, Mich., forwarded as a gift eight photographs of Indians of California and adjacent western States, made by commercial photographers about 1900.

Six photographs of Seminole Indians made in Collier County, Fla., ca. 1900–1928, were received from Dr. Charlton W. Tebeau, of Coral Gables, Fla., through Dr. William C. Sturtevant.

Two snapshots of the tombstone of Joseph Pawnee No Pashee, first governor of the Osage (d. 1883), located at Pawhuska, Okla., were received as a gift from R. B. Schackleford, of Pawhuska.

Manuscript collections.—There is a continued increase in the utilization of the manuscript collections by anthropologists and other students. About 305 manuscripts were consulted by searchers, either in person or by the purchase of 9,696 pages of reproductions. In addition, 68 mail inquiries concerning the manuscript collections were received, and a considerable number were examined by the archivist in preparing replies. As a result of this examination, new and more complete descriptions of 61 manuscripts were drafted for the catalog, annotations were added to numerous other catalog entries, and lists describing certain related groups were prepared for distribution.

Thirteen lots of manuscript material were received in the archives. The following have been cataloged and made available for reference:

4517. Beam, George L. (official photographer, Denver & Rio Grande Western Railroad). Miscellaneous correspondence and news clippings. Ca. 1917–27. 1 portfolio.

4507. Corbusier, William Henry. "Record of William Henry Corbusier, Colonel, U.S. Army, Retired." April 10, 1924. 30 pp., typed. Relates to the Apache Indians of Arizona.

4505. Gilfillan, J. A. Chippewa dictionary (original draft?), notes on place names, etc.; miscellaneous lot of notes, unarranged. Ca. 1911? 1 portfolio.

4521. Harrington, John P. Miscellaneous short manuscripts, unpublished. 1940–52 and n.d. 1 box. (Titles listed in catalog.)

3323. Marye, William B. Materials relating to the sites of Indian bridges, principally in Maryland and Virginia, and also in Delaware and North Carolina. 1932 ca.–1949 and 1956. 5 boxes.

4524. Marye, William B. "Indian Shell Heaps on Chesapeake Bay and its Estuaries in Maryland; Some Incomplete Data Collected by William B. Marye." 1913 ca.–1956. 1 portfolio.

4514. Newcomb, C. F. "Sketch of Southern Portion of Queen Charlotte Islands, B.C." 1901. Manuscript map, approx. 33″ x 58″.

4513. Niblack, Albert P. Notes and correspondence relating to the ethnology of the northwest coast of North America; miscellaneous papers, unarranged. Ca. 1884–89. 1 portfolio.

4525. Scott, Gen. Hugh L. Papers relating to Indian conditions, accumulated while serving on the Board of Indian Commissioners, February 25, 1919–July 25, 1933. 3 boxes. (Subject list in catalog.)

4504. Sturtevant, William C. "Notes on the History and Bibliography of Catawba Linguistic Studies." July–August 1957. 18 pp., typed.

A summary description of the holdings of the Bureau archives was prepared for the National Historical Publications Commission, U.S. National Archives, for inclusion in the guide to depositories of manuscripts in the United States being prepared by the Commission.

ILLUSTRATIONS

The Bureau staff artist, E. G. Schumacher, continued work during the year on a wide variety of artistic material for the Bureau of American Ethnology and River Basin Surveys. An appreciable amount of time was also devoted to various illustrative tasks needed by different departments of the Smithsonian Institution.

EDITORIAL WORK AND PUBLICATIONS

The Bureau's editorial work continued during the year under the immediate direction of Mrs. Eloise B. Edelen. There were issued one Annual Report and four Bulletins, as follows:

Seventy-fourth Annual Report of the Bureau of American Ethnology, 1956–1957. ii+28 pp., 2 pls. 1958.

Bulletin 164. Anthropological Papers Nos. 49–56. x+356 pp., 75 pls., 5 figs., 15 maps. 1957.

No. 49. The Ormond Beach Mound, east-central Florida, by Jesse D. Jennings, Gordon R. Willey, and Marshall T. Newman.

No. 50. Hair pipes in Plains Indian adornment, a study in Indian and White ingenuity, by John C. Ewers.

No. 51. Observations on some nineteenth-century pottery vessels from the Upper Missouri, by Waldo R. Wedel.

No. 52. Revaluation of the Eastern Siouan problem, with particular emphasis on the Virginia branches—the Occaneechi, the Saponi, and the Tutelo, by Carl F. Miller.

No. 53. An archeological reconnaissance in southeastern Mexico, by Matthew W. Stirling.

No. 54. Valladolid Maya enumeration, by John P. Harrington.

No. 55. Letters to Jack Wilson, the Paiute Prophet, written between 1908 and 1911, edited and with an introduction by Grace M. Dangberg.

No. 56. Factionalism at Taos Pueblo, New Mexico, by William N. Fenton.

Bulletin 165. Music of Acoma, Isleta, Cochiti, and Zuñi Pueblos, by Frances Densmore. xii+118 pp., 6 pls. 1957.

Bulletin 166. River Basin Surveys Papers, No. 8. Excavations in the McNary Reservoir Basin near Umatilla, Oregon, by Douglas Osborne. With appendixes by Marshall T. Newman, Arthur Woodward, W. J. Kroll, and B. H. McCleod. x+258 pp., 40 pls., 6 figs., 19 maps. 1957.

Bulletin 167. Archeological investigations at the mouth of the Amazon, by Betty J. Meggers and Clifford Evans. xxviii+664 pp., 112 pls., 206 figs. 1957.

The following publications were in press at the close of the fiscal year:

Bulletin 143, vol. 7. Index to the Handbook of South American Indians.

Bulletin 168. The Native Brotherhoods: Modern intertribal organizations on the Northwest coast, by Philip Drucker.

Bulletin 169. River Basin Surveys Papers, Nos. 9–14:

No. 9. Archeological investigations in the Heart Butte Reservior area, North Dakota, by Paul L. Cooper.

No. 10. Archeological investigations at the Tuttle Creek Dam, Kansas, by Robert B. Cumming, Jr.

No. 11. The Spain site (39LM301), a winter village in Fort Randall Reservoir, South Dakota, by Carlyle S. Smith and Roger T. Grange, Jr.

No. 12. The Wilbanks site (9CK–5), Georgia, by William H. Sears.

No. 13. Historic sites in and around the Jim Woodruff Reservoir area, Florida-Georgia, by Mark F. Boyd.

No. 14. Six sites near the Chattahoochee River in the Jim Woodruff Reservoir area, Florida, by Ripley P. Bullen.

Bulletin 170. Excavations at La Venta, Tabasco, 1955, by Philip Drucker, Robert F. Heizer, and Robert J. Squier. With appendixes by Jonas E. Gullberg, Garniss H. Curtis, and A. Starker Leopold.

Bulletin 171. The North Alaskan Eskimo: A study in ecology and society, by Robert F. Spencer.

Bulletin 172. The story of a Tlingit community: A problem in the relationship between archeological, ethnological, and historical methods, by Frederica de Laguna.

Bulletin 173. Anthropological Papers Nos. 57–62:

No. 57. Preceramic and ceramic cultural patterns in Northwest Virginia, by C. G. Holland.

No. 58. An introduction to Plains Apache archeology—the Dismal River Aspect, by James H. Gunnerson.

No. 59. The use of the atlatl on Lake Patzcuaro, Michoacan, by M. W. Stirling.

No. 60. A Caroline Islands script, by Saul H. Riesenberg and Shigeru Kaneshiro.

No. 61. Dakota winter counts as a source of Plains history, by James H. Howard.

No. 62. Stone tipi rings in north-central Montana and the adjacent portion of Alberta, Canada: Their historical, ethnological, and archeological aspects, by Thomas F. Kehoe.

Publications distributed totaled 28,131 as compared with 28,558 for the fiscal year 1957.

COLLECTIONS

Acc. No.

216667. Late 18th-century wine bottle.

219119. Miscellaneous archeological objects.

FROM RIVER BASIN SURVEYS

216556. Archeological and human skeletal material from Nebraska, excavated by River Basin Surveys archeologists in the summer of 1948.

217608, 218413. Archeological material excavated from Buffalo Pasture site in Oahe Reservoir, Stanley County, S. Dak.

214120, 217212. (through Dr. Robert L. Stephenson) 21 land and fresh-water mollusks from Oregon, Wyoming, and South Dakota.

MISCELLANEOUS

Dr. John R. Swanton, ethnologist on the staff of the Bureau from 1900 to 1944 and a research associate since his retirement, died at his home in Newton, Mass., on May 2, 1958. Dr. Swanton is best known for his extensive work on the Indians of the Southeastern United States and as chairman of the DeSoto Commission. He was the author of 5 extensive articles in the Annual Report series of the Bureau, 12 complete Bulletins, 2 Anthropological Papers, and 2 papers in the War Background Studies. He was coauthor of three Bulletins and edited Byington's Choctaw Dictionary. His *The Indians of the Southeastern United States*, Bulletin 137, and *The Indian Tribes of North America*, Bulletin 145, are outstanding contributions. The report of the DeSoto Commission, of which he was the unnamed author, is in continuing demand. Dr. Swanton was a member of the National Academy of Sciences. He received the Viking Medal and Award for Anthropology in 1948.

Dr. John P. Harrington and Dr. A. J. Waring continued as research associates of the Bureau of American Ethnology. Dr. M. W. Stirling, as research associate, used the facilities of the Bureau laboratory and continued his study of collections made on field trips to Panama and Ecuador in previous years.

There were 2,772 letters of inquiry about American Indians and related problems received in the Director's office during the year.

Information was furnished by staff members in answer to many of the queries, and to others, information leaflets or other printed items were supplied.

Eleven bibliographies or information leaflets were prepared or revised and duplicated for distribution to the public, as follows:

SIL-16, 2d rev., 6/58. Indian Crafts and Indian Lore. (Bibliography.) 3 pp.

SIL-50, rev., 8/57. Selected List of Portraits of Prominent Indians in the Collections of the Bureau of American Ethnology. 3 pp.

SIL-90, rev., 3/58. Dealers in Second-Hand Scientific and Government Publications. 2 pp.

SIL-100, 8/57. Anthropology as a Career. 18 pp. (Reading list, pp. 14-18.)

SIL-105, 8/57. Selected Bibliography on Cherokee Customs and History. 4 pp.

SIL-132, 12/57. Selected References on the Middle American Area. 5 pp.

SIL-133, 12/57. Bibliography on Indian Languages and Language Families. 6 pp.

SIL-134, 12/57. American Indian Languages. (Explanation.) 2 pp.

SIL-137, 12/57. The Cherokee Language. (Explanation with references.) 2 pp.

SIL-174, 6/58. Selected References on the Indians of the Southeastern United States. 12 pp.

SIL-175, 6/58. Selected References on Present-day Conditions among United States Indians. 9 pp.

In addition to the leaflets described above, many bibliographies and information leaflets were compiled on topics of a general or specific nature, linguistic problems or terms, picture information, etc., and typescript copies sent out to hundreds of civic organizations such as the Scouts, Campfire Girls, summer camps, church clubs, and women's clubs throughout the country, as well as to the general public. The information files and bibliographic material were constantly reviewed by staff members so that the most up-to-date material for term papers could be sent in answer to hundreds of requests from high school and college students. Manuscripts were frequently read and appraised by staff members for colleagues and scientific organizations. Specimens were identified for owners and data on them supplied.

Respectfully submitted.

Frank H. H. Roberts, Jr., *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the Astrophysical Observatory

SIR: I have the honor to submit the following report on the operations of the Astrophysical Observatory for the fiscal year ended June 30, 1958:

The Astrophysical Observatory includes two research divisions: the Division of Astrophysical Research, for the study of solar and other sources of energy impinging on the earth, and the Division of Radiation and Organisms, for investigations dealing with radiation as it bears directly or indirectly upon biological problems. Shops—for metalwork, woodwork, and optical electronic work—are maintained in Washington to prepare special equipment for both divisions, and a shop for high precision mechanical work at Cambridge. A field station for solar observation is located at Table Mountain, Calif.

DIVISION OF ASTROPHYSICAL RESEARCH

The most important event of the past year was the activation of the Optical Satellite Tracking Program, within two hours of the launching of the first artificial earth satellite on October 4, 1957. The resulting data have already produced vital new information about the density and temperature of the upper atmosphere and the earth's equatorial bulge. The exploration of space by manned and unmanned space vehicles continues to receive study, and specific plans have been formulated for placing an astronomical telescope in a satellite orbit.

The Observatory has pursued its investigation of solar-system phenomena, particularly of cosmic gas dynamics and celestial mechanics; and studies of the origin, structure, and probable age of meteorites have continued.

The close liaison between the Astrophysical Observatory and the Harvard College Observatory, the Massachusetts Institute of Technology, and other research centers in the Boston area continues to bring mutual benefit. Its long-term goal, to make crucial astronomical observations and experiments above the atmosphere, is well on the way to realization.

Solar astrophysics.—At the Table Mountain Station, Alfred G. Froiland has been measuring atmospheric ozone, to determine the light absorption of ozone in a vertical path, both in the visible spectral range and in the infrared, from a single spectrobologram; and also, possibly, to measure the quantity and quality of haze. This study

may reveal other related effects of energy absorption in the upper atmosphere. By calculating theoretical spectra for early-type stars, and calculating the blanketing effects in the solar atmosphere, Dr. Max Krook has been investigating the propagation of disturbances through a stellar atmosphere, and associated phenomena such as radio frequency emission and the acceleration of charged particles. With Dr. J. C. Pecker, of the Paris Observatory, he plans to apply a method he has devised for solving equations in nongray atmospheres. Dr. Krook continues his efforts to obtain exact numerical solutions of nonlinear kinetic equations for the case of shear flow with heat transfer, and to determine a wide range of values of the Mach number, the Knudsen number, and the temperature ratio. Such solutions will bear on the validity of various approximation procedures for solving Boltzmann equations. The formal mathematical analysis of these and related problems was completed this year.

Dr. Charles Whitney continued the investigation of gas-dynamical problems associated with the solar atmosphere and the atmospheres of variable stars. He has formulated the equations appropriate to the solar atmosphere; initial integrations have been performed on an electronic computer, and the stability of the equation is being investigated. From studying variable stars of small amplitude and their pulsational instability, he hopes to determine the exact limits to the domains of variable stars, and the properties of variables near these limits. Spectrographic data on cepheid variables will furnish an empirical foundation for subsequent investigations of the gas dynamics of variable stars. Dr. Whitney is also testing the theory that the ionization zone is the seat of pulsational instability. During the year he completed a detailed theoretical explanation of the period-luminosity relationship, which has significance for problems of stellar evolution and the size of the galaxy.

Dr. Alan S. Meltzer, before he left the Observatory in September 1957, carried out studies of solar line profiles and the variation of Doppler half-widths of lines with varying atomic weights, to determine whether the broadening mechanism is kinetic temperature or turbulence. The atomic-weight dependence of the Doppler broadening of these lines corresponds to a kinetic temperature of about 10,000° K, a value substantially higher than that predicted by accepted theories of the solar atmosphere.

Upper atmosphere.—Dr. Theodore E. Sterne has been studying the inferential methods used in evaluating observational data, and the probable degree of validity of the resulting conclusions—one of the most important problems in astronomy today. He has developed methods based on celestial mechanics for inferring the density of the upper atmosphere from the motions of artificial earth satellites;

application of the formula indicates a value several times higher than previous estimates. Such information will greatly improve our understanding of solar-terrestrial relationships in general. Dr. Sterne is also developing general literal analytical theories of the motions of satellites of flattened planets. Since adequate numerical treatments are costly and time-consuming, a comprehensive analytical treatment is desirable to facilitate the inference of air densities, and possibly of gravitational anomalies, from observations of satellites.

Balloon experiments relating to stellar scintillation are being carried out by Dr. J. Allen Hynek and George J. Nielson, in cooperation with Col. David G. Simons of the Aero Medical Field Laboratory, Holloman Air Force Base, the Winzen Laboratories of Minneapolis, and the Massachusetts Institute of Technology Instrumentation Laboratories. This project hopes to determine how the scintillation spectrum varies with atmospheric height and the altitude at which the scintillation effect terminates; to test miniature instrumentation for future use; and to initiate an airborne research program for the Astrophysical Observatory.

A new technique that will extend astronomical observations to the far ultraviolet region of the spectrum and to the X-ray region is being developed by the Director and Robert J. Davis of the Observatory staff. This involves the design of a telescope for use in space, and the completion of related theoretical scientific and engineering studies.

The Director completed a theoretical study of the nature and thickness of the lunar dust layer. He concludes that the layer of loose dust is not appreciable and that it can consolidate into a porous matrix, so that it will not be a major hindrance to our exploration of the moon.

Meteoritical studies.—Research on meteors has been emphasized at the Astrophysical Observatory. The Director's predictions as to the small number of meteoritic bodies likely to strike vehicles in space have been supported by the early data from the artificial earth satellites. Continuing studies of the relation between meteors and comets are expected to yield more information about the nature and origin of comets. Under the supervision of Dr. Luigi G. Jacchia, some 400 meteors photographed with Super-Schmidt cameras have been analyzed to determine the nature and distribution of meteoritic orbits. From analysis of the atmospheric decelerations, light curves, and photographic appearances, he concludes that meteors are highly fragmentable and often dissolve into a cluster of fragments. He finds no evidence for meteors of asteroidal origin among the precise data from the 400 reductions, and no hyperbolic meteors have been certainly detected. All photographic meteors appear to be of cometary origin. From a comparison of visual and photographic magnitudes of meteors,

Dr. Jacchia concludes that visual estimates of meteor brightness are strongly affected by the Purkinje effect when the meteors are fainter than magnitude -1. Such an effect is bound to influence all statistics and extrapolations based on visual meteor counts.

In a study of the width of meteor trails, the Director and Dr. G. S. Hawkins found that the meteor columns had a finite diameter of approximately 1.3 m larger than would be expected from diffusion; the width is attributed to a continuous fragmentation process.

Under the direction of Dr. John S. Rinehart, the Observatory has expanded its study of meteorites, as projected last year. Much has already been achieved toward the attainment of the four chief goals: Collecting and identifying micrometeorites in the upper atmosphere; designing and constructing an X-ray fluorescent microanalyzer, under the direction of Dr. F. Behn Riggs, Jr., to use for the point-to-point analysis of the metallic constituents of iron meteorites; measuring the abundance of isotopes in meteorites, under the direction of Dr. Edward L. Fireman; studying the surface features of meteorites for evidence of ablation. Dr. Rinehart has concentrated on the study of micrometeorites and ablation. He and Paul Hodge designed a special collector, for use in aircraft, which filters and recovers particulate matter from the air. Some 30 high-altitude flights have now collected several thousand particles which are almost certainly of extraterrestrial origin. This program will expand during the next year.

Edward P. Henderson of the U. S. National Museum and Prof. David Williams of the University of Florida have assisted in the detailed study of ablation; the surface features of the Grant Meteorite received particular attention.

Studies of high-speed impact, in which meteoritic material was fired at bricklike materials, were initiated, and results of these tests are now being analyzed.

Dr. Edward L. Fireman completed his investigation of the exposure time of meteorites to cosmic rays, and the energy of cosmic rays in space, by measuring the argon 39 in the Sikhote-Alin Meteorite. From measurement of this and other radioactive isotopes, he can estimate the probable age and original shape of various meteorites, and concludes that the Carbo Meteorite reached the earth about 1,500 years years ago, and was a nonspherical object in space.

John Wood is attempting to relate the various types of silicate meteorites to a parent planet, and investigate the processes that take place during the early stages of planetary evolution. Carlos Varsavsky, as consultant to the Astrophysical Observatory, carried out calculations that indicate a lunar origin for tektites; he showed that the Whipple-Rinehart model for the ejection of tektites from the

moon could account for their observed distribution over the earth's surface.

A metallographic study of the structure of meteorites is being made by Mrs. Lynne Farrell.

Satellite Tracking Program.—This program, under the direction of Dr. J. Allen Hynek, began operating on a 24-hour basis immediately after the launching of the first sputnik. By the end of the fiscal year, the 12 stations for the optical tracking of artificial earth satellites were completed. The Baker-Nunn cameras for the precision photographic program had been installed, and 20 observers and their families had reached their posts. Pending the installation of the cameras, an interim observational program was carried out, under the supervision of Dr. Richard E. McCrosky, in Hawaii, and Kenneth Morrison, in Argentina. Since the cameras began operation they have produced many successful observations of the satellites, serving as the basis for scientific research and analysis.

The Moonwatch program, under the supervision of Leon Campbell, Jr., was activated within a few hours of the first launching. As of the end of the year, 230 registered teams working all over the world have contributed valuable data on the various satellites. Since the beginning of the program on October 4, 1957, they have sent more than 4,000 observations to the computations center at the Astrophysical Observatory.

The reduction and analysis of the optical observations proceeded under the supervision of Richard Adams. From calculations based on the computational methods devised by Drs. L. E. Cunningham, T. E. Sterne, L. G. Jacchia, C. A. Whitney, and D. Lautman, the Astrophysical Obervatory has been able regularly to provide orbital predictions of satellite passages, vital for the successful optical tracking of the satellites, and subsequent evaluation of telemetered readings of on-board instrumentation.

Scientific analyses of data obtained by the Satellite Tracking Program were carried out by various members of the staff. From preliminary determinations of upper atmosphere parameters, basic new knowledge was gained of the density and temperature of the upper atmosphere above an altitude of 150 kilometers, which will apply to the design of future satellites and of rocket-powered glide and skip aircraft and to problems of reentry of objects in ballistic orbits. Other new information obtained to date includes an improved value of the coefficient "J" of gravitational flattening.

In partial fulfillment of its contractual obligations to the International Geophysical Year, through the National Science Foundation, the Observatory issued a series of special reports on the results of satellite data analysis, at intervals of roughly two weeks. Under

the supervision of Dr. Gerhard F. Schilling, 13 reports issued between October 15 and June 30 received wide distribution.

In conjunction with the satellite observations, a program has been developed for obtaining observations of the earth's albedo. For this study A. Danjon has developed an ingenious differential photometer. On the recommendations of Dr. J. Allen Hynek and Dr. George van Biesbroeck, six stations have now been equipped with the instrument and preliminary observations have already reached the Astrophysical Observatory.

PUBLICATIONS

Volume 2 of the Smithsonian Contributions to Astrophysics was completed, with the publication of numbers 5–13. Number 10 was of particular importance in presenting a complete collection of the optical observations of Satellites 1957 Alpha and 1957 Beta, during their entire lifetimes.

During the currrent year the following publications by staff members of the Astrophysical Observatory appeared in various journals:

Adams, R. M.; McCumber, N.; and Brinkman, M. Processed observational data for U.S.S.R. Satellites 1957 Alpha and 1957 Beta. Smithsonian Contr. Astrophys., vol. 2, pp. 287–337, 1958.

Ashbrook, J.; Schilling, G. F.; and Sterne, T. E. Glossary of astronomical terms for the description of satellite orbits. Smithsonian Contr. Astrophys., vol. 2, pp. 211–217, 1958.

Campbell, L., Jr., and Hynek, J. A. Visual observations of Satellite 1957 Alpha One made by Moonwatch stations. Smithsonian Contr. Astrophys., vol. 2, pp. 245–274, 1958.

Davis, R. J. 21-cm observations near galactic longitude 120°. Astrophys. Journ., vol. 125, p. 391, 1957.

Davis, R. J.; Welles, R. C.; and Whipple, F. L. On determining the orientation of a cylindrical artificial earth satellite. Astronautica Acta, vol. 3, p. 231, 1957.

Fireman, E. L. Argon-39 in the Sikhote-Alin meteorite fall. Nature, vol. 181, p. 1613, 1958.

———. The distribution of helium-3 in the Carbo meteorite. Nature, vol. 181, p. 1725, 1958.

———. Nuclear processes in geology. In "Nuclear Science Series," Nat. Res. Council, Nat. Acad. Sci., June 1958.

Fireman, E. L., and Zähringer, J. Depth variation of tritium and argon-37 produced by high-energy protons in iron. Phys. Rev., vol. 107, p. 1695, 1957.

Jacchia, L. G. On the "color-index" of meteors. Astron. Journ., vol. 62, p. 358, 1957.

———. On two parameters used in the physical theory of meteors. Smithsonian Contr. Astrophys., vol. 2, pp. 181–187, 1958.

———. Basic orbital data for Satellite 1957 $\beta 1$. Smithsonian Contr. Astrophys., vol. 2, p. 285, 1958.

———. Successive revisions of orbital elements for Satellite 1957 Beta. Smithsonian Contr. Astrophys., vol. 2, p. 339, 1958.

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RINEHART, J. S. Meteorites. Discovery, August 1957, p. 336.

———. Distribution of meteoritic debris about the Arizona meteorite crater. Smithsonian Contr. Astrophys., vol. 2, pp. 145–160, 1958.

———. Fracturing under impulsive loading. Bull. Univ. Missouri School of Mines and Metallurgy, No. 95, 1958.

———. Optical tracking of earth satellites. Bull. Amer. Phys. Soc., ser. 2, vol. 3, p. 290, 1958.

RINEHART, J. S., and SCHILLING, G. F. Additional orbit information for U.S.S.R. Satellites 1957 $\alpha 1$ and $\beta 1$. Smithsonian Contr. Astrophys., vol. 2, p. 199, 1958.

SCHILLING, G. F. Soviet orbit information for Satellites 1957 $\alpha 2$ and $\beta 1$. Smithsonian Contr. Astrophys., vol. 2, p. 281, 1958.

SCHILLING, G. F., and FERGUSSON, E. S. Soviet orbit predictions and orbital information for Satellites 1957 $\alpha 1$, $\alpha 2$, and Beta. Smithsonian Contr. Astrophys., vol. 2, p. 219, 1958.

SCHILLING, G. F., and STERNE, T. E. Preliminary orbit information for U.S.S.R. Satellites 1957 $\alpha 1$ and $\alpha 2$. Smithsonian Contr. Astrophys., vol. 2, p. 191, 1958.

SLOWEY, J. W. A chart for finding a satellite's distance and elevation. Smithsonian Contr. Astrophys., vol. 2, p. 343, 1958.

STERNE, T. E. A suggested analytical treatment of the orbit of a close satellite. Astron. Journ., vol. 62, p. 33, 1957.

———. Analytical orbits of close satellites of oblate planets. Astron. Journ., vol. 62, p. 96, 1957.

———. Celestial mechanics of artificial satellites. Sky and Telescope, vol. 17, p. 66, 1957.

———. The gravitational orbit of a satellite of an oblate planet. Astron. Journ., vol. 63, p. 28, 1958.

———. Formula for inferring atmospheric density from the motion of an artificial earth satellite. Science, vol. 127, p. 1245, 1958.

STERNE, T. E., and DIETER, N. The constancy of the "solar constant." Astron. Journ., vol. 62, p. 147, 1957.

STERNE, T. E.; FOLKART, B. M.; and SCHILLING, G. F. An interim model atmosphere fitted to preliminary densities inferred from U.S.S.R. satellites. Smithsonian Contr. Astrophys., vol. 2, p. 275, 1958.

STERNE, T. E., and SCHILLING, G. F. Some preliminary values of upper atmosphere density from observations of U.S.S.R. satellites. Smithsonian Contr. Astrophys., vol. 2, p. 207, 1958.

VARSAVSKY, C. M. Origin of tektites. Nature, vol. 181, p. 172, 1958.

WHIPPLE, F. L. Exploring the upper atmosphere. Think, vol. 23, p. 5, 1957.

———. Comments on the sunward tail of Comet Arend-Roland. Sky and Telescope, vol. 16, p. 426, 1957.

———. The meteoritic risk to space vehicles. *In* "Vistas in Astronautics," p. 115. Pergamon Press, 1957.

———. Orbit accuracy and ranges for ground-based optical tracking. *In* "Vistas in Astronautics," p. 258. Pergamon Press, 1957.

———. Optical tracking of artificial earth satellites. Proc. Amer. Philos. Soc., vol. 103, p. 215, 1958.

———. Stand by for satellite take-off. Pop. Mechanics, vol. 108, p. 65, 1957.

———. Observations of Satellite I. Sci. American, vol. 197, p. 37, 1957.

WHIPPLE, F. L.; BOYD, L. G.; HYNEK, J. A.; and SCHILLING, G. F. (editors). Orbital data and preliminary analyses of Satellites 1957 Alpha and 1957 Beta. Smithsonian Contr. Astrophys., vol. 2, No. 10, pp. 189–347, 1958.

WHITNEY, C. A. Comments on the present status of the pulsation theory. Astron. Journ., vol. 62, p. 149, 1958.

———. The Ca II emission of classical Cepheids. Mem. Soc. Roy. Sci. Liège, ser. 4, vol. 20, 1958.

———. Granulation and oscillations of the solar atmosphere. Smithsonian Contr. Astrophys., vol. 2, p. 365, 1958.

WHITNEY, C. A., and COX, J. P. Stellar pulsation. IV. A semitheoretical period-luminosity relation for classical Cepheids. Astrophys. Journ., vol. 127, p. 561, 1958.

WHITNEY, C. A., and STONE, P. Numerical integration for nonadiabatic compression waves in the solar atmosphere. Astron. Journ., vol. 62, p. 149, 1957.

WRIGHT, F. W.; JACCHIA, L. G.; and WHIPPLE, F. L. Photographic ι-Aquarid meteors and evidence for the northern Aquarids. Astron. Journ., vol. 62, p. 225, 1957.

OTHER ACTIVITIES

Various members of the staff attended meetings and presented papers before the American Astronomical Society, the American Physical Society, the American Geophysical Union, the National Telemetering Conference, the American Institute of Mining and Metallurgical Engineers Conference, and the American Meteorological Society.

Every member of the scientific staff has given lectures before schools, colleges, civic groups, and military organizations, on the subjects of satellites and space. Some have taken part in round-table discussions on television and radio.

For the annual meeting of the Regents of the Smithsonian Institution, the Observatory displayed a series of models illustrating the Baker-Nunn camera, the Norrman time standard, and the satellite tracking station buildings and layout.

Dr. J. Allen Hynek represented the Astrophysical Observatory at the opening ceremonies of the satellite tracking station at Curaçao. He also took part in two symposia: Space Telescopes, at the Air Technical International Center, Wright-Patterson Air Station; High Altitudes, at Bethesda, Md.

Leon Campbell, Jr., represented the Director at the Eighth Annual Congress of the International Astronautical Federation, in Barcelona, Spain.

Dr. Gerhard F. Schilling represented the Smithsonian Institution at the Eleventh National Conference on the Administration of Research, held in Washington, D.C. At a special meeting of the National Academy of Sciences, May 1958, he reported the scientific results obtained by the Optical Satellite Tracking Program.

Dr. John S. Rinehart participated in the Symposium on Properties of Materials of the American Institute of Metallurgical, Mechanical, and Petroleum Engineers in New York, and the Symposium on Mining Research at the Missouri School of Mines. He also lectured at the Summer Science Institute at Northeast Missouri State Teachers College.

Dr. Gerhard F. Schilling, Dr. J. Allen Hynek, and the Director participated in conferences of the Technical Panel on the Earth Satellite Program of the National Academy of Sciences' U.S. National Committee for the International Geophysical Year, as well as meetings of various working groups of the Special Committee on Space Technology of the National Advisory Committee for Aeronautics.

Dr. Luigi G. Jacchia, at the end of May, visited various Caribbean islands to make an on-the-spot investigation of the demise of Satellite 1957 Beta, from reports of eyewitnesses.

The Director served as delegate to the Eleventh General Assembly of the International Union of Geodesy and Geophysics in Toronto, last September, and was a participant in the Conference on America's Human Resources to Meet the Scientific Challenge, sponsored in February 1958 by the President's Committee on Scientists and Engineers at New Haven, Conn. He was a contributor to the Second Annual Air Force Office of Scientific Research Astronautics Symposium at Denver, Colo., in April 1958, presenting a paper "On the Lunar Dust Layer."

In national science and defense, the Director was called to testify, on April 21, 1958, before the U.S. House of Representatives Select Committee on Astronautics and Space Exploration, on the needs for the United States of America in space exploration. He served as consultant to the U.S. Office of Naval Research and to the U.S. Air Weather Service on problems related to the coming Age of Space. He has been elected chairman of the Technical Panel on Rocketry and is a member of the Technical Panel on the Earth Satellite Program of the International Geophysical Year; chairman of the Panel on the Atmosphere, Scientific Advisory Board to the Air Force; member of the Committee on Cosmic and Terrestrial Relationships of the American Geophysical Union; and member of the working group on Space Surveillance, National Advisory Committee on Aeronautics.

The Director is editor of the Smithsonian Contributions to Astrophysics and of a new international publication: Planetary and Space Physics.

DIVISION OF RADIATION AND ORGANISMS

Research on photomechanisms in plants continued, with special emphasis on those growth responses controlled by low levels of red and blue radiant energy. Further investigations by Dr. William H. Klein and Victor Elstad were made of the red, far-red mechanism that controls photomorphogenic processes in seed germination, seedling development, flowering, and other related responses. In these responses, the red (620–680 mμ) induces the growth response, which can be nullified by subsequent exposure to the far-red (710–730 mμ).

If bean seedlings are simultaneously exposed to monochromatic red and far-red radiant energy, the growth response elicited is determined by the energy ratio of the two sources. The red response is dominant, even up to ratios of 1 to 10, although at this ratio the response is only 50 percent of that produced by red used alone.

The interaction of gibberellin, kinetin, and cobalt with the photoprocess has been studied and evaluated. The results indicate that there is no direct interaction between red irradiance and the added substances, although all these materials do exert a modifying influence on the final growth response. These reactions were assayed by the measurement of the opening of the stem hook of young Black Valentine bean seedlings, which has been shown to be a quantitative determination of the growth response.

Dr. John B. Wolff and Leonard Price continued studies on the effects of radiant energy on the biosynthesis of protochlorophyll in leaves of higher plants grown in the dark. A single exposure to a saturating irradiance of red or blue energy converts most of the protochlorophyll present in the dark-grown leaf to chlorophyll *a*. Subsequently, protochlorophyll is resynthesized in the dark from precursors present in the leaf, but during the first 2 or 3 hours this process is very slow. Later, the rate of synthesis gradually increases. The experimental procedure followed was to expose the leaves briefly to monochromatic energy, then incubate in the dark overnight, and next test for their ability to resynthesize protochlorophyll. It was found that red energy near 650 mμ is more effective than an equal quantity of blue energy near 445 mμ in stimulating the rate of protochlorophyll resynthesis. These wavelengths were selected because they are at the maxima of the action spectrum for the photochemical conversion of protochlorophyll to chlorophyll *a*. If the red irradiation is followed immediately by a treatment with far-red energy between 710 and 730 mμ, the stimulatory action due to red energy can be largely nullified. The far-red energy by itself had little effect on pigment synthesis.

In a study of the biochemical changes involved in the development and maturation of the chloroplast of higher plants, some progress has been made in the isolation of intact proplastids from dark-grown leaves. In excised leaves which had been irradiated with red energy, both the protein concentration and dry weight of the isolated plastid fraction were found to have increased over those of etiolated leaves, but the protein had increased more rapidly than the dry weight. Studies are now in progress to determine the conditions for biosynthesis of plastid components, with emphasis on the carbohydrate energy sources required for such syntheses.

Dr. Alice P. Withrow and Dr. Walter Shropshire, Jr., measured the growth of tomato plants given various regimes of light sequences which involved supplementing a 17-hour period of high-intensity fluorescent light with 7 hours of red and/or far-red radiant energy. It was found that neither red nor infrared caused any increase in height as compared to those that received a 7-hour dark period. However, a far-red exposure given during the 7-hour period, either continuously or in a sequence of 15 minutes on and 15 minutes off, caused the stems to almost double in length. If, in the 7-hour period, the far-red were followed by red, only a slight growth was noted. If this procedure were in effect for 14 complete cycles on each of 15 consecutive days, totaling 210 cycles, more than 90 percent reversal of the far-red growth potentiation was secured. Undoubtedly, the far-red acts as a reversing agent of the red-inhibited stem growth initiated during the 17-hour high-intensity period. Cycling the far-red with red prevents the far-red action. It also was found that the chlorophyll content of the youngest mature leaves was reduced by 20 percent if they were exposed to 7 hours of far-red. There was little change if red or infrared were used during the 7-hour period.

It has previously been reported that far-red radiant energy in the spectral region from 710 to 820 mμ, when used as a supplement to X-rays, significantly increases the frequency of chromosomal aberrations. This year, Dr. Robert B. Withrow and Dr. Carl C. Moh extended the study to determine the region of far-red which gives the maximum effectiveness in increasing the X-ray effect on chromosomal breakage.

Root tips of broad bean (*Vicia faba*) were pretreated with a 3-hour exposure of far-red radiant energy of a specific wavelength and then irradiated with 100 roentgens of X-rays. Using an irradiance of 1500 $\mu w/cm^2$, wavelengths at 730, 760, 780, 800, and 820 mμ were tested. It was found that roots irradiated at 760 mμ yielded 67 percent more chromosomal aberrations than the control (X-rays only), and those with 780 mμ, 54 percent, both increases statistically significant. Pretreatment with radiant energy at 800 mμ increased the aberrations by 20 percent, but 730 and 820 mμ gave no increase. It may be concluded that far-red radiant energy from 760 to 780 mμ is most effective in increasing the frequency of chromosomal aberrations induced by X-rays. In the past year it also was found that red radiant energy from 620 to 680 mμ, when applied subsequent to or simultaneous with the far-red treatment, can nullify the far-red potentiating effect. On the other hand, blue energy was ineffective in reversing the potentiation induced by the far-red. This result implies that the red versus far-red reversible system found at the chromosomal level is analogous to that occurring in a wide variety of photo-

morphogenic responses, such as seed germination, seedling development, and flowering.

In studying the effect of blue light on growth, Dr. Walter Shropshire, Jr., investigated the detailed action spectrum of the first positive tip curvature of the oat coleoptile, using a grating monochromator and irradiating the coleoptile at 10 mμ steps from 350 to 520 mμ. From this action spectrum, it is concluded that the active pigment initiating the growth response is yellow, probably carotenoid in nature, with absorption maxima at 410–415, 440–445, and 470–475 mμ. A flavin photoreceptor appears unlikely, although a peak was observed in the near-ultraviolet at 370 mμ. The curvatures in the ultraviolet may be due to screening across the plant tissue by an inactive secondary pigment with an absorption at about 370 mμ.

PUBLICATIONS

WITHROW, R. B.; KLEIN, W. H.; and ELSTAD, V. Action spectra of photomorphogenic induction and its photoinactivation. Plant Physiol., vol. 32, pp. 453–462, 1957.

WOLFF, JOHN B., and PRICE, LEONARD. Terminal steps of chlorophyll *a* biosynthesis in higher plants. Arch. Biochem. and Biophys., vol. 72, pp. 293–301, 1957.

OTHER ACTIVITIES

Various staff members attended several national and international meetings to present results of research in progress. Early in the year, Dr. Robert B. Withrow and Dr. Alice P. Withrow attended the Gordon Conferences at Meriden, N.H., where Dr. Robert B. Withrow lectured on "Photocontrol of Growth by Red Light." At the annual meeting of the American Institute of Biological Sciences, Stanford, Calif., the following papers were presented:

Stimulation of protochlorophyll synthesis in dark-grown bean leaves by irradiation with low energy, by J. B. Wolff, L. Price, and R. B. Withrow.

Kinetics of the far-red inactivation of photomorphogenesis in the bean hook, by W. H. Klein, R. B. Withrow, and V. Elstad.

Interaction of red and far-red radiant energy in modifying X-ray-induced chromatid aberrations in broad bean, by C. C. Moh and R. B. Withrow.

The mode of action of light and temperature, by R. B. Withrow.

Status of action spectrum and photoreceptor pigment in phototropism, by W. Shropshire, Jr.

An International Symposium on Photoperiodism and Related Phenomena in Plants and Animals, sponsored by the National Research Council and the National Science Foundation, was organized under the chairmanship of Dr. Robert B. Withrow and held at Gatlinburg, Tenn. in October 1957. Papers entitled "Interaction of Growth Factors with the Photoprocess in Seedling Growth," by W. H. Klein, and "A Kinetic Analysis of Photoperiodism," by R. B. Withrow, were presented at the symposium.

Dr. Robert B. Withrow, Chief of the Division of Radiation and Organisms, died on April 8, 1958, of a heart attack at the University of Minnesota Hospital in Minneapolis, Minn. Dr. Withrow came to the Smithsonian Institution as Chief of the Division of Radiation and Organisms in 1948. Prior to this, he had held positions at the University of Cincinnati, Purdue University, and the Argonne National Laboratory and had served as consultant to the U.S. Army Air Force for gravel culture and hydroponics installations. Dr. Withrow was internationally recognized for his contributions to the knowledge of light reactions in plants.

Respectfully submitted.

F. L. Whipple, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the National Collection of Fine Arts

SIRS: I have the honor to submit the following report on the activities of the National Collection of Fine Arts for the fiscal year ended June 30, 1958.

SMITHSONIAN ART COMMISSION

The 35th annual meeting of the Smithsonian Art Commission was held in the Regents Room of the Smithsonian Building on Wednesday, December 4, 1957. Members present were Paul Manship, chairman; Robert Woods Bliss, vice chairman; Leonard Carmichael, secretary; Gilmore D. Clarke, David E. Finley, Lloyd Goodrich, Walker Hancock, Bartlett Hayes, Charles Sawyer, Stow Wengenroth, and Archibald G. Wenley. Thomas M. Beggs, Director, National Collection of Fine Arts, was also present.

A resolution on the death of Mahonri M. Young, a member of the Commission since 1933 to the time of his death November 2, 1957, was submitted and unanimously adopted.

Dr. Finley, chairman of the executive committee, reported that this committee had met on October 30, 1957. The executive committee, acting as a nominating committee, recommended the following actions, which were accepted by the Commission for recommendation to the Board of Regents:

Reappointment of Robert Woods Bliss and George Hewitt Myers for the usual 4-year period.

Election to the Commission of Henry P. McIlhenny, to fill the vacancy caused by the resignation of John Nicholas Brown, and of Ogden Pleissner, to fill that caused by the death of Mahonri M. Young.

Reelection of officers: Paul Manship, chairman; Robert Woods Bliss, vice chairman; and Leonard Carmichael, secretary.

Election of the executive committee: David E. Finley, chairman; Robert Woods Bliss, Archibald G. Wenley, and Gilmore D. Clarke, with Leonard Carmichael and Paul Manship, ex officio.

Congressional bills and their effect upon the National Collection of Fine Arts and priorities in the Smithsonian building program were discussed.

Discussion of the Smithsonian Traveling Exhibition Service, its activities and relations with other similar services, concluded with a resolution commending the Chief of the Service, Mrs. John A. Pope, and her assistants for their fine work, noting especially the steady improvement in the scope and quality of the Traveling Exhibition Service since its establishment 6 years ago.

The Commission recommended acceptance of the following objects:

Bronze, John Quincy Adams Ward (1830–1910), by Charles H. Niehaus (1855–1935). Gift of the National Sculpture Society, New York City.

Two oils, Fifth Lake, by Edgar Payne (1881–1947), and Heavy Sea, by Paul Dougherty, N.A. (1877–1947). Henry Ward Ranger Bequest.

Oil on wood, James Rumsey (1743–1792), by Benjamin West (1738–1820). Received from George A. Rumsey as a gift from Eugene A. Rumsey and brothers.

Watercolor on ivory, William Bass, by undetermined artist. Gift of Mr. and Mrs. Arthur P. Drury.

Wood paneling of Gothic library from "Miramar," Newport, R.I. Gift of Mrs. Alexander Hamilton Rice.

Wood paneling of an 18th-century French Renaissance drawingroom from "Miramar," Newport, R.I. Gift of George D. Widener and Eleanor Widener Dixon.

THE CATHERINE WALDEN MYER FUND

Two miniatures, watercolor on ivory, were acquired from the fund established through the bequest of the late Catherine Walden Myer as follows:

112. William Parsons, 2d, of Gloucester, Massachusetts, by Washington Blanchard (ac. 1831–43 in Boston), from A. C. Walling, Brookline, Mass.

113. Mordecai Manuel Noah (1785–1851), by John Wood Dodge (1807–1893), from the Estate of Ettie W. Noah Wilson, Washington, D.C.

WITHDRAWALS BY OWNERS

Two oils, Scene with Ruins (Tomb of Metellus, thought at the time of Richard Wilson to have been the Villa of Maecenas), said to have been by Richard Wilson (1714–1782), and Frances, Countess of Claremont, said to have been by Sir Joshua Reynolds (1723–1792), lent February 23, 1931, by the Estate of Henry Cleveland Perkins, were withdrawn February 24, 1958, by Robert R. Wallach, heir.

LOANS RETURNED TO THE SMITHSONIAN

Oil, Self Portrait, by George P. A. Healy, lent March 13, 1957, to the Corcoran Gallery of Art for an exhibition "Presidential Portraits" was returned September 6, 1957.

Two oils, President John Tyler, by George P. A. Healy, lent January 25, 1957, to the Bureau of the Budget, and Beach of Bass Rocks, Gloucester, Mass., by Frank Knox Morton Rehn, lent April 26, 1957,

to the Federal Communications Commission, were returned October 25, 1957.

Oil, The Sea, by Edward Moran, lent April 23, 1953, to the Department of State was returned November 6, 1957.

Four oils, Rustic Dance, in the manner of Jean Antoine Watteau, lent June 11, 1953, to the United States Court of Military Appeals, and Moonrise, by Ralph Albert Blakelock, September Afternoon, by George Inness, and Lago Maggiore, by William Stanley Haseltine, lent February 9, 1954, to the Department of State, were returned November 22, 1957.

Oil, Dr. George Washington Carver, by Betsy Graves Reyneau, lent October 4, 1955, to the Department of Health, Education, and Welfare, was returned December 5, 1957.

Two oils, Captain John Ericsson, by Arvid Nyholm, lent May 16, 1957, to the United States District Court for the District of Columbia, and Sunset, Navarro Ridge, California Coast, by Ralph Albert Blakelock, lent February 9, 1954, to the Department of State, were returned December 12, 1957.

An oil, Temple Mountain, by Chauncey Ryder, lent March 15, 1955, and a plaster bas relief, Charles Evans Hughes, by Harry L. Raul, lent January 24, 1956, to the Department of Justice, were returned February 3, 1958.

Three oils, Niagara, by George Inness, The Torrent, by John Henry Twachtman, and Autumn at Arkville, by Alexander H. Wyant, lent March 14, 1957, to the Department of State were returned March 5, 1958.

Oil, Figure Group, by O. Lear, and wood engraving, Rockwell Studio, by Macowin Tuttle, together with two paintings from the Lending Collection lent October 4, 1955, to the Department of Health, Education, and Welfare, were returned March 13, 1958.

Two oils, Male Wood Duck in a Forest Pool and Male Wood Duck, by Abbott H. Thayer, lent June 20, 1956, and June 26, 1956, respectively, to the Interstate Commerce Commission, were returned May 2, 1958.

Two oils, Major General Henry T. Allen and Major General Robert Lee Bullard, by Seymour M. Stone, lent May 23, 1952, to the Department of Defense, were returned June 3, 1958.

Oil, Furbelows, by Albert Sterner, lent April 26, 1957, to the Federal Communications Commission, was recalled June 20, 1958.

Oil, Evening Tide, California, by William Ritschel, lent February 6, 1957, to the United States Court of Military Appeals, was recalled June 26, 1958.

ART WORKS LENT

The following art works, oil paintings on canvas unless otherwise noted, were lent for varying periods:

To Blair House, Washington, D.C.:

November 22, 1957	Moonrise, by Ralph Albert Blakelock. (Returned March 13, 1958.)
	Lago Maggiore, by William Stanley Haseltine. (Returned March 13, 1958.)
	September Afternoon, by George Inness. (Returned March 13, 1958.)
	Rustic Dance, in the manner of Jean Antoine Watteau.

To the Bureau of the Budget, Washington, D.C.:

September 26, 1957	The Right Honorable Winston Churchill, by Hal Denton.
October 25, 1957	Soldat de Crimée, by Harriet Blackstone.

To Carnegie Institute, Pittsburgh, Pa., for an exhibition, "American Classics of the 19th Century," October 17 through December 1, 1957, afterward to be circulated by the Museum Exhibitions Association through July 15, 1958:

September 25, 1957	At Nature's Mirror, by Ralph Albert Blakelock. (Returned December 16, 1957.)
	Moonlight, by Albert P. Ryder.
	High Cliff, Coast of Maine, by Winslow Homer. (Courtesy of The National Gallery of Art.)

To the Cosmos Club, Washington, D.C.:

October 28, 1957	Woodrow Wilson, by John C. Johansen. (Returned November 12, 1957.)

To the United States District Court for the District of Columbia, Washington, D.C.:

December 12, 1957	Mrs. John Brooks Henderson, by Jean Joseph Benjamin-Constant.
	A Neopolitan Lady, by Cesare Biseo (watercolor).
	Landscape, by DeLancey Gill (watercolor).
	Roosevelt Haunts, Early Autumn, by Emile Walters.
	Unknown Lady, by Pierre Bouret (bronze bust).
	Fox Terrier and Rat, by Edward Kemeys (polychromed plaster).
January 28, 1958	Figure of a Moor, by Ascenzi (watercolor).
	The Mirror, by Robert Reid, N.A.
	The Walk to Gethsemane, by Johannes A. Oertel.

To the Federal Communications Commission, Washington, D.C.:

March 28, 1958	The Sea, by Edward Moran.

To the Department of Justice, Washington, D.C.:

April 4, 1958	September Afternoon, by George Inness.
April 29, 1958	Temple Mountain, by Chauncey F. Ryder.
May 7, 1958	October Breezes, by Albert Pike Lucas.

To the Meltzer Gallery, New York City (for color reproduction; prints to be used overseas by United States Information Agency):

November 4, 1957 ---------- Man in White, by Cecilia Beaux. (Returned February 25, 1958.)

To the Municipal Court for the District of Columbia, Washington, D.C.:

September 18, 1957 ------- Under Western Skies, by Carl Oscar Borg (etching).
On the Rim, Grand Canyon, Arizona, by Carl Oscar Borg (etching).
Back Door, by Charles W. Dahlgreen (etching).
Western Pines, by Charles W. Dahlgreen (etching).
U.S. Capitol Dome, by Frances Farrand Dodge (etching).
Glacier National Park, View of Lake Josephine, by Eugenie Fish Glaman (etching).

November 7, 1957 --------- Depths of the Woods, by Lillian M. Genth. (Returned December 6, 1957.)
The Bathers, by Robert Reid, N.A.
Round Hill Road, by John Henry Twachtman.

November 27, 1957 -------- Circe, by Frederick Stuart Church.
A Breton Sunday, by Eugene Vail.
Bell Foundry, Germany, by Walter Shirlaw.
Street Shrine, by Jerome Myers.
Song of the Sea, by William F. Halsall.

To the United States Court of Military Appeals, Washington, D.C.:

January 30, 1958 --------- The Flume, Opalescent River, Adirondacks, by Alexander Wyant.

June 26, 1958 ------------- Evening After a Shower, by Carleton Wiggins.

To Princeton University, Princeton, N.J., to be hung in the Joseph Henry House:

September 27, 1957 -------- Joseph Henry, by Christian Schussele.

To the House of Representatives, Honorable Richard B. Wigglesworth:

November 6, 1957 -------- Beach of Bass Rocks, Gloucester, Mass., by Frank Knox Morton Rehn, N.A.

To the Department of State, Washington, D.C.:

February 6, 1958 ---------- Canal in Venice, San Trovaso Quarter, by Robert F. Blum.
The Continentals, by Frank Blackwell Mayer.

To the District of Columbia Tax Court, Washington, D.C.;

December 6, 1957 --------- Depths of the Woods, by Lillian M. Genth.

To the United States National Museum, Division of Military History, Washington, D.C.:

May 26, 1958 ------------- German armor, in part 17th century, in part reproduction:
1 complete suit.
1 shield.
2 helmets; a burgonet, and a cabasset.
2 swords, one with scabbard.
2 halberds.

To the office of Vice President of the United States:

December 30, 1957 — Sunset, Navarro Ridge, California Coast, by Ralph A. Blakelock. (Returned March 13, 1958.)

Fifth Lake, by Edgar Payne.

February 4, 1958 — In the Plateau Country, by William Henry Holmes (watercolor).

Shin-Au-Av-Tu-Weap, God Land, Canyon of the Colorado, Utah, by Thomas Moran (watercolor). (Returned June 13, 1958.)

To the Walter Reed Army Medical Hospital, Washington, D.C.:

June 2, 1958 — Chester Arthur, by Lot Flannery (plaster bust). (Returned June 13, 1958.)

To The White House, Washington, D.C.:

July 29, 1957 — Emergence, by Andrey Avinoff (watercolor).

A Neopolitan Lady, by Cesare Biseo (watercolor).

A Yellowstone Geyser, by Richard N. Brooke (wash drawing).

Landscape, by DeLancey Gill (watercolor).

In Monument Park, Colorado, by Walter Paris (watercolor).

Landscape Sketch, by Walter Shirlaw (watercolor and pencil).

Roosevelt Haunts, Early Autumn, by Emile Walters.

(All returned October 3, 1957.)

September 12, 1957 — Man in White, by Cecilia Beaux. (Recalled from White House October 25, 1957, and lent to United States Information Agency for reproduction. Returned to White House February 28, 1958.)

January 20, 1958 — Heavy Sea, by Paul Dougherty.

March 5, 1958 — Landscape Sketch, by J. Frank Currier (watercolor).

Sketch on the Potomac, by Lorenzo James Hatch (watercolor).

Spring Brook, Rock Creek Park, by Macowin Tuttle (wood engraving).

Snowbound, by Macowin Tuttle (wood engraving).

Captain John Ericsson, by Arvid Nyholm.

A Tree Study, by Ross Sterling Turner (watercolor).

Aurora Australis, by Frank W. Stokes.

SMITHSONIAN LENDING COLLECTION

On August 5, 1957, 29 paintings by Alice Pike Barney and 5 by other artists were received from Dayton Art Institute to which they had been lent. On December 6, 1957, a pastel portrait of Head of a Negro Boy, received from Col. James Perrine Barney, was added to the Lending Collection.

A watercolor, Street in the Pueblo of Zuni, New Mexico, by DeLancey Gill, lent August 7, 1956, to the Bureau of the Budget, was returned October 25, 1957.

Two oils by Edwin Scott, The Seine at Paris, lent May 24, 1956, and Ships at Anchor, Cherbourg, No. 1, lent February 18, 1953, to the United States District Court for the District of Columbia, were returned January 28, 1958.

An oil, St. Germaine des Pres No. 1, by Edwin Scott, and a watercolor, Musketeer on Guard, by A. Arrunutegin, lent October 4, 1955, to the Department of Health, Education, and Welfare, were returned March 13, 1958.

The following paintings were lent for varying periods:

To The White House, Washington, D.C.:
- September 12, 1957 ------ Venice, by J. Hopkinson Smith (watercolor).
  Three Dogs, by John Morris.

To the Department of Agriculture, Washington, D.C.:
- September 20, 1957 ------ Porte St. Martin et Enterrement, by Edwin Scott.
  Ship at Anchor, Cherbourg, No. 1, by Edwin Scott.
  (Both returned September 26, 1957.)

To the Bureau of the Budget, Washington, D.C.:
- September 26, 1957 ------ The Honorable Theodore Roosevelt, by Sidney L. Smith (etching).

To the Municipal Court for the District of Columbia, Washington, D.C.:
- November 27, 1957 ------- Onteora, by Alice Pike Barney (pastel).
  In Southern France, by Alice Pike Barney (pastel).
  Vielles Maisons (Paris), by Edwin Scott.

To Colonel James Perrine Barney, Princeton, N.J.:
- December 9, 1957 -------- Head of a Negro Boy, by Alice Pike Barney (pastel).

To the Department of State, Washington, D.C.:
- January 2, 1958 ---------- Mirza Abul Fazl, by Alice Pike Barney (pastel).

To the United States District Court for the District of Columbia, Washington, D.C.:
- January 28, 1958 --------- Laura in Arabian Costume, by Alice Pike Barney (pastel).

To the Federal Communications Commission, Washington, D.C.:
- October 25, 1957 --------- Street in the Pueblo of Zuni, New Mexico, by DeLancey Gill (watercolor).
- June 20, 1958 ------------ Musketeer on Guard, by A. Arrunutegin (watercolor).

ALICE PIKE BARNEY MEMORIAL FUND

Additions to the principal during the year amounting to $1,275.01 have increased the total invested sums in this fund to $38,365.53.

THE HENRY WARD RANGER FUND

No. 186, Quince Street, by W. Emerton Heitland (1893–), watercolor, purchased by the Council of the National Academy of

Design April 4, 1955, was assigned by the Academy to Columbus Gallery of Fine Arts, Columbus, Ohio.

According to a provision in the Ranger bequest that paintings purchased by the Council of the National Academy of Design from the fund provided by the Henry Ward Ranger Bequest, and assigned to American art institutions, may be claimed during the 5-year period beginning 10 years after the death of the artist represented, the following two paintings were recalled for action of the Smithsonian Art Commission at its meeting December 4, 1957.

No. 70. Fifth Lake, by Edgar Payne (1881–1947), assigned to the James Lee Memorial Academy of Arts (now the Memphis Academy of Arts), Memphis, Tenn., in 1929, was accepted to become a permanent accession.

No. 110. Heavy Sea, by Paul Dougherty, N.A., (1877–1947), assigned to the William Rockhill Nelson Gallery of Art, Kansas City, Mo., in 1933, was accepted to become a permanent accession.

The following paintings, purchased by the Council of the National Academy of Design since the last report, have been assigned as follows:

Title and Artist	*Assignment*
188. Midnight Procession, by Paul W. Zimmerman (1921–).	Museum of Fine Arts, Houston, Tex.
189. Tranquil Dignity, by Robert Bidner (1930–).	Colorado Springs Fine Arts Center, Colorado Springs, Colo.
190. Cadiz at Dusk, by Dean Ellis (1922–).	Colgate University, Hamilton, N. Y.
191. Self Portrait, by Gerald Mofchum (1926–).	University of Wisconsin, Madison, Wis.
192. Houses Eastside (watercolor), by Ed Graves (1917–).	Oakland Art Museum, Oakland, Calif.
193. Ebbtide (watercolor), by Lenard Kester (1917–).	Baltimore Museum of Art, Baltimore, Md.
194. Circus Friends (watercolor), by A. Henry Nordhausen (1901–).	(Not yet assigned.)
195. That Lonesome Road (watercolor), by Roy M. Mason (1886–).	(Not yet assigned.)
196. Foundation (watercolor), by Carl R. Kinscherf (1919–).	Penn State University, University Park, Pa.
197. Portrait of an Old Man, by Sidney E. Dickinson (1890–).	Dallas Museum of Fine Arts, Dallas, Tex.
198. Between Shifts (watercolor), by Peter Paul Dubaniewicz (1913–).	Berkshire Museum, Pittsfield, Mass.
199. Gay Head (watercolor), by Amy Jones (1899–).	New Britain Institute Art Museum, New Britain, Conn.
200. Peace Memorial, Hiroshima (watercolor), by Mario Cooper (1905–).	Butler Institute of American Art, Youngstown, Ohio.

Title and Artist	*Assignment*
201. Freeway (watercolor), by Richmond I. Kelsey (1905–).	California Palace of the Legion of Honor, San Francisco, Calif.
202. Paisaje Espanol, # 2, by Paul Sample (1896–).	Fort Worth Art Center, Fort Worth, Tex.
203. Springtime in Paris, by Irving Nurick (1900–).	Lyman Allyn Museum, New London, Conn.
204. Coastal Landscape, by Edward Betts (1920–).	Butler Institute of American Art, Youngstown, Ohio.
205. Benares on the Ganges, by Maurice Sterne, N. A. (1877–1957).	(Not yet assigned.)
206. Sea and Wharf at Provincetown, by Eric Isenburger (1902–).	(Not yet assigned.)
207. Nets, by George Harding (1882–).	Crocker Art Gallery, Sacramento, Calif.
208. North Shore Shipyard, by Cleade Enders (1925–).	Staten Island Institute of Arts and Sciences, New York City.
209. Everyday is Washday (watercolor), by Frederic Whitaker (1891–).	(Not yet assigned.)
210. Philadelphia (watercolor), by by Hugh Gumpel (1926–).	(Not yet assigned.)
211. The Horseless Carriage (watercolor), by John W. McCoy, II (1910–).	The Newark Museum, Newark, N.J.

SMITHSONIAN TRAVELING EXHIBITION SERVICE

Ninety-six exhibitions were circulated and shown in 264 museums and galleries during the past season, 95 in the United States and 1 abroad, as follows:

UNITED STATES

Paintings and Drawings

Title	*Source*
American Primitive Paintings.	Dr. Otto Kallir of the Galerie St. Etienne, New York; artists, galleries, museums, and private collections.
California Painting	Municipal Art Center, Long Beach.
Canadian Abstract Paintings	National Gallery of Canada; Embassy of Canada.
Paintings by Sir Winston Churchill.	Artist; Hallmark Cards, Inc.; British Embassy.
Paintings by Jan Cox	Belgian Government; private collectors; Boston Museum of Fine Arts.
Dutch Art 1945–1955 (including sculpture).	Dr. W. Sandberg, Stedelijk Museum; E. L. de Wilde, Van Abbe Museum; A. M. Hammacher, Kroller-Muller State Museum; Embassy of the Netherlands.
A Frenchman in America, Charles-Alexandre Lesueur.	Museum of Le Havre; American Embassy in Paris.

Paintings and Drawings—Continued

Title	*Source*
Indian Paintings from Rajasthan.	Sri Gopi Krishna Kanoria; Arts Council of Great Britain; W. G. Archer, Victoria and Albert Museum.
Kokoschka's Magic Flute	Minneapolis Institute of Arts; artist; Embassy of Austria.
Mexican Work by Cock van Gent.	Cock van Gent; Catherwood Foundation.
A. J. Miller Watercolors	Walters Art Gallery, Baltimore, Md.
Second Pacific Coast Biennial	Santa Barbara Museum of Art; artists, dealers, and private collectors.
Plant Portraits	University of Colorado Museum, Boulder.
Seal Islands	Cleveland Museum of Natural History.
Paintings by Tessai	Kokusai Bunka Shinkokai; National Museum of Modern Art, Tokyo; Kioshi Kojin Temple in Takarazuka; Rev. Bishop Kojo Sakamoto.
Watercolor Today	Toledo Museum of Art; dealers, artists.

Graphic Arts

The American City in the 19th Century.	Prints and Photographs Division of the Library of Congress.
American Printmakers	University of Illinois, Urbana; artists.
Recent American Prints	University of Illinois, Urbana; Lee Chesney; artists.
George Bellows Prints and Drawings.	National Gallery of Art; Boston Public Library; Library of Congress; Fogg Art Museum of Harvard University.
A Century of City Views	Royal Library of Stockholm; Embassy of Sweden.
Early Prints and Drawings of California.	Robert B. Honeyman, Jr.; Los Angeles County Museum.
Contemporary German Prints	National Gallery of Art.
Japanese Fish Prints	Dr. Yoshio Hiyama; Kokusai Bunka Shinkokai; Japanese Embassy; American Museum of Natural History.
Japanese Woodblock Prints	Un'ichi Hiratsuka; American Embassy in Tokyo; artists.
Japanese Woodcuts I Japanese Woodcuts II	United Nations Educational, Scientific, and Cultural Organization; Japanese National Commission.
Theatrical Posters of the Gay Nineties.	Prints and Photographs Division of the Library of Congress.
Birds by Emerson Tuttle	Yale University; Mrs. Tuttle.

Architecture

100 Years of American Architecture.	American Institute of Architects; Immaculate Heart College in Los Angeles; architects.
A Half Century of Architectural Education.	School of Architecture, Georgia Institute of Technology.
Architectural Photography II	American Institute of Architects; Architectural Photographers Association; George Eastman House.

Architecture—Continued

Title	*Source*
Contemporary Danish Architecture.	Prof. Kay Fisker, Royal Academy of Copenhagen; Embassy of Denmark.
Contemporary Finnish Architecture.	Finnish American Society; Association of Finnish Architects; Embassy of Finland.
German Architecture Today	Bund Deutscher Architekten; German Embassy.
Landscape Architecture Today	California Redwood Association.
A Century of New England Architecture.	Norman C. Fletcher, architect; New England State and Regional Chapters of American Institute of Architects.
Contemporary Portuguese Architecture.	Portuguese National Secretariat for Information and the National Syndicate of Architects; Embassy of Portugal.
San Francisco Bay Region Architecture.	California Redwood Association; Northern California Chapter, American Institute of Architects.
Venetian Villas I	Soprintendenza ai Monumenti Medievali e Moderni, Venice; Embassy of Italy.
Venetian Villas II	

Design

Title	*Source*
American Craftsmen, 1957	Robert von Neumann, University of Illinois, Urbana; artists.
Contemporary American Glass.	Corning Museum of Glass.
American Jewelry and Related Objects II.	Rochester Memorial Art Gallery, Rochester, N.Y.; artists; Hickok Company.
Recent Work by Harry Bertoia.	Knoll Associates; artist.
National Ceramic Exhibition, Sixth Miami Annual.	Ceramic League of Miami; Lowe Art Gallery of the University of Miami; designers.
Design in Holland (formerly Dutch Arts and Crafts).	Department of Education, Art and Science in The Hague; Netherlands Embassy.
European Glass Design	Georg Jensen, Inc., New York; designers.
Two Finnish Craftsmen (formerly Finnish Crafts).	Waertsila-Arabia and other Finnish Manufacturers; Finnish-American Society, Helsinki; Finnish Embassy; artists.
Fulbright Designers	Institute of International Education; Museum of Contemporary Crafts in New York; Edgar J. Kaufmann, Jr.; designers.
Italian Arts and Crafts	Compagnia Nazionale Artigiana, Rome; Italian Embassy.
Midwest Designer-Craftsmen	Art Institute of Chicago; artists.
Nylon Rug Designs	Dorothy Liebes; duPont Company; designers.
Religious Banners	Teachers and students of Immaculate Heart College, Los Angeles.
Twelve Scandinavian Designers.	Georg Jensen, Inc., New York; designers.
Swedish Textiles Today	Royal Swedish Embassy; Foreign Office, the Society of Industrial Design; four leading manufacturers in Sweden; Mrs. Susanne Wasson-Tucker; designers.
Good Design in Switzerland	Schweizer Werkbund; Embassy of Switzerland.

Books

Title	*Source*
The Austrian Book	Austrian Embassy; publishers.
German Art Books	Association of German Booksellers; German Embassy.
Art Books from Italy	Cultural Division of the Italian Embassy; publishers.
Sixty Swedish Books	Dr. Uno Willers, Royal Library of Stockholm; Embassy of Sweden.
A World of Children's Books	Washington Post and Times Herald Book Fair; Embassies.
Books for Young Scientists	Washington Post and Times Herald 1957 Children's Book Fair; Drs. Kerlan and Blackwood; publishers.

Oriental Art

Burmese Embroideries	James H. W. Thompson; Embassy of Burma.
The Way of Chinese Landscape Painting.	Dr. Fritz van Briessen.
Chinese Ivories from the Collection of Sir Victor Sassoon.	Sir Victor Sassoon.
Japanese Dolls	Japan Society, Inc.
Six Japanese Painters	Dr. Chisaburoh Yamada; National Museum of Modern Art in Tokyo; artists.
Paintings by Jamini Roy	Jamini Roy.
Thai Painting	James H. W. Thompson.

Folk Art

Early American Woodcarving	Index of American Design, National Gallery of Art.
Punch and Judy	Index of American Design, National Gallery of Art.
Swiss Peasant Art	R. Hanhart, Director, Museum, St. Gall; Pro Helvetia Foundation; Embassy of Switzerland.

Photography

The Anatomy of Nature	Andreas Feininger; American Museum of Natural History.
Photographs of Angkor Wat	Loke Wan Tho; Right Honorable Malcolm MacDonald, High Commissioner for India.
Image of America	Library of Congress.
Japan I by Werner Bischof	Magnum Photos, Inc.
Japan II by Werner Bischof	Magnum Photos, Inc.
Perceptions	Mrs. Dody Warren Weston and Donald Ross; San Francisco Museum of Art; photographers.
Pup, Cub, and Kitten	American Museum of Natural History; William Vandivert.
Photographs of Sarawak	Raffles Museum; Professor Gibson-Hill; Hedda Morrison; USIS.
Glimpses of Switzerland	Pro Helvetia Foundation; Embassy of Switzerland.

Photography—Continued

Title	*Source*
The World of Edward Weston	Beaumont and Nancy Newhall; National Park Service; California Academy of Sciences; Sierra Club.
This is the American Earth	Ansel Adams; Nancy Newhall; artists; George Eastman House.
Young Germans Behind the Camera.	Dr. L. Fritz Gruber, "Photokina," Cologne; German Embassy.

Anthropology

Carl Bodmer Paints the Indian Frontier.	Karl Viktor, Prinz zu Wied; German Embassy.
Swedish Rock Carvings	Dr. Per Nystrom, Governor of the Province of Goteberg and Bohus; Embassy of Sweden.

Children's Exhibitions

Argentine Children as Illustrators.	Editorial Guillermo Kraft Ltd., Buenos Aires; Argentine Embassy.
Art in Opera I—Tosca	Metropolitan Opera Guild.
Art in Opera II—Carmen	Metropolitan Opera Guild.
As I See Myself	Junior Arts and Activities; Galerie St. Etienne.
Children's Paintings from 45 Countries.	Embassy of Denmark; Friendship Among Children and Youth Organizations.
The Four Seasons	Arts and Activities Magazine; Galerie St. Etienne.
Children's Paintings from Japan.	United Nations Educational, Scientific, and Cultural Organization.
Children's Paintings from Morocco.	Division of Youth and Sports of Ministry of Public Instruction, Rabat; Embassy of Morocco.

Exhibitions Circulated Abroad

American Folk Art.

INFORMATION SERVICE AND STAFF ACTIVITIES

In addition to the many requests for information received by mail and telephone, inquiries made in person at the office numbered 1,944. Examination was made of 153 works of art submitted for identification.

Effective July 1, 1957, the Pell Collection and other miscellaneous ceramics were transferred to the United States National Museum collections to form the division of ceramics and glass of the newly established Museum of History and Technology, and the curator of ceramics, formerly under the National Collection of Fine Arts, was made acting curator of the division.

Special catalogs were published for the following 10 exhibitions: Sculpture by Paul Manship, a Retrospective Exhibition, with an ap-

preciation by Mr. Beggs, illustrated; Recent American Prints; A Century of City Views; Cock van Gent; 2d Pacific Coast Biennial; Contemporary Portuguese Architecture; Fulbright Designers; Indian Paintings from Rajasthan; Swedish Textiles Today; and Nylon Rug Designs. Mrs. Annemarie H. Pope, chief of the Smithsonian Traveling Exhibition Service, wrote special acknowledgments for the last two and a foreword for Indian Paintings from Rajasthan; acknowledgments for the Fulbright Designers were written by Mrs. Jo Ann Sukel Lewis, research assistant.

Mr. Beggs gave a talk on Regionalism in American Art to the Art League of Manatee County, Fla.; spoke on Paintings of the Passion of Christ at the Rock Springs Congregational Church, Arlington, Va.; and gave a talk on Private Collections Publicly Maintained to the Arts Club of Washington. He served on the juries of two local shows.

Mrs. Pope departed June 18 for Europe to see the exhibits of the United States and other countries at the Brussels International Fair and to visit England, Holland, France, Italy, Greece, and Switzerland to study new exhibitions and make selections of some for circulation here.

Rowland Lyon served as juror for eight local shows.

Thirty-three paintings in oil on canvas from the permanent collections were cleaned and revarnished, 2 were relined, and 48 picture frames were repaired and refinished. One plaster cast and one bronze statue were cleaned and refinished. One painting by George Catlin was relined to repair a 22-inch tear in the canvas, for the United States National Museum.

The 18-foot ceiling decoration, "Dawn," by Thomas W. Dewing, in the Gellatly Collection, was renovated by Henri G. Courtais and installed in a specially constructed pavilion. In addition, Mr. Courtais restored "Aurora Borealis," by Frederick E. Church, "Madonna and Child with Apple," by an Old Flemish Master, and made minor repairs to "Entombment," by Rogier van der Weyden.

Glenn J. Martin cleaned and removed old repaint on 11 paintings recently acquired.

Twenty oil portraits of World War II leaders by John C. Johansen and pastel drawings of the Civil War Veterans by Walter Beck have been removed from the second floor gallery and are to be installed at the south end of the foyer together with the miniature portraits in specially lighted cases.

The oil portrait of President John Tyler, by G. P. A. Healy, was copied by C. Gregory Stapko in November 1957.

SPECIAL EXHIBITIONS

Thirteen special exhibitions were held during the year:

July 11 through July 31, 1957.—Recent Works by Cock van Gent, sponsored by the Catherwood Foundation and circulated by the Smithsonian Traveling Exhibition Service, consisting of 20 oils, 10 watercolors, and 20 drawings. A catalog was privately printed.

August 27 through September 27, 1957.—The Sixth International Exhibition of Ceramic Art under the auspices of the Kiln Club of Washington, D.C., consisting of 223 pieces (140 by local artists, 49 by invited American artists, and 34 lent by various Washington embassies and legations as representative of national artists of 10 countries). Craft demonstrations were given. A catalog was privately printed.

October 20 through November 11, 1957.—The Twentieth Metropolitan State Art Contest, held under the auspices of the D.C. Chapter, American Artists Professional League, consisting of 278 paintings, sculpture, prints, ceramics, and metalcrafts. A catalog was privately printed.

November 20 through December 15, 1957.—The Sixty-Fifth Annual Exhibition of the Society of Washington Artists, consisting of 82 paintings and 13 sculptures. A catalog was privately printed.

January 26 through February 16, 1958.—The Twenty-second Exhibition of the Society of Washington Printmakers, consisting of 198 works in the graphic media. A catalog was privately printed.

February 23 through March 16, 1958.—A Retrospective Exhibition of Sculptures by Paul Manship, consisting of 117 items. An illustrated catalog was printed.

March 23 through April 13, 1958.—The Biennial Art Exhibition of the National League of American Pen Women, consisting of 202 paintings, sculpture, prints, ceramics, textiles, jewelry, and other craftswork. A catalog was privately printed.

April 19 through May 11, 1958.—Swedish Textiles Today, sponsored by the Ambassador of Sweden and Madame Boheman and circulated by the Smithsonian Traveling Exhibition Service, consisting of 113 textiles with additional display items including glass, silver, chairs, and stools. A catalog was privately printed.

April 26 through May 18, 1958.—Exhibition of Paintings by Sir Winston Churchill, consisting of 35 paintings being circulated by the Smithsonian Traveling Exhibition Service and a portrait of Churchill by Lamar lent by the British Embassy. President Eisenhower previewed this exhibition on April 24, 1958. A catalog was privately printed.

May 25 through June 13, 1958.—The 61st Annual National Exhibition of the Washington Watercolor Club, consisting of 109 watercolors, etchings, and drawings. A catalog was privately printed.

May 25 through June 13, 1958.—The Twenty-fifth Annual Exhibition of the Miniature Painters, Sculptors, and Gravers Society of Washington, D.C., consisting of 172 examples. A catalog was privately printed.

June 20 through July 13, 1958.—The Seventh Interservice Photography Contest, consisting of 89 photographs by members of the Armed Forces.

Respectfully submitted.

THOMAS M. BEGGS, *Director.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Freer Gallery of Art

SIR: I have the honor to submit the 38th annual report on the Freer Gallery of Art for the year ended June 30, 1958.

THE COLLECTIONS

Fourteen objects were added to the collections by purchase as follows:

BRONZE

57.22 Chinese, Late Chou dynasty (ca. 5th century B.C.). Ceremonial vessel of the type *hu;* decorated with casting in relief in six main horizontal zones; tiger-form handles. 0.446 x 0.266.

GLASS

57.19. Egyptian, 14th century (ca. A.D. 1360). Mosque lamp decorated with colored enamels and traces of gilding; inscription names the Madrasa of Sulṭān al-Nāṣir Ḥasan b. Muḥammad (Cairo) for which it was made. 0.336 x 0.305 (Illustrated.)

IVORY

57.25. Chinese, Sung dynasty (A.D. 960–1279). Standing figure of a Buddha with small Buddha on a lotus, and a dragon at the feet; inscription of 16 characters includes date, A.D. 1025. 0.457 x 0.130.

JADE

58.1 Chinese, Ch'ing dynasty (A.D. 1644–1912). Amber-colored agalmatolite carved in the round to represent a phoenix among clouds and plants; signed Chou Pin. 0.115 x 0.050 x 0.023.

MANUSCRIPT

57.16. Persian, Mongol period, Inju school (ca. A.D. 1330). First volume of *Tarjama-i Tārikh-i Tabari;* 193 folios, end missing; 29 miniatures in colors and gold. (The Freer Gallery has most of volume II: 30.21 and 47.19.) Average page: 0.422 x 0.287.

METALWORK

57.20. Persian, Sasanian period, 3d century A.D. Silver bowl, semispherical, fluted interior with gilded central medallion framing a bearded male bust in high relief. 0.210 x 0.062.

PAINTING

57.15. Chinese, Sung dynasty (A.D. 960–1279). "Three Worthies of Wu-chung," attributed to Li Kung-lin (late 11th–early 12th century). Handscroll in ink and colors on silk; 4 inscriptions and 33 seals on painting, 1 inscription and 2 seals on mount. 0.443 x 1.490.

57.19

58.2

Recent additions to the collections of the Freer Gallery of Art.

57.18

Recent addition to the collections of the Freer Gallery of Art.

57.17. Japanese, Ashikaga period (A.D. 1335–1568). Landscape with birds and flowers by Kano Motonobu (1476–1559); handscroll in ink on paper; one seal on painting. 0.280 x 4.830.

POTTERY

58.2 Chinese, Ming dynasty (A.D. 1368–1644). Large flask with unglazed back; decorated in underglaze blue; early 15th century. 0.475 x 0.418 x 0.213. (Illustrated.)

57.26. Japanese, Edo period (A.D. 1615–1868), Kutani ware. Large bottle-shaped vase decorated with peonies and formal patterns in red, yellow, and green overglaze enamels. 0.468 x 0.253.

57.23. Mesopotamian, Abbasid period, 9th century. Flat dish with interlacing ribbon pattern and floral motifs in low linear relief; remains of gold lustered lead glaze. 0.028 x 0.280.

57.24. Persian, Sāmānid period, 10th century. Deep bowl decorated in dark brown, brick red, and white slip with floral patterns and *kufic* script. 0.112 x 0.393.

57.12. Persian, Seljuq period, 12th century, Rayy. Large dish decorated with a young horseman on an arabesque ground; gold luster. 0.075 x 0.432.

WOOD SCULPTURE

57.18. Japanese, Kamakura period (A.D. 1186–1334). Figure of Bishamon-ten with the usual attributes and standing on a crouching dwarf; painted and gilded, metal halo, glass eyes. H. 0.572 x W. (base) 0.268. (Illustrated.)

Total number of accessions to date (including the above), 10,991.

REPAIRS TO THE COLLECTIONS

Fifty Chinese and Japanese objects were restored, repaired, or remounted by T. Sugiura. In addition to this work on the collections, Mr. Sugiura completed *t'ao* for 18 Chinese books and repaired 11 books for the library.

CHANGES IN EXHIBITIONS

Changes in exhibitions amounted to 1,468. This unusually large number is accounted for by the air-conditioning of the building which was completed in the fall of 1957, reinstallation of exhibitions, and redecoration of exhibition galleries. The changes were as follows:

American art:	
Copper plates	17
Etchings	18
Lithographs	18
Oil paintings	97
Pastels	32
Watercolors	28
Chinese art:	
Bronze	210
Gold	10
Jade	116
Marble	2

Chinese art—Continued	
Metalwork	24
Paintings	90
Pottery	158
Stone sculpture	18
Christian art:	
Crystal	2
Glass	6
Gold	18
Manuscripts	18
Paintings	8
Stone sculpture	2
Indian art:	
Bronze	2
Manuscripts	12
Paintings	30
Stone sculpture	8
Japanese art:	
Bronze	2
Lacquer	21
Paintings	174
Pottery	69
Wood sculpture	12
Korean art:	
Bronze	2
Pottery	36
Near Eastern art:	
Bookbindings	10
Crystal	2
Glass	8
Manuscripts	16
Metalwork	40
Paintings	86
Pottery	40
Stone sculpture	2
Tibetan art:	
Paintings	4

LIBRARY

The prime requirement of the library is service from and through books. It is well known that what has once been published is often forgotten and the rediscovery in the library may be a more difficult process than the first discovery. All the modern refinements of cataloging and the invention of the fabulous fact-finding push-button machines are directed toward making rediscovery easy, but in the last analysis the ultimate dependence is still upon human brains and skills.

The expanding program of work and the many new projects being initiated find some of the subjects inadequately covered by the literature in the Gallery library. Other libraries owning the required material have been most generous in furnishing it through interlibrary loan.

The 878 publications acquired during the year included purchases, gifts, and those sent in exchange for Freer publications. Unfortunately, the prices of books and periodicals continue to increase, and a good many institutions and societies that formerly sent their journals freely, in exchange or gratis, now find it necessary to charge for them in order to assure continuity of publication.

Outstanding among the purchases last year were: *Japan Biographical Encyclopedia & Who's Who*, compiled by the Japan Biographical Research Department, 1958, which is the first good Japanese biography in English since Papinot did his *Historical and Geographical Dictionary* in 1909; *Gunsho ruishō* [*Shin ko*], a collectanea of miscellaneous writing, compiled by Kawamata Kyōichi, Tokyo, 1931–37, 24 volumes with 3 supplements and index in 105 volumes; *Kuei-ch'ü-lai*, a makimono painting illustrating T'ao Ch'ien's "Homecoming Ode." This is a copy of a part of the Freer painting *19.119*, which is attributed to Li Kung-lin. Professor Sirén's notes and comments on the paintings are attached to the scroll. The *Yunkang, the Buddhist Caves . . .*, which began publication in 1951, was completed with 16 volumes in 36 folio volumes.

The year's record of cataloging included a total of 1,879 entries of which 714 analytics were made, 451 titles of books and pamphlets were cataloged, and 48 titles were recataloged and reclassified. Once more the specialized nature of the library and its unique importance for the study of Oriental art are emphasized by the fact that less than 8 percent of the necessary cards were available as printed cards at the Library of Congress. This shows the original and difficult cataloging required in a specialized library.

PUBLICATIONS

One publication was issued by the Freer Gallery as follows:

Ars Orientalis. The Arts of Islam and the East, vol. II. The Charles Lang Freer Centennial Volume. 637 pp., 224 pls., and text ills. (Smithsonian Publication 4298. Published jointly with the Department of Fine Arts, University of Michigan. Three members of the staff contributed to this issue.)

Papers by staff members appeared in this and in outside publications as follows:

Cahill, James F. Review of "The Arts of the T'ang Dynasty." Catalog of an exhibition held at the Los Angeles County Museum, 1957. In *The Journal of Asian Studies*, vol. 17, No. 1, pp. 142–143, November 1957.

Ettinghausen, Richard. Bibliographie der Islamischen Einbandkunst, 1871–1956, von Emil Gratzl, K. A. C. Creswell, und Richard Ettinghausen. In *Ars Orientalis*, vol. II, pp. 519–540, 1957.

———. Bibliography of the writings of K. A. C. Creswell. In *Ars Orientalis*, vol. II, pp. 509–512, 1957.

———. Bibliograph of the writings of Mehdi Bahrami. In *Ars Orientalis*, vol. II, pp. 625–627, 1957.

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REPRODUCTIONS

The photographic laboratory made 8,432 items during the year as follows: 5,391 prints, 361 negatives, 1,716 color transparencies, and 248 black-and-white slides. Total negatives on hand, 11,563; 3,000 old slides were removed, and present inventory for lantern slides totals 7,005; 354 reproductions in the round of Freer Gallery objects were sold. Slide loans were as follows: 765 black-and-white, 1,354 color.

BUILDING

The roof and exterior of the building appear to be in good condition; minor repairs were made and leaks in the skylights fixed from time to time. The daylights in each of the Gallery ceilings and the east and west corridors were replaced.

The work of making exhibition cases for the galleries and new bookcases continued in the cabinet shop, and miscellaneous odd jobs related to storage, exhibition, restoration, crating, and maintenance of office and Gallery equipment were carried on as usual. Much time was given to various jobs arising as air-conditioning of the building was completed, such as a thorough cleaning of the attic and reinstallation of the exhibition galleries.

All plants, trees, and shrubs appear to be doing well. The trumpet-vine and trellis at either end of the south side were removed and the azalea bed was transplanted and rearranged. One *Mahonia beali* was planted in the southwest corner. One *Cotoneaster salicifolia* was replaced. The four plots of grass were removed and resodded completely with zoysia grass. The grass, as well as all the plantings around the fountain, has made an excellent showing. Lantanas have been planted for the present season and are doing well.

HERZFELD ARCHIVE

On October 29, 1957, a gift of one notebook and three booklets of Arabic inscriptions to be added to the Herzfeld Archive was received from Prof. Dr. Adolf Grohmann.

ATTENDANCE

The Gallery was open to the public from 9 to 4:30 every day except Christmas Day. The total number of visitors to come in the main entrance was 111,674. The highest monthly attendance was in April, 14,539, and the lowest was in February, 3,517.

There were 2,253 visitors to the office for the following purposes:

For general information	911
To submit objects for examination	434
To study in library	439
To see staff members	180
To take photographs in court or exhibition galleries	117
To see building and installations	26
To examine or borrow slides	23
To sketch in galleries	10
To see objects in storage:	
American art	26
Armenian, Byzantine, Greek MSS., etc	2
Christian art (Washington MSS.)	45
Far Eastern jade, lacquer, wood, ivory, etc	23
Far Eastern metalwork	32
Far Eastern paintings	97
Far Eastern pottery	61
Near Eastern glass, bookbindings, etc	8
Near Eastern metalwork	5
Near Eastern paintings	20
Near Eastern pottery	8

AUDITORIUM

The series of illustrated lectures was continued as follows:

1957

October 8. Dr. John Alexander Pope, Assistant Director, Freer Gallery of Art. "Ceramic Finds in the Far East." Attendance, 222.

November 5. Dr. John D. Cooney, Curator of Egyptology, Brooklyn Museum. "Adventures in Collecting." Attendance, 108.

1958

January 7. Harold P. Stern, Associate in Japanese Art, Freer Gallery of Art. "The Korean Imperial Treasures." Attendance, 165.

February 11. Dr. Jane Mahler, Associate Professor of Fine Arts, Columbia University. "The Glory of Medieval Burma." Attendance, 173.

March 11. Dr. Charles K. Wilkinson, Curator, Ancient Near Eastern Art, Metropolitan Museum of Art. "Achaemenian Art: The Art of a Persian Empire." Attendance, 175.

April 15. W. G. Archer, Keeper, Indian Section, Victoria and Albert Museum, London. "The Loves of Krishna." Attendance, 166.

Outside organizations used the auditorium as follows:

1957

August 13. The United States Department of Agriculture held a meeting of 4-H Club representatives. Attendance, 220.

November 19. The United States Department of Agriculture held a meeting of the Commodity Stabilization Service, Sugar Division. Attendance, 311.

November 20. The United States Department of Agriculture held an all-day meeting of the Federal Extension Service. Attendance, 255.

1958

January 27. The United States Department of Agriculture held a meeting of the Rural Electrification Agency, Southern Region, Telephone Program. Attendance, 125.

January 28. The United States Department of Agriculture held a meeting of the Secretary's Offices, Farmers Union Meeting. Attendance, 151.

Four other meetings were held in the Freer Gallery of Art building as follows:

1957

September 23. Board of Governors of the Washington Society of the Archaeological Institute of America met in the library. Attendance, 7.

December 14. Far Eastern Ceramic Group met in the library. Attendance, 25.

1958

May 14. Board of Governors of the Washington Society of the Archaeological Institute of America met in the library. Attendance, 6.

June 4. Through the Department of Commerce, National Bureau of Standards, it was arranged to have the Freer Gallery of Art open the evening of June 4, 8:30 to 10:30 P.M., to members of the Sugar Refinery Congress. Docent service was given by Harold P. Stern and James F. Cahill. Attendance, 46.

STAFF ACTIVITIES

The work of the staff members has been devoted to the study of new accessions, of objects contemplated for purchase, and of objects submitted for examination, as well as to individual research projects in the fields represented by the collections of Chinese, Japanese, Persian, Arabic, and Indian materials. Reports, oral and written, and exclusive of those made by the technical laboratory (listed below), were made on 4,049 objects as follows: For private individuals, 2,538; for dealers, 1,067; for other museums, 444. In all, 863 photographs were examined, and 471 Oriental language inscriptions were translated for outside individuals and institutions. By request, 19 groups totaling 453 persons met in the exhibition galleries for docent service by staff members.

Three groups totaling 41 persons were given docent service by staff members in the storage rooms.

Among the visitors were 84 distinguished foreign scholars or persons holding official positions in their own countries who came here under the auspices of the State Department to study museum administration and practices in this country.

In the technical laboratory 130 objects from the Freer Collections and 69 from outside sources were examined. The following projects were begun:

1. For a period of four weeks in March-April, Mr. Gettens worked as research collaborator in the chemistry department of Brookhaven National Laboratory, Upton, L.I., N.Y., where he carried out analytical studies, mainly spectrographic, on ancient glass and ancient bronze. Some 30 specimens from inscribed ceremonial bronzes in the Freer Collection were analyzed spectrochemically.
2. Chemical quantitative analysis by wet methods was started on samples of the same series of inscribed ceremonial bronzes.
3. Systematic collection of data was begun on the technology of ancient copper and bronze in the Far East.

The following projects were continued:

1. X-ray diffraction analysis of corrosion products on ancient metals.
2. Identification, by X-ray diffraction methods, of the jade objects in the Freer Collection.
3. Studies on the salt efflorescence on earthenware bodies. Carried on exchange of specimens and information with Museum of Natural History, Brussels.

During the year, 8 written reports were made and 37 verbal reports given on objects examined in the technical laboratory.

In August 1957 Mr. Wenley left for 2½ months to attend the International Congress of Orientalists in Munich where he delivered a paper on inscriptions on bronze vessels found at Lo-yang in 1929. During his trip to Europe he also studied museums and private collections in the following places: Briefly in France and Switzerland, 9 days in Munich, 5 days in Stockholm, 7 days in London, 3 days each in Brussels, The Hague, and Athens, and 16 days in Italy.

By invitation of the Government of Pakistan and the University of the Panjab in Lahore, Dr. Ettinghausen left in December to attend the International Islamic Colloquium. As the initial speaker he delivered a paper entitled "Comments on the Nature of Islamic Art and Its Symbols." His 4-month trip took him to the following places where he delivered lectures and studied museums and private collections in connection with his research in Near Eastern art: 4 weeks in Pakistan, 4 weeks in India, 10 days in Iran, 8 days in Israel, 2½ weeks in Germany and England respectively, and 2 days in Ireland.

On March 27, 1957, Mr. Stern left on a 9-month trip to the Far East to prepare the catalog for editing and supervise photographing of the objects and arrangements for packing and shipping of the Korean Government Loan Exhibition. While in the Far East he delivered lectures and studied museums and private collections in the following places: 5 weeks in Seoul, 5 months in Japan, 2 weeks in Hong Kong, 1 week in Formosa, 1 week in Honolulu, and 1 week in San Francisco and Seattle.

By invitation the following lectures were given outside the Gallery by staff members (illustrated unless otherwise noted):

1957

July 15. Dr. Cahill, at the State Teachers College, New Paltz, N.Y., "Chinese and Japanese Art." Attendance, 32.

July 11. Dr. Ettinghausen, at the University of Washington, Seattle, "Historical Travel in Iran, Afghanistan, and India." Attendance, 250.

July 16. Dr. Ettinghausen, at the University of Washington, Seattle, "Miniature Albums of the Mughal Emperors of India." Attendance, 220.

July 18. Dr. Ettinghausen, at the Seattle Art Museum, "Masterpieces of Near Eastern Pottery." Attendance, 150.

July 23. Dr. Ettinghausen, at the University of British Columbia, Vancouver, B.C., "Historical Travel in Iran, Afghanistan, and India." Attendance, 85.

August 8. Mr. Stern, at the American Cultural Center, Kyoto, Japan, "Some Japanese Objects in the Freer Gallery of Art." Attendance, 55.

August 14. Mr. Stern, at the Kyoto University, Kyoto, Japan, in Japanese, on "Japanese Art in the Freer Gallery of Art." Attendance, 50.

August 23. Mr. Stern, in Osaka, Japan, in Japanese, on "Japanese Art in the Freer Gallery of Art." Attendance, 20.

September 16. Mr. Stern in Nara, Japan, in Japanese, on "Japanese Art in the Freer Gallery of Art." Attendance, 25.

September 30. Dr. Cahill, at All Souls Unitarian Church, Washington, D.C., on "Chinese Painting." Attendance, 25.

October 12. Dr. Ettinghausen, at the Phillips Gallery, Washington, D.C., "Iran, the Country and Its Art." Attendance, 41.

October 16. Mr. Stern, in Tokyo, Japan, at the National Museum, in Japanese, "Japanese Art in the Freer Gallery of Art." Attendance. 50.

October 24. Dr. Pope, in New York, to the Chinese Art Society, "Pottery Hunting in the Far East." Attendance, 70.

November 21. Dr. Cahill, in New York, at the Metropolitan Museum of Art, "Album Painting in Japan." Attendance, 45.

November 22. Dr. Pope, in Baltimore, at the Baltimore Museum of Art, "Asiatic Collections of Chinese Art." Attendance, 135.

December 11. Dr. Pope, at the Corcoran Gallery of Art, Washington, D.C., "Asiatic Collections of Chinese Art." Attendance, 100.

December 30. Dr. Ettinghausen, at the University of the Panjab, Lahore, Pakistan, delivered official message of greetings of the Smithsonian Institution to the Vice Chancellor of the University. Attendance, 1,500.

December 31. Dr. Ettinghausen, at the University of the Panjab, Lahore, delivered opening speech, "Comments on the Nature of Islamic Art and its Symbols." Attendance, 650.

1958

January 5. Dr. Ettinghausen, at the University of the Panjab, Lahore, presided at a meeting of the International Islamic Colloquium. Attendance, 30.

January 7. Dr. Ettinghausen, at the University of the Panjab, Lahore, before a meeting of the International Islamic Colloquium, "Miniature Albums of the Mughal Emperors." Attendance, 30.

1958

January 11. Dr. Ettinghausen, in Peshawar, Pakistan, a brief address to the Board of Historical Research.

January 12. Dr. Ettinghausen, at Peshawar University, Pakistan, "Mughal Miniatures." Attendance, 150.

January 15. Dr. Ettinghausen, at the University of Dacca, East Pakistan, Department of Arabic Studies, "Mughal Miniatures." Attendance, 40.

January 16. Mr. Wenley addressed the annual dinner of the Smithsonian Board of Regents, "Far Eastern Collections in the Freer Gallery of Art Compared with Those Abroad." Attendance, 26.

January 16. Dr. Ettinghausen, at the University of Dacca, East Pakistan, "Pottery from Muslim Countries." Attendance, 55.

January 17. Dr. Ettinghausen, at the University of Dacca, East Pakistan, Department of Islamic Civilization, "The Paintings of Behzad." Attendance, 75.

January 20. Mr. Gettens, at the Sidwell Friends School, Washington, D.C., "Source of Paint Material of the Ancients." Attendance, 20.

January 21. Dr. Ettinghausen, at the United States Information Service, Chittagong, East Pakistan, "Muslim Art and Painting." Attendance, 150.

January 24. Dr. Ettinghausen, in Calcutta, India, at the home of Chester R. Chartrand, Public Affairs Officer of the Consulate General, "Mughal Paintings." Attendance, 25.

January 26. Dr. Ettinghausen, in Calcutta, India, at the home of Robert B. Jaffie, Cultural Affairs Officer, "Mughal Paintings." Attendance, 15.

February 1. Dr. Ettinghausen, in Banaras, India, under the auspices of the Department of Indology and the Bharat Kala Bhawan (Museum of Indian Art) of the Banaras Hindu University, "Mughal Paintings in the Freer Gallery of Art." Attendance, 40.

February 7. Mr. Gettens, in New York at the Brooklyn Museum, "Optical Aids in the Examination of Paintings." Attendance, 25.

February 13. Dr. Ettinghausen, at the National Gallery of Modern Art, New Delhi, India, "Mughal Miniatures in the Freer Gallery of Art." Attendance, 40.

February 19. Dr. Ettinghausen at the Bhulabhai Memorial Institute, Bombay, India, "The Near Eastern Collection of the Freer Gallery of Art." Attendance, 50.

February 20. Dr. Ettinghausen, at the Bhulabhai Memorial Institute, Bombay, India, "Mughal Miniatures in the Freer Gallery of Art." Attendance, 110.

February 21 Dr. Ettinghausen, at the Bhulabhai Memorial Institute, Bombay, India, "Near Eastern Potteries in the Freer Gallery of Art." Attendance, 45.

March 5. Dr. Ettinghausen, in Tehran, Iran, to the Theological Faculty of the University of Tehran, "Persian Elements in Mughal Painting." Attendance, 400.

1958

March 11. Dr. Ettinghausen, at the Hebrew University, Jerusalem, Israel, "Characteristic Features of Mughal Paintings." Attendance, 45.

April 1. Dr. Pope, in New York City, to members of the American Oriental Society, "Chinese Remains in Sarawak." Attendance, 75.

April 3. Mr. Stern, at China House, New York, "Japanese Painting as Represented by the Hauge Collection." Attendance, 40.

May 1. Mrs. Usilton, in Charleston, S.C., to the Librarians' Section of the American Association of Museums, "What's New in Museum Libraries." Attendance, 30.

May 2. Mr. Gettens, in Charleston, S.C., to the Art Technical Section of the American Association of Museums, "Examining Tables." Attendance, 50.

May 2. Miss Elisabeth West, in Charleston, S.C., to the Art Technical Section of the American Association of Museums, "Cross-Sections of Layered structures in Polyester Resin." Attendance, 50.

May 14. Mr. Gettens, to the Abracadabra Club, Bethesda, Md., "Adventure in Color." Attendance, 20.

Mrs. Usilton attended the two sessions of the Regional Catalogers and Classifiers meeting of the American Libraries Association at the Folger Library, Washington, D.C. Members of the staff traveled outside Washington on official business as follows:

1957

July 1–December 23. Mr. Stern in the Far East.

July 1–3. Mr. Gettens, in Boston, visited the Museum of Fine Arts, where he examined 10 Far Eastern objects; and the Isabella Stewart Gardner Museum, where he examined 1 Far Eastern object; and in Cambridge, Mass., visited the Fogg Art Museum where he examined 1 Far Eastern object.

August 26–November 12. Mr. Wenley attended meetings of the International Congress of Orientalists in Munich, Germany.

September 13. Miss Elisabeth West, in Baltimore, visited the Walters Art Gallery where she examined 96 pieces of jade and sampled 17.

September 30–October 4. Dr. Ettinghausen, in New York, visited various dealers and museums and examined 155 Near Eastern objects.

October 15. Dr. Ettinghausen, in Baltimore, visited the Baltimore Museum of Art, where he examined 3 pieces of Turkish pottery, 4 pieces of Persian pottery, and 1 piece of Hispano-Moresque pottery.

October 24–26. Dr. Pope, in New York, visited various dealers and museums and examined 80 Japanese prints and 35 miscellaneous Far Eastern objects.

1957

November 1–19.	Mr. Gettens, in Chicago, visited the Art Institute of Chicago; in Denver, Colo., visited the Chappelle House, the Schlier Gallery, and the Denver Art Museum; in Boulder, Colo., examined Mayan pottery sherds belonging to Miss Anna Shepard; in Salt Lake City, Utah, visited the Utah Musuem of Fine Arts; in San Francisco, saw the collection of Neil E. Compton; also visited the E. B. Crocker Art Gallery in Sacramento, Calif., Sutters Museum, Sutters Fort, Calif.; the Portland Art Museum, Portland, Oreg.; the Seattle Art Museum, Seattle, Wash.; and the Minneapolis Institute of Art, Minneapolis, Minn. Examined 106 objects in addition to general collections.
November 6–9.	Mr. Gettens and Dr. Cahill, as delegates, attended meetings of the UNESCO Conference in San Francisco.
November 7–12.	Dr. Cahill, in San Francisco, examined 30 Chinese and Japanese objects belonging to S. Tsuchiya, a dealer. In Kansas City, Mo., examined 50 Chinese paintings at the William Rockhill Nelson Gallery of Art; in Cleveland, Ohio, examined 25 Chinese and 5 Japanese paintings at the Cleveland Museum of Art.
November 17–20.	Dr. Ettinghausen, in Boston and Cambridge, Mass., examined 20 Arabic and Persian MSS. in the Houghton Library, 60 Persian and Indian miniatures in the Fogg Art Museum, and 1 Coptic woodcarving with bone inlay at the Museum of Fine Arts, Boston.
November 19.	Dr. Ettinghausen, in Boston, attended the annual meeting of the Trustees of "The American Research Center in Egypt" at the Boston Museum of Fine Arts.
November 20–24.	Dr. Cahill, in New York, examined 8 Far Eastern paintings at the Metropolitan Museum of Art; 30 Indian and Far Eastern paintings belonging to a private collector; and 119 paintings in the hands of five dealers; he also attended an exibition of modern Chinese paintings at the Mi Chou Gallery.
November 25–December 9.	Dr. Pope, in London, England, attended the Exhibition, "Arts of the Ming Dynasty," sponsored by the Arts Council of Great Britain and the Oriental Ceramic Society; also saw collections belonging to the following: Mrs. Alfred Clark, Percival David Foundation, the British Museum, J. M. Addis, Gerald Reitlinger, F. Brodie Lodge, G. Gompertz, R. F. A. Riesco, Sir Harry Garner, and R. H. R. Palmer.
December 11.	Dr. Ettinghausen left on a trip taking him to Lahore, Pakistan, to attend the International Islamic Colloquium.
December 16–17.	Mr. Wenley attended the meeting of the Freer Fund Committee at the University of Michigan, Ann Arbor, Mich.

1958	
January 2.	Miss Elisabeth West and Mr. Gettens, in Baltimore, examined 2 European oil paintings and 1 Etruscan bronze pitcher at the Walters Art Gallery; they then attended the exhibition of Near Eastern Bookbindings at the Baltimore Museum of Art.
February 5.	Mr. Stern attended the opening of the Korean Exhibition at the Metropolitan Museum of Art, New York.
February 6.	Mr. Gettens, in New York, called at Brookhaven National Laboratory, Upton, L.I. to discuss technical matters with members of their staff.
March 3–4.	Mr. Wenley and Dr. Pope, in Cleveland, Ohio, attended the official opening of the new wing of the Cleveland Museum of Art.
March 24–April 18.	Mr. Gettens visited the Brookhaven National Laboratory, Upton, L. I., where he acted as research collaborator in the department of chemistry with Dr. E. V. Sayre, working on spectrochemical analysis of specimens of glass from the Ray Winfield Smith Collection, as well as on specimens from early Chinese bronzes in the Freer Collection.
March 27–April 4.	Mr. Stern, in New York, attended the official opening of the Hauge Collection at China House and examined 22 objects of Far Eastern art at dealers.
March 31–April 4.	Mr. Wenley, in New York, attended meetings of the American Oriental Society, including meetings of the Executive Committee, where he presented the annual report of the Louise Wallace Hackney Scholarship Committee. Also attended meetings of the Association of Asian Studies. Examined 31 various Far Eastern objects belonging to five different dealers.
March 29–April 3.	Dr. Pope, in New York, attended meetings of the American Oriental Society.
April 17–18.	Mr. Wenley, in Ann Arbor, Mich., attended the opening of an exhibition of Mexican Art from Pre-Columbian to Modern Times.
April 28–30.	Mrs. Lnor O. West, in New York, attended meetings of Museum Store Managers at the Metropolitan Museum of Art and the Brooklyn Museum.
April 28–29.	Mr. Wenley, in Winterthur, Del., attended meetings of the Association of Art Museum Directors.
May 17.	Mr. Wenley and Dr. Pope, in Boston, attended the meeting of the Council of the Far Eastern Ceramic Group, and the general meeting of the society; Dr. Pope presided at both meetings. Later, they went to the home of Paul Bernat, where they examined approximately 90 Far Eastern objects.
June 16–21.	Dr. Ettinghausen, in New York, visited the Metropolitan Museum of Art, where he examined 8 Near Eastern carpet fragments; the American Numismatic Society, where he examined 40 Mesopotamian copper coins; and four dealers, where he examined 227 miscellaneous Near Eastern objects.

Members of the staff held honorary posts, received recognition, and undertook additional duties outside the Gallery as follows:

Mr. Wenley: Appointed member of the Visiting Committee, Dumbarton Oaks Research Library and Collection, Washington, D. C., for 1 year from July 1, 1957.

Research Professor of Oriental Art, Department of Fine Arts, University of Michigan, Ann Arbor, Mich., for 1 year from July 1, 1957.

President, Cosmos Club, Washington, D. C.

Served on Special Advisory Committee of the Cultural Development Committee to formulate plans for a Festival of the Arts and Music to be held in Washington, D.C., in 1959 or 1960.

Appointed Chairman of the Time of Year Selection Subcommittee.

Elected Trustee, Japan-American Society.

Dr. Pope: Member, Visiting Committee, Board of Overseers of Harvard College to the Department of Far Eastern Civilizations.

Member, Editorial Board, *Archives* of the Chinese Art Society of America.

President, Far Eastern Ceramic Group

Member, House Committee, Cosmos Club, Washington, D.C.

Member, Committee on Asia, American Council of Learned Societies.

Chairman of Committee to organize and supervise the Annual Birthday Reception and Dinner of Cosmos Club.

Appeared on television program out of Philadelphia, WCAU, on November 19, 1957, University Museum Show, "What in the World."

Dr. Ettinghausen: Member, Editorial Board, *The Art Bulletin*.

Trustee, American Research Center in Egypt.

Honorary member of the Board of Historical Research, Peshawar, Pakistan.

Member, Board of Governors, Washington Society of Archaeological Institute of America, Washington Branch.

Appointment extended, Research Professor of Islamic Art, Department of Fine Arts, University of Michigan.

"Exhibition of Iranian Photographs," at the Middle East Institute, Washington, D.C. Voice of America recorded an interview in Persian with Dr. Ettinghausen who made comments about the exhibition.

Gave a short address at Wildenstein Galleries, New York, at the opening of an exhibition of Hossein Behzad's illustrations to Omar Khayyam's Rubaiyat.

Mr. Gettens: Chairman, Art Committee, Cosmos Club, Washington, D. C.

Chairman, American Committee for International Institute for the Conservation of Museum Objects.

Ordinary Member, Council of the International Institute for the Conservation of Museum Objects, National Gallery, London, England.

Mr. Stern: As representative of the United States Government and American museums, cataloged selected objects of the Korean Government Exhibition, and acted as liaison in arranging for packing and shipping to the United States.

Represented the Freer Gallery of Art in the 60th Anniversary Celebration of the Kyoto National Museum, Kyoto, Japan.

Organized and supervised the installation of the Loan Exhibition from the collections of Mr. and Mrs. Osborne Hauge and Mr. Victor Hauge, at the China House, New York, April 1–30, 1958.

Read and commented on the doctoral dissertation of Won-Yong Kim, "Studies on Silla Pottery," for the Department of Fine Arts, New York University, New York.

Dr. Cahill: Gave a course of illustrated lectures on Chinese and Japanese art at American University, Washington, D.C., February–June, 1958. Attendance, 17 each lecture.

Mrs. Usilton: Critic of the schedules for 700's (Fine Arts) of the Dewey Decimal Classification, 16th edition.

Contributor to *IIC Abstracts*.

In 1957 the Freer Gallery for the first time took part in the Wellesley-Vassar Washington Summer Intern Program under which a group of specially qualified students get actual experience working as volunteers in various Government offices. Miss Ellen McCance, a fine-arts major from Vassar College, worked under the immediate supervision of the librarian of the Freer Gallery. During the 8-week period she helped on a variety of projects, thus gaining a well-rounded idea of the general functions of the organization and the different phases of Gallery activity, and at the same time making a useful contribution to the work of the Gallery.

Respectfully submitted.

A. G. Wenley, *Director*.

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the National Air Museum

Sir: I have the honor to submit the following report on the activities of the National Air Museum for the fiscal year ended June 30, 1958:

Of outstanding importance to the National Air Museum during the year was the progress made in the matter of a site for a new building. On June 26, 1958, the United States Senate passed S. 1985, a bill introduced by Senator Clinton P. Anderson, authorizing the preparation of plans for the construction of a suitable building for a National Air Museum to be located on the site bounded by Fourth and Seventh Streets, SW., Independence Avenue, and Jefferson Drive. At the close of the year the bill had gone to the House of Representatives and had been referred to the Committee on Public Works. The passage of this bill by the Senate marks a long step toward the realization of many years' efforts in the matter of adequate housing for the National Air Museum.

Many important accessions were received. Notable among these were the General William Mitchell statue and a Vanguard rocket. These are on exhibition in the Arts and Industries Building.

Progress was made in the improvement and preparation of storage and restoration facilities. These facilities take on increasing importance as the planning of the exhibit for the new building progresses.

A new and improved exhibit in the Aircraft Building is in the planning stage. In addition to providing a much-needed change in this old exhibition space, it will serve as useful experience in planning the aeronautical exhibits for the new building.

The Museum's information service continued as a growing and active function during the year. Technical, historical, and biographical information pertaining to the development of aviation was furnished by the staff for Government agencies, universities, research workers, authors, teachers, students, and the inquiring public. The reference files, photographic files, and library of the Museum continued to expand in volume and usefulness with the acquisition of additional data and materials from many sources.

Two Honorary Fellows of the National Air Museum, Capt. John J. Ide, USNR, and Frederick Crawford, were appointed during the year. A Director of the National Air Museum, Philip S. Hopkins, was appointed and assumed his duties in February 1958. An associate curator, Louis S. Casey, was also added to the staff.

ADVISORY BOARD

One meeting of the Advisory Board was held, on October 11, 1957. The Secretary introduced the new member of the Board, Rear Adm. R. E. Dixon, USN, who succeeded Rear Adm. James S. Russell, whose appointment terminated July 12, 1957. The other members, Dr. Leonard Carmichael, chairman; Maj. Gen. Reuben C. Hood, Jr., representing the Chief of Staff, Department of the Air Force; and the Presidentially appointed citizen members, Lt. Gen. James H. Doolittle, USAF (Ret.), and Grover Loening, continued their service on the Board.

At this meeting the Board recommended the appointment of the Director and Honorary Fellows above named, and also recommended the appointment of Paul E. Garber as head curator and historian of the National Air Museum.

The Board reaffirmed its approval of the Mall site for the National Air Museum Building.

SPECIAL EVENTS

Several notable presentation ceremonies took place during the year. The outstanding one was the unveiling and acceptance of the Gen. William Mitchell statue, sculptured by Bruce Moore, and the gift of the late George H. Stephenson. The statue was unveiled on December 17, 1957, by William Mitchell, Jr., in the presence of members of the Mitchell family, the Stephenson family, and some 200 distinguished guests.

Other special ceremonies during the year included the presentation of a "Falcon" guided missile by the Honorable Barry Goldwater, United States Senator from Arizona, on behalf of the Hughes Aircraft Co., on April 15, 1958; an Air Mail Medal of Honor, presented by Deputy Postmaster General Edson G. Sessions on May 14, 1958; and a "Vanguard" rocket and satellite, presented by Rear Adm. Rawson Bennett of the United States Navy, on May 26, 1958.

At these presentation ceremonies, Dr. Carmichael accepted the gifts for the Musuem with appropriate remarks.

The National Air Museum was well represented on numerous occasions throughout the year by the head curator and historian, Paul E. Garber. Mr. Garber's activities included the following:

The Early Birds, an organization of those who flew solo during the first 13 years of powered heavier-than-air flight (prior to December 17, 1916) held their annual reunion in Washington July 27–29, 1957. They enjoyed a tour of the aeronautical exhibits conducted by Mr. Garber, who is secretary of this organization. Their interest was increased not only because of their personal association with the

beginnings of aviation but also because this Museum has been designated by them as depository for their archives and historic specimens.

The Institute of Aeronautical Sciences held a joint meeting with the Navy at San Diego, August 1 to 16, where, at the Institute Building, a display of aircraft, scale models, photographs, and paintings illustrated the growth of naval aviation from its origin in 1911 to the present. In the opinion of many persons who attended, this was the most complete historical display of this type ever assembled. The organizers acknowledged the important assistance extended by this Museum which provided most of the scale models. During this meeting Mr. Garber lectured on "Glenn Curtiss, Founder of Naval Aviation," illustrating his talk with slides, a number of which were rare views of the aircraft developed by this famous air pioneer.

On May 13, the District of Columbia Chapter of the Institute of Aeronautical Sciences heard a lecture by the head curator on "The History of Aeronautics." This was a condensation of a four-part series delivered by him at monthly meetings of the Institute chapter formed of students in aeronautical engineering at the Catholic University in Washington.

The association of Air Mail Pioneers, composed of those who operated the governmental postal aviation system from its beginning in 1918 until 1927 when the routes were converted into commercial airlines, held the annual meeting of the Eastern Division in Washington, October 10–11. The Museum cooperated with preparation of a special display of airmail relics, scale models and photographs of airmail planes, and related material. A conducted tour of the collections and a talk on Max Miller, the first postal aviator in the departmental service, were given by Mr. Garber, who was recently president of the District of Columbia chapter of this organization. On May 15, 1958, this chapter headed the celebration of the fortieth anniversary of the first continuously scheduled public service airmail route. The head curator assisted with arrangements for a flight over the original Washington-to-New York route in an airplane of 1918 piloted by Leon Smith, one of the original group of airmail pilots; and with the preparation of a bronze plaque which was unveiled on the anniversary date to mark the field from which the inaugural flight had started. Another feature of this airmail anniversary was a ceremony at the National Aviation Club when an example of the Air Mail Flyers' Medal of Honor was added to the Museum collections. Authorized by act of Congress in 1931, it has been awarded only 10 times, "for distinguished service as an airmail pilot."

Cooperating with the Armed Forces, Mr. Garber lectured on the history of aeronautics to the Non-Commissioned Officers' School at the Air Force Base in Orlando, Fla., and gave talks on various phases

of aviation to the Air Force Flying Club at Andrews Air Force Base in Maryland, the Army Flying Club at Fort Myer, Va., and to several units of reserve officers and the Civil Air Patrol. At the request of the Navy Department, the talk on Glenn Curtiss was repeated before the combined Naval Reserve companies of the Washington area. Conducted tours of the aeronautical exhibits were provided for a group of naval enlisted men selected for their proficiency in aviation, and for units of the Reserve Officers Training Corps. A talk on Brig. Gen. William Mitchell and a description of his statue in the Museum was given at the Air Force Historical Association meeting at Bolling Air Force Base, September 6. A similar talk was made on January 8 at a meeting of the Phi Kappa Psi fraternity, of which the General had been a member. On February 19 the Washington chapter represented the fraternity in laying a wreath at the base of that statue, and on April 25 the American Legion paid similar tribute.

The head curator served as chief judge at the National Model Airplane Contest held in Cleveland, March 27, where he spoke on the recent progress by the Museum in acquiring significant material; and during the same month he was judge at a model contest conducted by the Washington Junior Chamber of Commerce.

Tours of the aeronautical collections were conducted for groups of young aviation enthusiasts at the request of Congressmen Peter Mack of Illinois, and Robert W. Kean of New Jersey. In all, Mr. Garber gave during the year 24 lectures, conducted 6 tours, and made 7 trips in connection with these educational services and for inspection of material offered to the Museum.

IMPROVEMENTS IN EXHIBITS

Some improvements were made during the year in the exhibits in the Aircraft Building and the Arts and Industries Building. With the unveiling of the William Mitchell statue, this became a permanent part of the exhibit in the Aeronautical Hall of the Arts and Industries Building. With the statue is a case containing Mitchell memorabilia, and directly adjacent is the restored and reconditioned SPAD–XVI, General Mitchell's airplane. Twenty dioramas lent by the U.S. Air Force, depicting the development of military aeronautics from the Civil War to the present time, were installed in this hall and provide a colorful and instructive exhibit. A revolving globe, with flight path and model airplanes illustrating the first "Around the World Flight," was added to the Collier Trophy case. The "Falcon" guided missile exhibit was added to the Aircraft Building.

Improvements were made to several exhibition cases by adding overhead lighting and powered displays. These improvements involved the Pulitzer, Lowe, Mitchell, and Collier cases.

Minor repairs were made to a number of aircraft and models on exhibition.

REPAIR, PRESERVATION, AND RESTORATION

It has been a year of activity at the Suitland storage facility in respect to improving equipment and facilities and in preservation, restoration, and warehousing. The proper warehousing of stored aircraft, engines, and parts was completed. Five aircraft were cleaned, preserved, and restored, awaiting exhibition. Twenty engines were cleaned, preserved, and stored. Four aircraft were preserved for outdoor storage.

Water and electrical connections were installed for Building 10, and a concrete ramp was placed in front of the building. The heating of Bay C of this building was improved and the insulation of Bays A and B was begun. Other improvements in progress include roof repairs, the installation of a paint booth and equipment, a wash pit for aircraft and engines, and an engine hoist. The storage of miscellaneous reference material in Building 2 was improved by boxing and warehousing.

Considerable long-range planning was done in preparation for the major job of restoration and preparation of aircraft for exhibition in the proposed new building.

ASSISTANCE TO GOVERNMENT DEPARTMENTS

The National Air Museum had occasion to serve many Government agencies during the year. Among these were the Department of Justice in connection with patent litigation; the Department of Health, Education, and Welfare with relation to rocket information; the Voice of America in connection with material for its programs; the Department of State with reference to early aviation history information; the Department of the Air Force; the Department of the Navy; the Department of Agriculture; the Civil Aeronautics Administration of the Department of Commerce; and the Post Office Department.

PUBLIC INFORMATION SERVICES

As previously indicated, furnishing information to the public is a very active function of the Museum and requires an increasing amount of staff time. The requests for information vary from "pictures of airplanes" for school children to highly technical information required by scientists and research workers. The requests come by telephone, mail, and personal visitation. The following examples will illustrate the diverse nature of this information service:

The Chance Vought Aircraft Co. and the Douglas Aircraft Co. were furnished photographs for their publications.

The Museum has rendered assistance, by way of photographs, technical and historical information to such publishers as Brown Brothers, H. S. Stuttman, Charles Scribner's Sons, Baltimore Sunday Star, Washington Evening Star, Flying Magazine, Toledo Blade, Our Navy Magazine, The Airman, Air Force Magazine, and Model Airplane News.

Many authors of books and articles on aviation were provided with help through our information services. Among these were Maj. Kimbrough Brown, Douglas Ingles, Henry R. Palmer, Jr., W. D. Johnston, Frank O'Hasson, George Lonog, John W. Underwood, Harold Morehouse, Roy Wagner, Lawrence H. Conover, and C. R. Faust.

The Wilbur Wright Junior High School of Milwaukee, Wis., received aid in selecting photographs for display and in planning a memorial exhibit. Assistance was rendered American University in connection with its First Annual Aviation Education Institute.

The Museum also aided the U.S. Information Service with material for exhibition in Athens, Greece, and Paris, France. The Comité de Wilbur Wright of Le Mans, France, was provided with appropriate photographs for display at their commemoration celebration of the first flights of Wilbur Wright in France.

Many individual teachers and students were furnished information in connection with their school aviation programs.

REFERENCE MATERIAL AND ACKNOWLEDGMENTS

Valuable additions to the reference files, photographic files, and library of the Museum were received during the year. These records and documents are most valuable to the Museum staff in preparing labels, providing information services, and authenticating data.

The cooperation of the following persons and organizations is sincerely appreciated:

AIRCRAFT INDUSTRIES ASSOCIATION, Washington, D.C. (through Joseph Geuting, Jr.): The Aircraft Yearbook for 1957–58.

AIR FORCE, DEPARTMENT OF THE, 1365th PHOTOGRAPHIC GROUP, M.A.T.S., Orlando, Fla.: A motion-picture film and tape recording of the ceremony when the statue of Brig. Gen. William Mitchell was unveiled, Dec. 17, 1957.

ALDRIN, COL. E. E., New York, N.Y.: Photostatic copies of two letters received by him from Dr. Robert H. Goddard, pertaining to rocket experiments in 1920–21.

ALLWARD, MAURICE, Middlesex, England: A copy of his recent book, "Milestones in Science."

BARLOW, FLOYD E., Shoreham, Vt.: Scrapbook containing photographs and clippings of his early career in aviation (loan). A folder illustrating airplanes at the Dominguez Field aviation meet in California, 1910.

BRISCOE, MISS YOLANDO, Brooklyn, N.Y.: A contemporary poster pertaining to the "Spirit of St. Louis."

Bumphrey, Cecil, Kent, Ohio: A photograph of Charles Lindbergh taken at St. Louis during his transcontinental flight in 1927.

Caler, John W., North Hollywood, Calif.: Copy of his recent book, "Experimental Light Aircraft and Midget Racers."

Campbell, Mrs. Marjorie, Washington, D.C.: Copy of the book which she coauthored with Glenn O. Blough, "Making and Using Classroom Science Materials in the Elementary School"

Carl Byoir & Associates, Washington, D.C. (through H. G. Leader): Two reels of motion pictures illustrating the presentation ceremony when the Hughes "Falcon" missile was given to the Museum, Apr. 15, 1958.

Casey, Louis S., Washington, D.C.: A collection of books on aeronautics.

Cato, Joseph L., Turlock, Calif.: Photographs and drawings of aircraft produced by the L. W. F. Company of College Point, L.I., N.Y., 1917–22, where he was a designer.

Civil Aeronautics Administration, Washington, D.C.: A collection of books on aeronautics.

Claudy, Carl H. (deceased), Washington, D.C.; 2 boxes of original glass negatives of the photographs taken by him at Fort Myer, Va., during flights there by Orville Wright in 1908 and 1909; framed photographs; and negatives of photographs taken at Arlington, Va., showing experiments with kites by Alexander Graham Bell.

Clemons, Mrs. Anna B., Elmira, N.Y.: A collection of photographs illustrating aircraft developed by Glenn H. Curtiss.

Cram, Miss Eloise (deceased), Bethesda, Md., and Mrs. Margaret Cram Siemen, Hemet, Calif. (daughters of the late Ralph Cram): Illustrations, clippings, and texts collected by Mr. Cram during his extensive career as an aviation enthusiast and journalist, including many of his own writings.

Crawford, James J., Strasburg, Va.: A copy of the book "Up," by Mrs. George Gray, 1931, describing flights by her husband and herself during the period 1912–16 and later flights by her husband and other famous flyers.

Deckard, Richard, Washington, D.C.: A copy of the booklet describing the Waco-F airplane, and data pertaining to the German V–1, De Havilland "Moth," and other aircraft.

Dolan, Col. Carl, USAF (Ret.), Greenwich, Conn.: A photograph of the original members of the Lafayette Escadrille, famous group of American flyers in World War I, with whom he served.

Hackett, Warren B., Mount Hermon, Calif.: Copy of the book "The Balloon Section of the American Expeditionary Forces," 1919.

Harmel, Falk, Washington, D.C.: A collection of photographs of members of the "Caterpillar Club," composed of those whose lives have been saved by parachutes; texts pertaining to them and to A. L. Welsh, pioneer pilot of Wright Brothers' airplanes, who was killed in an airplane crash at College Park, Md., 1912.

Hiller Helicopters, Inc. (representative), Washington, D.C.: A 16-mm. motion-picture film showing types of helicopters.

Holloway, William S., Honolulu, T.H.: Copy of the book "Aviation in Hawaii," by W. P. Yates.

Hubbell, Charles H., Cleveland, Ohio: A contemporary 3-view dimensioned scale drawing of the De Havilland–4 airplane, 1918.

Hutchinson, J. D., Denver, Colo.: A collection of magazines, photographs, and material pertaining to aircraft and flight operations of the 1920's and 1930's collected during the donor's service as a military and commercial pilot.

LEES, MRS. WALTER L., Turlock, Calif.: Scrapbooks containing photographs and clippings pertaining to the career of her late husband as a pilot from 1912 until his recent death; including references to his flight instruction of Gen. William Mitchell in 1917 and his establishing, with F. A. Brossy, of an 84½-hour nonrefueled duration record in 1931 (loan).

LONGO, ROBERT R., Wichita, Kans.: Copies of "The Ford Story," by William T. Larkins, and "Operation Grasshopper," by Dario Politella.

MODEL AERONAUTICAL PRESS, LTD., Watford, England: 23 copies of "Aero Modeller" magazine.

NAVY, DEPARTMENT OF THE, Washington, D.C.: 3-view dimensioned scale drawings of aircraft: Curtiss F8C-1 and F9C, the Wright "Apache," and the PN-9.

POE, MRS. MORGAN, Washington, D.C.: 4 photographs of the Wright family: Bishop Milton Wright and Wilber, Orville, and Katherine Wright as children.

RANSOM, ARTHUR K., Freehold, N.J.: Copy of "The Curtiss Standard JN4-D Military Tractor Handbook."

ROWE, GEOFFREY, Ontario, Canada: Posters prepared in World War II illustrating aircraft of that period, and used for training personnel to recognize friend from foe.

SEMPLE, MRS. CECELLA, Shirley, L.I., N.Y.: 12 contemporary photographs of the Wright EX airplane "Vin Fiz" in which Calbraith Perry Rodgers made the first transcontinental flight, 1911.

SHORT, V. R., Clinton, Conn.: A collection of photographs of helicopters illustrating progress in design during the past 50 years.

SMITHSONIAN INSTITUTION, Washington, D.C. (River Basin Surveys, Missouri Basin Project, through Robert L. Stephenson): A collection of aeronautical photographs, taken by Nathaniel L. Dewell, pertaining principally to the airmail service operated by the U.S. Post Office Department during the 1920's.

SULLIVAN, R. O. D., JR., Washington, D.C.: A collection of photographs illustrating the aircraft and operations of the Aeromarine and Pan American airlines during the 1920's, when the donor's father was one of the pilots with those organizations.

THORSEN, ARTHUR, Encino, Calif.: A copy of the booklet "The Story of Art Smith," a pioneer pilot who in 1911 taught himself to fly in a homemade airplane, and continued in aviation until his death in 1926 while flying the mail.

UNDERWOOD & UNDERWOOD, New York, N.Y.: Photographs of Amelia Earhart (loan).

UNION TITLE INSURANCE CO., San Diego, Calif.: A collection of photographs, pertaining mainly to aviation activities in the San Diego area, particularly those of Glenn Curtiss and his associates, and Charles Lindbergh and the Ryan Co., for the period 1911–32.

UNITED AIRCRAFT CORP., East Hartford, Conn. (through Charles Stewart and Harvey Lippincott): Texts pertaining to aeronautical history and development, including several describing Pratt and Whitney engines.

VERVILLE, ALFRED, Washington, D.C.: A scrapbook of photographs associated with the lender's career as an aircraft designer from 1913 to the middle 1930's, including many pertaining to Glenn Curtiss (loan).

VILLARD, HENRY, Washington, D.C.: Scrapbooks and contemporary pamphlets pertaining to airships, airplanes, and air meets from the early 1900's to the latter 1920's, most of the material related to the lender's personal association with air history.

WHEELER, MRS. HUBBARD, Washington, D.C.: Three photographs of the "Spirit of St. Louis" made during Lindbergh's landing at the Virgin Islands, January 31, 1928.

WILLIAMS, MAJ. ALFORD (deceased), Elizabeth City, N.C.: A 3-view dimensioned scale drawing of the Grumman "Gulfhawk-II" airplane, which he flew during the period 1936–48 and presented to the Museum.

YOUNGER, DR. JOHN E., University Park, Md.: Texts pertaining to pressurization of airplane cabins, particularly of the Lockheed XC–35, which was the subject for the Robert J. Collier Trophy award for 1937. The donor was acclaimed for his important developments in this field.

ACCESSIONS

Additions to the National Aeronautical collections received and recorded during the fiscal year 1958 total 193 specimens in 52 separate accessions from 46 sources.

Those from Government departments are entered as transfers; others were received as gifts except as noted.

AEROPRODUCTS OPERATIONS, ALLISON DIVISION, GENERAL MOTORS CORP., Dayton, Ohio: An airplane propeller, 6-bladed, dual rotating, as used on the Allison T–40 turboprop-engined "Tradewind" Convair flying boat, and "Skyshark" Douglas Navy fighter of 1955. (N.A.M. 966.)

AIR FORCE, DEPARTMENT OF THE, AIR FORCE MUSEUM, Wright-Patterson Air Base, Ohio: A series of 18 dioramas, illustrating the history of the U.S. Air Force and associated units from 1907 to 1957 (loan). (N.A.M. 957.) PERSONNEL AND TRAINING RESEARCH CENTER, AIR RESEARCH AND DEVELOPMENT COMMAND, Randolph Air Force Base, Tex.: A complete "line" of equipment used by the U.S. Army Air Forces during World War II for the psychological testing of flight personnel to determine mental reaction, muscular control, coordination, and other factors associated with the operation of aircraft. (N.A.M. 980.)

ALL-WOMAN TRANSCONTINENTAL AIR RACE, INC., MRS. KAY BRICK, VICE CHAIRMAN, NORWOOD, N.J.: Four display panels, with photographs of the winners of this annual race, popularly known as "The Powder Puff Derby," for the years 1947–1957. (N.A.M. 995.)

BARGER, CADET MAJ. ROBERT M., C.A.P., Peoria, Ill.: The Performance Data plate from the Douglas C–124 Globemaster which was the first U.S. Air Force plane to fly over the South Pole. The donor was aboard on this airdrop mission, October 26, 1956. (N.A.M. 960.)

BEECH, MRS. OLIVE ANN, Wichita, Kans.: A sculptured portrait in bronze of the late Walter Beech, 1891–1950, cofounder of Beech Aircraft Corp., made from life, by Bruce Moore; and a bronze medal, sculptured by Carl Paul Jennewein, commemorating the twenty-fifth anniversary of the Beech Aircraft Corp. (N.A.M. 956.)

BEECH AIRCRAFT CORP., Wichita, Kans.: A scale model, 1:16 size, of the Beechcraft-17, stagger-wing 5-place cabin biplane of 1932. (N.A.M. 974.)

BELL AIRCRAFT CORP., Buffalo, N. Y.: A scale model, 1:16 size, of the Bell X–1 first supersonic airplane, 1947, illustrating the award for 1947 of the Robert J. Collier Trophy. (N.A.M. 952.) A scale model, 1:32 size, of the Bell "Rascal" G.A.M.–63, an air-to-surface guided missile in current use by the U.S. Air Force. (N.A.M. 975.)

BOGGESS, R., Alexandria, Va.: Breeches and puttees of the donor's U.S. Army officer's type uniform worn during World War I, and a 37-mm. cartridge used with a German aircraft gun of that war. (N.A.M. 981.)

Statue of Gen. William Mitchell, unveiled December 17, 1957.

Bucks County Scientific Society, Morrisville, Pa. (through E. L. Robinson, Pres.): A Bristol "Hercules" 14-cylinder, sleeve-valve, 2-row radial, air-cooled aircraft engine, of 1,600 hp., made about 1941 by the Bristol Aeroplane Co. of England. (N.A.M. 949.)

Cessna Aircraft Co., Wichita, Kans.: Four scale models, 1:36 size, of aircraft made by the donor: The "Airmaster" 4-place high-wing single-engine monoplane of 1938; the "310" 5-place low-wing twin-engined monoplane of 1954; the YH–41 2-place helicopter of 1954; and the "172" 4-place high-wing single-engined monoplane of 1955. (N.A.M. 996.)

Cleveland, Ohio, Division of Airports (through Claude King, Commissioner of Airports): An airport light, of the large ground-flooding type, used at Cleveland Airport in the early 1920's when that city became a stop on the first transcontinental air mail and passenger route. (N.A.M. 961.)

Cline, Capt. Joseph, Coronado, Calif.: A U.S. naval aviator's uniform coat, worn by the donor in World War I. He was a member of the U.S. Navy First Aeronautic Detachment, which was the first American offensive unit to arrive in France, landing there June 7, 1917, and flying the first American patrol, from Le Croisic, November 13, 1917. (N.A.M. 979.)

Convair, A Division of General Dynamics Corp., San Diego, Calif.: A scale model, 1: 16 size, of the F–102A "Delta Dagger" supersonic jet-powered interceptor, in current use by the U.S. Air Force. (N.A.M. 948.) Five scale models, 1:16 and 1:48 size, of aircraft prominent in Convair history: The Consolidated PT–1 "Trusty," standard Army Air Corps trainer of 1924; the Vultee SNV "Valiant" Navy and Army Air Force basic trainer of 1939; the Consolidated PBY–5 "Catalina" Navy patrol plane of World War II; the Consolidated B–24 "Liberator" Army Air Force bomber of World War II; and the Convair B–58 "Hustler" supersonic 4-jet delta-winged bomber which is one of the most recent additions to the U.S. Air Force. (N.A.M. 983.)

Curtiss-Wright Corp., Wood-Ridge, N.J.: A scale model, 1:16 size, of the Curtiss "Triad" of 1911, one of the earliest water-borne aircraft. This model was made with precise detail by Frederick Howard of Denver, Colo. The Department of the Navy, through Alfred Verville and A. O. Van Wyen, assisted with research and helpful contacts. It is presented to the Museum in tribute to Glenn H. Curtiss as founder of one of the units from which the donor corporation was formed. (N.A.M. 993.)

Douglas Aircraft Co., Inc., Santa Monica, Calif.: A world globe, on which is marked the route of the first flight around the world and to which are attached scale models of the Douglas U.S. Army Air Service airplanes which accomplished that flight in 1924. This exhibit illustrates the award for that year of the Robert J. Collier Trophy. (N.A.M. 954.) A scale model, 1: 72 size, of the Douglas DC–8 Jetliner, 590-mile-per-hour transport, which is scheduled to enter service on commercial airlines in 1959, and scale models of four Douglas-made guided missiles: the Nike-Ajax, 20-foot-long surface-to-air weapon for defense against enemy aircraft; the Nike-Hercules which is heavier and more than twice the diameter of the Ajax, and equipped to carry a nuclear warhead for similar defense; the Sparrow which was developed by the Navy and Sperry Gyroscope Co., and made by Douglas under license for use in air-to-air combat; and the Honest John designed for Army tactical use to provide close fire support for ground operations, surface-to-surface. (N.A.M. 997.)

Ecker, Herman A., Fort Lauderdale, Fla.: Two aircraft engines, a Roberts 6-cylinder vertical in-line 2-cycle water-cooled engine, developing 75 hp. at 1100 r. p. m.; used by the donor in his flying boat of 1912; and a Velie

M-5 5-cylinder radial air-cooled engine of 55 hp., produced in 1928 for light airplanes. (N.A.M. 955.)

EVANS, RICHARD, Lathrop, Mo.: Aviation goggles without lenses, reported to have belonged to Miss Amelia Earhart, 1929. (N.A.M. 967.)

FLEMING, MRS. MARGARET EDDY, La Jolla, Calif.: A collection of kites and related material used by William A. Eddy of Bayonne, N.J., who was outstanding in the design, construction and use of kites for aerial photography, meteorological research, military signaling and other practical purposes during the latter period of the nineteenth century. He was assisted in his experiments by a grant from the Hodgkins Fund of the Smithsonian Institution. (N.A.M. 982.)

GATTY, MRS. HAROLD, Suva, Fiji: A collection of notebooks, papers, and other records used and acquired by Harold Gatty during his flight around the world with Wiley Post in the Lockheed Vega airplane "Winnie Mae," June 23–July 1, 1931, when Mr. Gatty was navigator. (N.A.M. 973.)

GODDARD, MRS. ESTHER, Worcester, Mass.: A portrait of the late Dr. Robert H. Goddard, 1882–1945, "Father of Rocketry," painted in oils by Mrs. Emily Burling Waite Manchester. (N.A.M. 970.)

HAMILTON, EDWARD G., Old Westbury, L.I., N.Y.: The donor's original Flight Log for the years 1922–1926, including the period in 1924 when he was test flying Stout Air Pullman planes, in 1925 when he was pilot for the inaugural run of the Ford Airlines, and in 1926 when he flew the first contract airmail between Detroit, Cleveland, and Chicago. (N.A.M. 958.)

HERRICK, SCOTT H., AND CORNELL, MRS. SUZANNE HERRICK, New York, N.Y.: The Herrick "Vertoplane" of 1937, and devices associated with the aeronautical experiments of the late Girard P. Herrick. This aircraft is an early example of the types generally classed as convertoplanes which combine the flight performance of airplanes with the vertical-lift, sustentation, and descent characteristics of rotorcraft. In July 1937 this piloted aircraft accomplished what is believed to be the first midair conversion from fixed-wing to rotary-wing flight. The associated devices received with this aircraft include wind-tunnel models, control mechanisms, test models of rotors, and instruments. The donors are the children of Mr. Herrick. The assistance of Mrs. G. P. Herrick, Ralph McLarren, and John Glennon in obtaining this material is gratefully acknowledged. (N.A.M. 994.)

HUGHES AIRCRAFT CO., Culver City, Calif.: A "Falcon" GAR-1 guided missile, mounted on a display panel having transparency illustrations of air-combat methods, and a sound recording describing this missile, which is in current use by U. S. Air Force interceptor planes, for air-to-air combat. The formal presentation of this display was by Senator Barry Goldwater of Arizona, the Missile Manufacturing Division of the donor being in that State. (N.A.M. 984.)

KALLIR, OTTO, New York, N.Y.: Six glider models made by Robert Kronfeld, famous Austrian designer and pilot of high-performance sailplanes. He was first to make a continuous glide for 100 kilometers, first to soar across the Alps, and made notable intercity glides. These beautifully made models, given to the donor who was a close friend, include the "Wien," in which Kronfeld established world records for motorless flight of 93.15 miles distance and 7.084 feet altitude in 1929. He was killed while test piloting an English military airplane, 1948. (N.A.M. 989.)

LEAR, INC., Grand Rapids, Mich.: The Lear F-5 Electropilot equipment, developed by the donors to provide automatic flight control for high-performance aircraft. Subject of the Robert J. Collier Trophy Award for 1949. (N.A.M. 950.)

LOCKHEED AIRCRAFT CORP., Burbank, Calif. (through Washington, D.C., representative): Scale models, 1:48 size, of a Lockheed Q-5 drone, which is an unmanned radio-guided aircraft in current use by the U.S. Air Force as a supersonic missile target; and a Lockheed X-7 research vehicle used as a flying test bed for ramjet engines. (N.A.M. 978.)

MARTIN CO., THE, Baltimore, Md.: Two scale models of Martin pilotless aircraft in current use: The Air Force "Matador" TM-61B guided missile, and the Navy "Vanguard" earth satellite vehicle. (N.A.M. 977.)

MCCAULEY, ERNEST G., Fort Lauderdale, Fla.: Two 2-bladed metal propellers for airplanes; production examples invented by the donor. One is of solid steel and adjustable pitch with an airfoil of thin section to reduce weight and of concave-convex shape to improve rigidity. Following a test by the Army Air Corps in 1933 when this make of propeller improved the takeoff, climb, and speed of a training plane, it was adopted by both the Army and Navy, for use with trainers, and continued in use for 10 years. The other propeller received, with the trade name MET-L-PROP, was developed in 1947 for use with light airplanes. It is of aluminum alloy, fixed pitch, forged in one piece including the hub section. (N.A.M. 990.)

NAFE, DR. JOHN ELLIOTT, Columbia University, Palisades, N. Y.: The cap and gown worn by the late Robert Hutchings Goddard, "Father of Rocketry," when receiving his doctorate of physics at Clark University, 1912 (loan). (N.A.M. 998.)

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS, Langley Field, Va.: A Nike-Cajun sounding rocket, the N.A.C.A. jet-supported platform which utilizes a teetering rotor, the N.A.C.A. jet-supported platform which utilizes a jet of compressed air, and an N.A.C.A. wing flow balance. (N.A.M. 963.)

NAVY, DEPARTMENT OF THE, Washington, D.C.: An enlarged photograph of a De Havilland-4B airplane, one of the U.S. Air Force Service types flown by Brig. Gen. William Mitchell in 1921. Enlargement made from an Air Force negative for exhibition with General Mitchell's statue. (N.A.M. 968). A full-size exterior duplicate of the "Vanguard" rocket-powered satellite vehicle which on March 17, 1958, carried America's second satellite into orbit around the earth. This achievement by the U.S. Navy, with the vehicle manufactured by The Martin Company, followed about six weeks after the U.S. Army's "Jupiter" had carried America's first satellite, the "Explorer," into orbit, and over 5 months after Russia had made the initial success. This "Vanguard" was formally received for the National Air Museum by Dr. Leonard Carmichael, Secretary of the Smithsonian Institution, from Rear Adm. Rawson Bennett, Chief of Naval Research. The ceremony was held in the rotunda of the Arts and Industries Building of the U.S. National Museum where the top of the "Vanguard," exhibited in launching position, reaches 72 feet in height. Near the floor beside the vehicle is shown a reproduction of the 6-inch-diameter, 3¼-pound satellite which has been continuously circling the earth since launched, and will probably continue to orbit for years to come. (N.A.M. 992.)

NEVIN, ROBERT S., Denver, Colo.: A 1:16-size scale model of the Wright Company type "H" airplane of 1915; a 2-place, twin-pusher biplane, developed as a weight carrier with a useful load of 1,000 pounds and speed of 56 mph. Model constructed by Mr. Nevin (purchase). (N.A.M. 947.)

NEWBURGH FREE ACADEMY, Newburgh, N.Y.: A LeRhone rotary engine, air cooled; a type used in World War I. Its nine cylinders radiate from the central crankcase and revolve like the spokes of a wheel. (N.A.M. 987.)

PARKER, WILLIAM D., Bartlesville, Okla.: An aircraft altimeter, of the Paulin type, with level-flight indicator; used about 1930. (N.A.M. 953.)

PEASE, WARD, Winnetka, Ill.: A model airplane of the flying-stick, twin-pusher rubberband-powered canard-monoplane type, made and flown by the donor in 1916. A sport competition of the Illinois Model Aero Club was won by this model on May 24, 1916, when its longest flight was 4.423 feet. (N.A.M. 972.)

PFEIFFER, REV. ROBERT F., Richmond, Ind.: A communion service made from aircraft parts by American "GI's" stationed at the First Strategic Air Depot, Honington, England, in 1943. All material used had been in combat. The set consists of 200 cups of .50-caliber machinegun shells and silver plated; bread plates made from the tops of B–17 pistons; a cross formed from parts of a damaged B–17; and candlesticks made from antiaircraft shells. The donor was the Chaplain at that Depot. (N.A.M. 988.)

POST OFFICE DEPARTMENT, Washington, D.C.: The Air Mail Flyers' Medal of Honor, authorized by Congress February 14, 1931, for presentation by the President of the United States to pilots who perform distinguished service in connection with airmail operations. Ten pilots have received it. The placing of this medal in the National Aeronautical collections was one of the ceremonies of the fortieth anniversary of the first continuously scheduled public service airmail route, established May 15, 1918, between Washington, Philadelphia, and New York. At the anniversary ceremony, Dr. Leonard Carmichael, Secretary of the Smithsonian Institution, received the medal for the Museum from Deputy Postmaster General Edson G. Sessions. (N.A.M. 991.)

RICKENBACKER, CAPT. EDWARD V., Eastern Air Lines, New York, N.Y.: A Verville-Sperry "Messenger" airplane of 1920, designed by Alfred Verville, and manufactured by the Lawrence Sperry Aircraft Co. by order of Brig. Gen. William Mitchell who realized that a "motorcycle of the air" was required for military liaison services; and a Pitcairn "Mailwing" of 1928, developed by Pitcairn Aviation, Inc., for their use in operating Contract Air Mail Route No. 19 between New York and Atlanta, later absorbed by Eastern Air Lines. "Mailwings" were used also on other airmail routes of the 1920's and early 1930's. This example was Eastern Air Lines' first airplane, and was obtained in later years by a group of his employees who presented it to Capt. Rickenbacker as a mark of esteem. (N.A.M. 959.)

SMITHSONIAN INSTITUTION, Washington, D. C. (from Department of Arts and Manufactures, U.S.N.M.): A transparent conical nose section as made for a Lockheed "Hudson" bomber of 1941, illustrating the use of the acrylic resin "Plexiglas," manufactured by Rohm & Haas Co. of Philadelphia. (N.A.M. 986.) (From the library): A scale model, 1:12 size, of an aircraft-control device originated by James Means of Boston about 1910. (N.A.M. 951.)

STEPHENSON, GEORGE H. (deceased), Philadelphia, Pa.: A bronze statue of Brig. Gen. William Mitchell standing in his World War I uniform; sculptured 1⅙ times natural size by Bruce Moore. (N.A.M. 969.)

TOPPING, INC., Akron, Ohio (through William Topping, president): Three scale models of guided missiles in current use by U.S. Armed Forces: a Boeing "Bomarc" IM–99 Air Force ground-to-air pilotless interceptor; a Martin Lacrosse Army surface-to-surface demolition weapon; and a Martin "Bull Pup" Navy air-to-surface weapon, launched by attack planes against major ship and ground targets. (N.A.M. 976.)

UNITED AIRCRAFT CORP., PRATT & WHITNEY AIRCRAFT DIVISION, East Hartford, Conn.: A Pratt & Whitney R–2800 Double Wasp aircraft engine, type CB–16, No. X–88, of 18 cylinders, 2-row radial, air cooled, rated 2,400 hp. at takeoff. (N.A.M. 971.)

WALDEN, DR. HENRY W., New York, N.Y.: Scale models, 1:16 size, of the Walden-III and the Walden-IX, early American monoplanes, designed, built, and flown 1909–11 by the donor, who also made these models; and a scale model, 1:8 size, of a guided missile, radio-controlled air-to-ground free-drop bomb invented by him in 1915. (N.A.M. 965.)

WEEKS, E. D., Des Moines, Iowa: Parts of a Wright Type "G" flying boat, originally constructed by the Wright Co. of Dayton, Ohio, 1914. Flown and later modified by Ernest Hall. The parts include struts, wires, braces, and the seat. (N.A.M. 964.)

WHITE, GEN. THOMAS D., Chief of Staff, U.S. Air Force, Washington, D.C.: A framed letter from General White to Dr. Leonard Carmichael, Secretary of the Smithsonian Institution, in reference to the use of the "Falcon" guided missile as "the first operational air-to-air guided missile . . . an effective deterrent to enemy air attack." (N.A.M. 985.)

YOUNGER, DR. JOHN E., University Park, Md.: The "Spirit of St. Louis" gold medal, awarded to Professor Younger by the American Society of Mechanical Engineers, June 18, 1941, "for meritorious service in the advancement of aeronautics . . . particularly in the conception, analysis, and supervision of the development of the fundamental design principles, requirements and criteria which first assured the success of the pressure-cabin type of high-altitude airplane." (N.A.M. 962.)

Respectfully submitted.

PHILIP S. HOPKINS, *Director*.

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the National Zoological Park

Sir: I have the honor to submit the following report on the activities of the National Zoological Park for the fiscal year ended June 30, 1958.

EXHIBITS

A complete animal exhibit is one in which the animals are kept in secure surroundings that satisfy the requirements of the animal, is esthetically pleasing to the public, and contributes to an increased knowledge of the animals and their behavior. This is the goal of the National Zoological Park.

During the year the collection has been balanced and adjusted. Progress is being made toward exhibiting more North American fauna, while not neglecting the display of exotic species.

The year's most important zoological event at the Park and perhaps in any zoo in the United States was the conception and birth on May 18, 1958, of a snow-leopard kitten. Never before has there been a birth of this rare and beautiful leopard in the Western Hemisphere, and the records indicate that only five kindlings are known in the worldwide history of zoos. So far as can be ascertained, there have been only two kittens successfully reared. The kitten, a female, was abandoned by its mother after 24 hours and has been hand-reared by Zoo personnel. The first six weeks of its life were extremely critical, requiring almost constant attention. After a great deal of uncertainty and suspense, it is now apparently healthily established and vigorously growing.

A new program was instituted for training the elephants. A professional elephant man, Roger MacDonald, was hired as a keeper, and he has been teaching the two 10-year-old Indian elephants, Ashoka and Shanti, and the two little elephants, Nancy, an African, and Dixie, an Asiatic, to obey commands. The ends of the tusks of Ashoka, the male Indian, were growing so close together that it was beginning to be difficult for him to raise his trunk or feed himself. Rather than saw off the tusks, Mr. MacDonald fashioned a set of braces which are correcting the defect.

The Siberian crane, *Grus leucogeranus*, celebrated its 52d birthday in the Park shortly before the close of the fiscal year. As far as is known, this constitutes a longevity record for cranes in captivity. The rare female Mongolian wild horse has also achieved a longevity record for its species of 32 years.

GIFTS

The Fish and Wildlife Service of the Department of the Interior has continued to cooperate in the procurement of desirable species of North American birds and animals. Outstanding among accessions this year are a pair of trumpter swans on deposit here. These beautiful North American birds had almost vanished a few years ago, but by careful management on the part of the Department of the Interior they have been saved from extinction. These two were collected by Winston E. Banko in the Red Rock Lakes National Waterfowl Refuge in western Montana. Other stations of the Fish and Wildlife Service have sent the Zoo four woodcock, a bald eagle, an osprey, and numerous species of wild ducks.

Through the Animal and Bird Protection Board of Hobart, Tasmania, three Tasmanian devils were obtained. They had not been shown in this collection for many years.

The Royal Zoological Society of Antwerp, Belgium, sent the Zoo a fine pair of great black-casqued hornbills. These were formally presented by Baron Leopold Dhanis of the Belgian Embassy on January 16, 1958.

Jack Marks, director of the Portland, Oreg., Zoo, in cooperation with the U.S. Navy, Operation Deepfreeze, brought back a number of Adelie penguins. Some of them went to the zoos in Portland, Oreg., San Diego, Calif., and New York, N. Y., and 12 were brought to the National Zoological Park and Johns Hopkins University. These birds are being studied by specialists in aspergillosis, the fungus disease that attacks penguins and other birds. The U.S. Navy also obtained for the Zoo a group of albatrosses of two species, *Diomedea nigripes* and *D. immutabilis*, but unfortunately the birds did not survive, the longest that any one lived being three months.

The U.S. Army, 6th Infantry Division, stationed in Berlin, Germany, sent the Zoo a European brown bear that had been given them as a mascot by the citizens of Berlin on Armed Forces Day, 1957. The new recruit was so successful in his placement as mascot that he was soon promoted to private first class. Later he did what many soldiers have wanted to do—bit the first sergeant. He was immediately demoted to private, and in consequence thereof a short time later he went AWOL, causing great consternation in the regiment and in the city of Berlin. Despite his seemingly erratic Army career, he has been discharged honorably from the United States Army and is now enjoying his civilian life at the National Zoological Park. "Teddy" was formally presented by the Honorable Dewey Short, Assistant Secretary of the Army; representing the West German Republic was Brig. Gen. Wolf Dietrich Von Steinmetz; and Dr.

Leonard Carmichael accepted for the Smithsonian Institution and the National Zoological Park. The bear's cage is appropriately decorated with the seal of the Sixth Infantry and the seal of Berlin.

The Zoo is fortunate in having among its friends members of the Armed Forces who, when stationed abroad, are always on the lookout for rare and interesting animals. Dr. Robert E. Kuntz, of the Navy Medical Research Unit in Taipei, Taiwan, sent a number of specimens including an eared pangolin, which, although it seemed to be doing well, lived only four months. Lt. Col. Robert Traub, stationed in Kuala Lumpur, Malaya, sent a linsang (*Prionodon linsang*), a species never before exhibited in this collection, as well as a number of particularly interesting reptiles. Other animals collected by these men are included in the following list of gifts of special interest:

Animal Shop, Norfolk, Va., canebrake rattlesnake, copperhead, water moccasin.

Badgley, Eugene, District Heights, Md., albino weasel.

Cahill, Carl B., Washington, D.C., 3 masked lovebirds.

Child, Mrs. William S., Falls Church, Va., tovi parakeet.

Dawkins, H. C., Entebbe, Uganda, black-and-white casqued hornbill.

DePrato, Mario, Langley Park, Md., black racer, brown water snake, common king snake, red-bellied water snake, 2 rainbow snakes, 3 water moccasins, 2 blue-tailed skinks, brown skink.

duPont, Irénée, Wilmington, Del., 2 Cuban tree boas.

Hafer, F. L., Arlington, Va., collection of tropical fish.

Hecht Co., through S. Haken, display manager, Washington, D.C., 11 ring-necked doves, 10 fan-tailed pigeons, peacock, golden pheasant.

Hoogstral, Dr. Harry, U.S. Naval Medical Research Unit #8, Cairo, Egypt, 2 hedgehogs, 18 jerboas, 25 gerbils.

Hubbell, Mrs. Robert L., Falls Church, Va., Mexican double yellow-headed parrot.

Kilham, Dr. Lawrence, Bethesda, Md., 2 hand-reared flickers.

Kuntz, Dr. Robert E., Taipei, Taiwan, 3 Chinese vipers, 10 rat snakes, racer, pangolin, 3 monkeys, 6 squirrels, Formosan masked civet, 6 Formosan cobras, sea snake, 3 Habu snakes, 3 Russell's vipers, 6 kraits, Formosan rat snake, Swinhoe's pheasant, 2 quail, Formosan red-billed pie, 2 Formosan flying squirrels, 11 palm vipers, 11 Europholis.

Magens, Dr. Hans, Okinawa, 8 Habu snakes, 2 Asian moccasins.

McGuire, L. S., Falls Church, Va., cockatiel.

National Capital Parks, Great Falls, Md., copperhead, queen snake, pilot black snake, water snake, wood turtle, red-bellied water turtle.

New York Zoological Park, New York, N.Y., 4 baby king cobras, born in their collection.

Nye, Alva, McLean, Va., golden eagle.

Owen, Roger L., Mount Rainier, Md., red-fronted parrot.

Phelps, C. F., Game and Inland Fisheries, Richmond, Va., 3 wild turkeys.

Safeway Warehouse, Washington, D.C., emperor boa, tropical king snake.

Society for the Prevention of Cruelty to Animals, Richmond, Va., Cuban flamingo.

Thorington, David W., Richmond, Va., margay cat.

Townsend, Dr. W. C., Washington, D.C., 2 boa constrictors, green tree boa, rainbow boa.

Traub, Lt. Col. Robert, Kuala Lumpur, Malaya, linsang, twin-barred tree snake, 2 Pope's vipers, pit viper, Malayan racer, blue Malayan coral snake, 2 regal pythons, grass-green whipsnake, 4 giant geckos, 4 forest lizards, 2 skinks.

Urlass, H. M., Bangkok, Thailand, leopard.

Welch, Mrs. A. L., Washington, D.C., collection of tropical fish.

Williams, Mrs. Fred A., Washington, D.C., red and blue macaw.

Xanten, William Jr., Washington, D.C., chicken snake, 2 Florida king snakes, corn snake, 4 garter snakes, ribbon snake, 2 Florida water snakes, green water snake, scarlet king snake, 4 skinks, eastern diamond-backed rattlesnake, 2 Florida water terrapins, musk turtle.

PURCHASES

Included among animals acquired from dealers this year were three species of African sunbirds, a bataleur eagle, a pair of Argus pheasants, a Cape monitor, a large Indian monitor, a young Brazilian tapir, eight quokkas (*Setonix brachyurus*) from the Perth (Australia) Zoological Gardens, a white-headed piping guan, 2 nocturnal curassows, 2 gray hornbills, 2 little black woodpeckers, 2 female red deer, 2 forest falcons, a chimango, and an olingo.

EXCHANGES

Animals were obtained by exchanges made with the following zoos:

Calgary Zoological Park, Calgary, Alberta, Swainson's hawk, 2 Steller's jays, 4 evening grosbeaks.

Cincinnati Zoo, Cincinnati, Ohio, eland, 2 jaguars, a Queen of Bavaria conure.

Crandon Park Zoo, Miami, Fla., 2 vulturine guineafowl, 2 tree ducks, ocellated turkey.

Edmonton Zoological Society, Edmonton, Alberta, 4 snowy owls, 2 wolverines.

Houston Zoo, Houston, Tex., western rattlesnakes, copperheads, and other reptiles.

San Diego Zoological Society, San Diego, Calif., Uta lizards.

Woodland Park Zoo, Seattle, Wash., 2 band-tailed pigeons, 2 magpies, 2 Steller's jays.

BIRTHS AND HATCHINGS

The snow leopard, previously referred to, is the outstanding birth of the year. A gibbon hybrid, offspring of another hybrid, was born on January 6, 1958, and is being raised at home by Keeper Herbert R. Stroman. Vicky Jean, the black-faced chimpanzee born on June 20, 1957, has become one of the Zoo's most popular exhibits. She now spends most of each day in her cage but is still taken home at night by Bernard Gallagher, the keeper who raised her.

Because of their curious life history, the hatching of Surinam toads in captivity is always of interest. One of the Zoo's females laid eggs, the male carefully embedded them in her back, and 30 little toads eventually hatched.

A new incubator and brooding pens have been installed in the bird house. Intensive efforts are being made to incubate eggs laid at the Zoo.

One of the signs that an animal is doing well in captivity is its ability to reproduce its kind and, as the following list shows, the number of mammals, birds, and reptiles born in the National Zoological Park during the year is gratifying:

MAMMALS

Scientific name	*Common name*	*Number*
Acomys cahirinus	Egyptian spiny mouse	5
Ammotragus lervia	Aoudad	4
Anoa depressicornis	Anoa	1
Atilax paludinosus	Water civet	1
Bibos gaurus	Gaur	1
Bos taurus	West Highland cattle	2
	British Park cattle	2
Cebus sp.	Capuchin monkey	1
Cercopithecus cephus	Mustached guenon	1
Cercopithecus neglectus	DeBrazza's guenon	1
Cervus canadensis	American elk	1
Cervus elaphus	Red deer	1
Cervus nippon	Sika deer	2
Choloepus didactylus	Two-toed sloth	1
Dama dama	Brown fallow deer	1
	White fallow deer	4
Equus burchelli boehmi	Grant's zebra	1
Felis concolor	Puma	3
Felis pardus	Black leopard	2
Felis uncia	Snow leopard	2
Hylobates agilis × *H. lar pileatus* × *H. lar.*	Hybrid gibbon	1
Hypsiprymnodon moschatus	Rat kangaroo	2
Hystrix galeata	African porcupine	2
Jaculus jaculus	Jerboa	4
Lama glama	Llama	5
Lama pacos	Alpaca	1
Macropus giganteus	Great gray kangaroo	1
Macaca sinica	Bonnet macaque	1
Macaca sylvanus	Barbary ape	2
Nasua narica	Coatimundi	4
Odocoileus virginianus	Virginia deer	1
Taurotragus oryx	Eland	1
Thalarctos maritimus × *Ursus middendorffi.*	Hybrid bear (2d generation)	2
Ursus horribilis	Grizzly bear	2

BIRDS

Branta canadensis	Canada goose	4
Columba livia	Homing pigeon	5
Cygnus cygnus	Whooping swan	2
Dendronessa galericulata	Mandarin duck	18

BIRDS—Continued

Scientific name	Common name	Number
Gallus gallus	Red junglefowl	5
Melopsittacus undulatus	Grass parakeet	12
Munia oryzivora	Java finch	5
Pavo cristatus	Peafowl	4

REPTILES

Ancistrodon contortrix	Copperhead	13
Chamaeleon bitaeniatus hoehneli	African chameleon	14
Chelydra serpentina	Snapping turtle	8
Chrysemys picta	Painted turtle	20
Epicrates angulifer	Cuban tree boa	3
Eumeces fasciatus	Blue-tailed skink	4
Mabuya multifasciata	Skink	8
Natrix septemvittata	Queen snake	6
Pipa pipa	Surinam toad	30
Pseudemys scripta	Red-lined turtle	53
Sceloporus undulatus	Pine lizard	9
Terrapene carolina	Box turtle	8

FISH

Tanichthys albonubes	White Cloud Mountain fish	5

The total number of accessions for the year was 1,411. This includes gifts, purchases, exchanges, deposits, births, and hatchings. A determined effort was made this year to accept as gifts, purchases, or exchanges only those animals that fit into the long-range exhibition plans of the National Zoological Park.

The collection has fewer individuals listed this year because many species were felt to have an excessive number of individuals and have been adjusted to a more reasonable number in relation to the over-all collection, thus providing a more balanced exhibition. Several minor species which are best displayed in large numbers do not have an individual count, merely being listed as "many."

STATUS OF THE COLLECTION

Class	Orders	Families	Species or subspecies	Individuals
Mammals	13	50	214	634
Birds	20	67	304	889
Reptiles	4	23	155	555
Amphibians	2	11	23	124
Fish	5	11	23	75
Arthropods	4	5	5	39
Mollusks	1	1	1	Many
Total	49	168	725	2,316

ANIMALS IN THE COLLECTION ON JUNE 30, 1958

MAMMALS

MONOTREMATA

Scientific name	*Common name*	*Number*
Tachyglossidae:		
Tachyglossus aculeatus	Echidna, or spiny anteater	1

MARSUPIALIA

Scientific name	*Common name*	*Number*
Didelphiidae:		
Didelphis marsupialis virginiana	Opossum	1
Dasyuridae:		
Sarcophilus harrisii	Tasmanian devil	3
Phalangeridae:		
Trichosurus vulpecula	Vulpine opossum	1
Petaurus norfolcensis	Lesser flying phalanger	3
Phascolomidae:		
Lasiorhinus latifrons	Hairy-nosed wombat	2
Wombatus hirsutus	Mainland wombat	1
Macropodidae:		
Macropus rufus	Red kangaroo	1
Macropus giganteus	Gray kangaroo	2
Hypsiprymnodon moschatus	Rat kangaroo	8

INSECTIVORA

Scientific name	*Common name*	*Number*
Erinaceidae:		
Erinaceus europaeus	European hedgehog	1
Soricidae:		
Blarina brevicauda	Short-tailed shrew	1

PRIMATES

Scientific name	*Common name*	*Number*
Lemuridae:		
Lemur mongoz	Mongooz lemur	1
Lorisidae:		
Nycticebus coucang	Slow loris	2
Galago crassicaudatus	Thick-tailed galago	4
Galago senegalensis	Bushbaby or night-ape	2
Cebidae:		
Aotus trivirgatus	Night monkey	5
Cacajao rubicundus	Red uakari	1
Cebus nigrivittatus	Brown capuchin monkey	3
Cebus albifrons	White-throated capuchin	3
Saimiri sciureus	Squirrel monkey	5
Ateles fusciceps robustus	Colombian black spider monkey	2
Ateles geoffroyi geoffroyi or *griscesens*	Spider monkey	2
Ateles geoffroyi vellerosus	Spider monkey	2
Lagothrix pygmaea	Woolly monkey	2
Callithricidae:		
Leontocebus rosalia	Golden lion tamarin	1
Saguinus nigricollis	Black-and-red tamarin	4
Cercopithecidae:		
Macaca sinica	Toque or bonnet monkey	3
Macaca nemestrina	Pig-tailed monkey	1

MAMMALS—Continued

PRIMATES—continued

Scientific name	Common name	Number
Cercopithecidae—Continued		
Macaca philippinensis	Philippine macaque	1
Macaca mulatta	Rhesus monkey	3
Macaca lasiotis	Chinese macaque	1
Macaca cyclopis	Formosan monkey	3
Macaca speciosa	Red-faced macaque	1
Macaca sylvanus	Barbary ape	9
Macaca maurus	Moor macaque	2
Allenopithecus nigroviridis	Allen's monkey	2
Cercocebus albigena	Gray-cheeked mangabey	1
Cercocebus aterrimus	Black-crested mangabey	3
Cercocebus aterrimus opdenboschii	Crested mangabey	2
Cercocebus galeritus agilis	Agile mangabey	1
Cercocebus galeritus chrysogaster	Golden-bellied mangabey	1
Cercocebus torquatus torquatus	Red-crowned mangabey	2
Cercocebus fuliginosus	Sooty mangabey	4
Mandrillus sphinx	Mandrill	1
Papio comatus	Chacma baboon	1
Papio cynocephalus	Golden baboon	2
Papio hamadryas	Hamadryas baboon	1
Theropithecus gelada	Gelada baboon	1
Cercopithecus aethiops pygerythrus	Vervet guenon	1
Cercopithecus aethiops sabaeus	Green guenon	3
Cercopithecus aethiops sabaeus × *C. a. pygerythrus.*	Hybrid, green guenon × vervet guenon.	2
Cercopithecus cephus	Moustached monkey	4
Cercopithecus diana	Diana monkey	2
Cercopithecus diana roloway	Roloway monkey	1
Cercopithecus l'hoesti preussi	Preussi's guenon	1
Cercopithecus neglectus	DeBrazza's guenon	3
Cercopithecus nictitans	White-nosed guenon	1
Cercopithecus nictitans petaurista	Lesser white-nosed guenon	1
Presbytis phayrei	Spectacled langur	1
Pongidae:		
Hylobates hoolock	Hoolock	1
Hylobates lar	White-handed gibbon	6
Hylobates moloch	Wau-wau gibbon	1
Hylobates agilis × *H. lar pileatus*	Hybrid gibbon	1
Hylobates agilis × *H. lar pileatus* × *H. lar.*	Hybrid gibbon	1
Pongo pygmaeus pygmaeus	Sumatran orangutan	2
Pongo pygmaeus abelii	Bornean orangutan	1
Pan satyrus	Chimpanzee	4
Gorilla gorilla	Gorilla	2

LAGOMORPHA

Scientific name	Common name	Number
Leporidae:		
Sylvilagus floridanus	Cottontail rabbit	1
Oryctolagus cuniculus	Domestic or European rabbit	1

MAMMALS—Continued

RODENTIA

Scientific name	Common name	Number
Sciuridae:		
Sciurus carolinensis	Gray squirrel, albino	1
Sciurus niger	Fox squirrel	1
Ratufa indica	Giant Indian squirrel	1
Callosciurus erythraeus	Formosan tree squirrel	5
Callosciurus caniceps	Asiatic forest squirrel	4
Marmota monax	Ground-hog	1
Cynomys ludovicianus	Prairie-dog	29
Tamias striatus	Eastern chipmunk, albino	1
Petaurista grandis	Formosan flying squirrel	1
Glaucomys volans volans	Eastern flying squirrel	21
Cricetidae:		
Nyctomys sumichrasti	Vesper rat	2
Mesocricetus auratus	Hamster	6
Meriones unguiculatus	Mongolian gerbil	2
Muridae:		
Acomys cahirinus	Egyptian spiny mouse	43
Phloeomys cumingii	Slender-tailed cloud rat	5
Gliridae:		
Graphiurus murinus	African dormouse	5
Dipodidae:		
Jaculus jaculus	Jerboa	11
Allactaga tetradactyla	Four-toed jerboa	9
Hystricidae:		
Acanthion brachyura	Malay porcupine	1
Hystrix galeata	African porcupine	7
Erethizontidae:		
Coendou prehensilis	Prehensile-tailed porcupine	1
Caviidae:		
Cavia porcellus	Guinea-pig	13
Dasyproctidae:		
Cuniculus paca	Paca	1
Dasyprocta punctata	Speckled agouti	3
Chinchillidae:		
Lagidium viscaccia	Peruvian viscaccia	1
Chinchilla chinchilla	Chinchilla	2
Capromyidae:		
Myocastor coypus	Coypu	1

EDENTATA

Scientific name	Common name	Number
Myrmecophagidae:		
Myrmecophaga tridactyla	Giant anteater	2
Bradypodidae:		
Choloepus didactylus	Two-toed sloth	4
Dasypodidae:		
Dasypus novemcinctus	Nine-banded armadillo	1

MAMMALS—Continued

CARNIVORA

Scientific name	Common name	Number
Canidae:		
Canis antarcticus	Dingo	1
Canis lupus nubilus	Timber wolf	4
Canis niger rufus	Red wolf	1
Vulpes fulva	Red fox	2
Vulpes fulva	Platinum fox	3
Fennecus zerda	Fennec fox	2
Urocyon cinereoargenteus	Gray fox	1
Nyctereutes procyonoides	Raccoon dog	6
Speothos venaticus	Bush dog	2
Lycaon pictus	African, or Cape, hunting dog	2
Otocyon megalotis	Big-eared fox	4
Ursidae:		
Tremarctos ornatus	Spectacled bear	1
Selenarctos thibetanus	Himalayan black bear	2
Selenarctos thibetanus japonicus	Japanese black bear	1
Selenarctos thibetanus ussuricus	Korean black bear	2
Euarctos americanus	American black bear	2
Ursus sp	Alaskan brown bear	1
Ursus arctos	European brown bear	4
Ursus arctos occidentalis	Iranian brown bear	2
Ursus gyas	Alaskan Peninsula bear	2
Ursus horribilis	Grizzly bear	2
Ursus sitkensis	Sitka brown bear	2
Thalarctos maritimus	Polar bear	1
Thalarctos maritimus × *Ursus middendorffi*.	Hybrid bear	4
Helarctos malayanus	Malay sun bear	3
Procyonidae:		
Bassariscus astutus	Ringtail, or cacomistle	1
Procyon lotor	Raccoon	5
Nasua nasua	Red coatimundi	2
Nasua narica	Coatimundi	8
Potos flavus	Kinkajou	3
Bassaricyon gabbi	Olingo	2
Mustelidae:		
Mustela frenata	Eastern weasel	2
Mustela eversmanni	Ferret, albino	1
Eira barbara	Tayra	1
Galictis vittata	Grison	1
Gulo luscus	Wolverine	1
Mephitis mephitis	Common skunk	1
Spilogale gracilis phenax	California spotted skunk	1
Lutra cinerea	African small-clawed otter	1
Pteronura brasiliensis	South American flat-tailed otter	1
Viverridae:		
Genetta genetta neumanii	Genet	4
Viverra tangalunga	Ground civet	1

MAMMALS—Continued

CARNIVORA—continued

Scientific name	Common name	Number
Viverridae—Continued		
Prionodon linsang	Linsang	1
Paguma larvata taivana	Formosan masked civet or kitsume	2
Arctictis binturong	Binturong	1
Herpestes ichneumon	African gray mongoose	2
Atilax paludinosus	Water civet	4
Ichneumia albicauda	White-tailed civet	1
Cryptoproctidae:		
Cryptoprocta ferox	Fossa	1
Hyaenida:		
Crocuta crocuta germinans	Spotted hyena	2
Hyaena hyaena	Striped hyena	2
Felidae:		
Lynx canadensis	Lynx	1
Lynx rufus	Bobcat	2
Felis chaus	Jungle cat	2
Felis serval	Serval cat	1
Felis pajaros	Pampas cat	1
Felis pardalis	Ocelot	3
Felis wiedii tigrina	Margay cat	3
Felis concolor	Puma	7
Felis pardus	Leopard	4
	Black leopard	2
Felis leo	Lion	6
Felis tigris	Bengal tiger	3
Felis onca	Jaguar	2
Felis uncia	Snow leopard	3
Acinonyx jubata	Cheetah	2

PINNIPEDIA

Scientific name	Common name	Number
Otariidae:		
Zalophus californianus	Sea-lion	2
Otaria flavescens	Patagonian sea-lion	2

TUBULIDENTATA

Scientific name	Common name	Number
Orycteropodidae:		
Orycteropus afer	Aardvark	1

PROBOSCIDEA

Scientific name	Common name	Number
Elephantidae:		
Loxodonta africana	African elephant	1
Elephas maximus	Indian elephant	3

PERISSODACTYLA

Scientific name	Common name	Number
Equidae:		
Equus przewalskii	Mongolian wild horse	1
Equus kiang	Asiatic wild ass, or kiang	1
Equus asinus	Burro, or donkey	1
Equus burchelli boehmi	Grant's zebra	5
Equus grevy	Grevy's zebra	3

MAMMALS—Continued

PERISSODACTYLA—continued

Scientific name	Common name	Number
Tapiridae:		
Tapirus terrestris	Brazilian tapir	2
Rhinocerotidae:		
Rhinoceros unicornis	Great Indian one-horned rhinoceros.	1
Ceratotherium simum	White or square-mouthed rhinoceros.	2
Diceros bicornis	African rhinoceros	1

ARTIODACTYLA

Scientific name	Common name	Number
Suidae:		
Sus scrofa	European wild boar	1
Tayassuidae:		
Pecari tajacu angulatus	Collared peccary	2
Hippopotamidae:		
Hippopotamus amphibius	Hippopotamus	4
Choeropsis liberiensis	Pygmy hippopotamus	3
Camelidae:		
Lama glama	Llama	9
Lama glama guanicoe	Guanaco	3
Lama pacos	Alpaca	4
Camelus bactrianus	Bactrian camel	2
Cervidae:		
Dama dama	Brown fallow deer	10
	White fallow deer	13
Axis axis	Axis deer	5
Cervus elaphus	Red deer	5
Cervus canadensis	American elk	4
Cervus nippon	Sika deer	5
Elaphurus davidianus	Père David's deer	2
Odocoileus virginianus	Virginia deer	7
Odocoileus virginianus costaricensis	Costa Rican deer	1
Giraffidae:		
Okapia johnstoni	Okapi	2
Giraffa camelopardalis	Nubian giraffe	4
Antilocapridae:		
Antilocapra americana	Pronghorn antelope	1
Bovidae:		
Taurotragus oryx	Eland	4
Anoa depressicornis	Anoa	3
Bos taurus	West Highland, or Kyloe, cattle	3
Bos indicus	Zebu	1
Poephagus grunniens	Yak	3
Bibos gaurus	Gaur	5
Syncerus caffer	African buffalo	1
Bison bison	American bison	3
Bison bonasus	European bison, or wisent	2
Cephalophus nigrifrons	Black-fronted duiker	1
Saiga tatarica	Saiga antelope	1

MAMMALS—Continued

ARTIODACTYLA—continued

Scientific name	*Common name*	*Number*
Bovidae—Continued		
Hemitragus jemlahicus	Tahr	2
Pseudois nayaur	Blue, or Bharal, sheep	1
Ammotragus lervia	Aoudad	6
Ovis musimon	Mouflon	2

BIRDS

STRUTHIONIFORMES

Struthionidae:		
Struthio camelus	Ostrich	1

RHEIFORMES

Rheidae:		
Rhea americana	Rhea	1

CASUARIFORMES

Casuariidae:		
Casuarius unappendiculatus	One-wattled cassowary	1
Dromiceiidae:		
Dromiceius novaehollandiae	Emu	4

SPHENISCIFORMES

Spheniscidae:		
Aptenodytes patagonica	King penguin	4
Pygoscelis adeliae	Adelie penguin	7
Spheniscus humboldti	Humboldt's penguin	2

TINAMIFORMES

Tinamidae:		
Tinamus major	Chestnut-headed tinamou	1

PELICANIFORMES

Pelecanidae:		
Pelecanus onocrotalus	Rose-colored pelican	2
Pelecanus erythrorhynchus	White pelican	6
Pelecanus occidentalis occidentalis	Brown pelican	1
Phalacrocoracidae:		
Phalacrocorax auritus albociliatus	Farallon cormorant	1

CICONIIFORMES

Balaenicipitidae:		
Balaenicipes rex	Shoebill	1
Ardeidae:		
Notophoyx novaehollandiae	White-faced heron	1
Florida caerulea	Blue heron	2
Leucophoyx thula	Snowy egret	3
Nycticorax nycticorax hoactli	Black- crowned night heron	24
Tigrisoma lineatum	Tiger bittern	5

BIRDS—Continued

CICONIIFORMES—continued

Scientific name	Common name	Number
Cochleariidae:		
Cochlearius cochlearius	Boat-billed heron	2
Ciconiidae:		
Dissoura episcopus	Woolly-necked stork	1
Leptoptilus crumeniferus	Marabou stork	1
Leptoptilus javanicus	Lesser adjutant	2
Threskiornithidae:		
Mycteria americana	Wood ibis	1
Threskiornis melanocephala	Black-headed ibis	1
Ajaia ajaja	Roseate spoonbill	2
Eudocimus alba	White ibis	3
Eudocimus ruber	Scarlet ibis	3
Phoenicopteridae:		
Phoenicopterus antiquorum	Old World flamingo	1
Phoenicopterus ruber	Cuban flamingo	2
Phoenicopterus chilensis	Chilean flamingo	2

ANSERIFORMES

Scientific name	Common name	Number
Anhimidae:		
Chauna torquata	Crested screamer	4
Anatidae:		
Cygnus cygnus	Whooper swan	2
Cygnus columbianus	Whistling swan	4
Cygnus buccinator	Trumpeter swan	2
Plectropterus gambensis	Spur-winged goose	1
Cereopsis novaehollandiae	Cape Barren goose	1
Anseranus semipalmata	Australian pied goose	1
Chenopis atrata	Black swan	3
Chen caerulescens	Blue goose	6
Chen hyperborea	Lesser snow goose	2
Chen atlantica	Snow goose	7
Chen rossi	Ross's goose	4
Anser albifrons	White-fronted goose	2
Eulabeia indica	Indian bar-headed goose	6
Philacte canagica	Emperor goose	2
Branta canadensis	Canada goose	13
Branta canadensis canadensis × *Chen caerulescens.*	Hybrid, Canada goose × blue goose.	2
Branta canadensis occidentalis	White-cheeked goose	7
Branta canadensis minima	Cackling goose	6
Branta canadensis leucopareia	Lesser Canada goose	7
Chloephaga leucoptera	Upland goose	1
Dendrocygna autumnalis	Black-bellied tree duck	8
Sarkidiornis melanota	Comb duck	1
Tadorna tadorna	European shell duck	1
Anas platyrhynchos	Mallard duck	14
Anas platyrhynchos	Mallard duck, albino	1
Anas platyrhynchos domestica	Peking duck	5
Anas platyrhynchos × *A. acuta*	Hybrid, mallard duck × American pintail duck.	1

BIRDS—Continued

ANSERIFORMES—continued

Scientific name	Common name	Number
Anatidae—Continued		
Anas poecilorhyncha	Indian spotted-bill duck	1
Anas rubripes	Black duck	2
Anas acuta	Pintail duck	1
Mareca americana	Baldpate	9
Aix sponsa	Wood duck	5
Aix sponsa × *Aythya americana*	Hybrid, wood duck × red-headed duck.	1
Dendronessa galericulata	Mandarin duck	29
Netta rufina	Red-crested pochard	1
Aythya valisineria	Canvasback duck	9
Aythya americana	Red-headed duck	10
Aythya marila	Greater scaup duck	4
Aythya affinis	Lesser scaup duck	7

FALCONIFORMES

Scientific name	Common name	Number
Cathartidae:		
Sarcoramphus papa	King vulture	1
Coragyps atratus	Black vulture	3
Cathartes aura	Turkey vulture	3
Sagittariidae:		
Sagittarius serpentarius	Secretarybird	2
Accipitridae:		
Odontriorchis cayanensis	Cayenne kite	1
Milvus migrans parasitus	African yellow-billed kite	2
Haliastur indus	Brahminy kite	1
Buteo poecilochrous	Buzzard eagle	1
Buteo jamaicensis	Red-tailed hawk	5
Buteo swainsoni	Swainson's hawk	2
Leucopternis melanops	Black-faced hawk	1
Busarellus nigricollis	Black-throated buzzard	1
Morphnus guianensis	Guianan crested eagle	1
Harpia harpyja	Harpy eagle	1
Pithecophagus jefferyi	Monkey-eating eagle	1
Aquila chrysaetos canadensis	Golden eagle	1
Haliaeetus leucocephalus	Bald eagle	7
Gyps rueppelli	Ruppell's vulture	2
Pseudogyps africanus	White-backed vulture	1
Terathopius ecaudatus	Bataleur eagle	1
Falconidae:		
Micrastur semitorquatus	Forest falcon	2
Milvago chimango	Chimango	2
Polyborus plancus	South American caracara	3
Polyborous cheriway	Audubon's caracara	1
Falco mexicanus	Prairie falcon	1
Falco peregrinus anatum	Duck hawk	1
Falco sparverius	Sparrow hawk	5

BIRDS—Continued

GALLIFORMES

Scientific name	Common name	Number
Megapodiidae:		
Alectura lathami	Brush turkey	1
Cracidae:		
Nothocrax urumutum	Nocturnal curassow	2
Crax alberti	Blue-cered curassow	2
Crax globulosa	Wattled curassow	2
Pipile cumanensis	White-headed piping guan	1
Crax panamensis	Panama curassow	1
Phasianidae:		
Alectoris graeca	Chukar quail	2
Colinus virginianus	Bobwhite quail	1
Perdix perdix	Hungarian partridge	2
Coturnix japonica	Japanese king quail	1
Gennaeus leucomelanus	Nepal pheasant	2
Gennaeus swinhoii	Swinhoe's pheasant	2
Gallus gallus	Red junglefowl	6
Phasianus colchicus torquatus	Ring-necked pheasant	4
	White ring-necked pheasant	2
Syrmaticus reevesi	Reeves's pheasant	2
Chrysolophus amherstiae	Lady Amherst pheasant	3
Chrysolophus pictus	Golden pheasant	9
Argusianus argus	Argus pheasant	3
Pavo cristatus	Peafowl	5
	Blue peafowl	3
Numididae:		
Acryllium vulturinum	Vulturine guineafowl	1
Meleagrididae:		
Agriocharis ocellata	Ocellated turkey	1
Meleagris gallopavo	Wild turkey	2

GRUIFORMES

Scientific name	Common name	Number
Gruidae:		
Grus leucogeranus	Siberian crane	1
Anthropoides virgo	Demoiselle crane	1
Psophiidae:		
Psophia crepitans	Trumpeter	2
Rallidae:		
Rallus limicola	Virginia rail	1
Laterallus leucopyrrhus	Black-and-white crake	1
Gallinula chloropus cachinnans	Florida gallinule	1
Porphyrio poliocephalus	South Pacific swamp hen	1
Fulica americana	American coot	2
Eurypygidae:		
Europyga helias	Sun bittern	2
Cariamidae:		
Cariama cristata	Cariama, or seriama	1

BIRDS—Continued

CHARADRIIFORMES

Scientific name	*Common name*	*Number*
Jacanidae:		
Jacana spinosa hypomelaena	Black jacana	1
Haematopodidae:		
Haematopus ostralegus	Oystercatcher	3
Charadriidae:		
Belonopterus cayennensis	South American lapwing	2
Charadrius vociferus	Killdeer	1
Recurvirostridae:		
Himantopus himantopus mexicanus	Black-necked stilt	1
Burhinidae:		
Burhinus bistriatus	South American thick-knee	2
Stercorariidae:		
Catharacta maccormacki	MacCormack's skua	4
Laridae:		
Larus delawarensis	Ring-billed gull	2
Larus dominicanus	Kelp gull	2
Larus atricilla	Laughing gull	1
Larus novaehollandiae	Silver gull	12

COLUMBIFORMES

Columbidae:		
Columba livia	Homing pigeon	16
Columba fasciata	Band-tailed pigeon	2
Columba nigrirostris	Black-billed pigeon	1
Zenaidura macroura	Mourning dove	3
Zenaida asiatica	White-winged dove	2
Streptopelia decaocto	Ring-necked dove	16
Streptopelia tranquebarica	Blue-headed ring dove	2
Geopelia cuneata	Diamond dove	1
Gallicolumba luzonica	Bleeding-heart dove	2
Goura victoria	Crowned pigeon	2

PSITTACIFORMES

Psittacidae:		
Nestor notabilis	Kea parrot	2
Domicella garrula	Red lory	1
Calyptorhynchus magnificus	Banksian cockatoo	2
Callocephalon fimbriatum	Gang-gang cockatoo	4
Kakatoe alba	White cockatoo	2
Kakatoe ducrops	Solomon Islands cockatoo	1
Kakatoe galerita	Sulphur-crested cockatoo	6
Kakatoe sanguineus	Bare-eyed cockatoo	5
Kakatoe moluccensis	Great red-crested cockatoo	2
Kakatoe leadbeateri	Leadbeater's cockatoo	8
Nymphicus hollandicus	Cockatiel	5
Ara ararauna	Yellow-and-blue macaw	3
Ara chloroptera	Red-and-blue macaw	3
Ara macao	Red-blue-and-yellow macaw	3
Aratinga canicularis	Petz's parakeet	1
Aratinga pertinax	Rusty-cheeked parrot	3

BIRDS—Continued

PSITTACIFORMES—continued

Scientific name	Common name	Number
Psittacidae—Continued		
Brotogeris jugularis	Tovi parakeet	1
Amazona aestiva	Blue-fronted parrot	1
Amazona auropalliata	Yellow-naped parrot	3
Amazona finschi	Finsch's parrot	1
Amazona leucocephala	Cuban parrot	1
Amazona bodini	Red-fronted parrot	1
Amazona ochrocephala	Yellow-headed parrot	1
Amazona oratrix	Double yellow-headed parrot	3
Psittacula eupatria	Red-shouldered parakeet	1
Psittacula fasciata	Moustache parakeet	1
Polytelis swainsoni	Barraband's parakeet	2
Agapornis roseicollis	Rosy-faced lovebird	1
Agapornis fischeri	Yellow-collared lovebird	1
Agapornis personata	Masked lovebird	6
Platycercus elegans	Pennant's parakeet	3
Platycercus eximius	Rosella parakeet	1
Melopsittacus undulatus	Grass parakeet	Many

CUCULIFORMES

Scientific name	Common name	Number
Musophagidae:		
Tauraco persa	Purple turaco	1
Tauraco corythaix	South African turaco	1
Crinifer africanus	Plantain-eater	2
Cuculidae:		
Eudynamys scolopacea	Koel	1
Geococcyx californianus	Roadrunner	1

STRIGIFORMES

Scientific name	Common name	Number
Tytonidae:		
Tyto alba pratincola	Barn owl	2
Strigidae:		
Otus asio	Screech owl	1
Bubo virginianus	Great horned owl	5
Bubo virginianus elutus	Colombian great horned owl	1
Ketupa ketupu	Malay fishing owl	1
Nyctea nyctea	Snowy owl	4
Strix varia varia	Barred owl	10

TROGONIFORMES

Scientific name	Common name	Number
Trogonidae:		
Priotelus temnurus	Cuban trogan	1

CORACIIFORMES

Scientific name	Common name	Number
Alcedinidae:		
Dacelo gigas	Kookaburra	3
Momotidae:		
Momotus lessoni	Motmot	2
Coraciidae:		
Coracias benghalensis	Indian roller	2

BIRDS—Continued

CORACIIFORMES—continued

Scientific name	Common name	Number
Upupidae:		
Upupa epops	Hoopoe	2
Bucerotidae:		
Tockus birostris	Grey hornbill	2
Aceros undulatus	Malayan hornbill	1
Aceros plicatus	Wreathed hornbill	1
Anthracoceros malabaricus	Pied hornbill	1
Bycanistes subcylindricus	Black-and-white casqued hornbill	2
Ceratogymna atrata	Black-casqued hornbill	2
Buceros hydrocorax	Philippine hornbill	1
Bucorvus abyssinicus	Abyssinian ground hornbill	1

PICIFORMES

Scientific name	Common name	Number
Capitonidae:		
Megalaima zeylonica	Streaked barbet	2
Cyanops asiatica	Asiatic red-fronted barbet	1
Ramphastidae:		
Aulacorhynchus albivittatus	White-lined toucanet	1
Pteroglossus torquatus	Ringed aracari toucanet	1
Ramphastos culminatus	White-breasted toucan	1
Ramphastos carinatus	Sulphur-breasted toucan	2
Ramphastos swainsoni	Swainson's toucan	1
Ramphastos toco	Toco toucan	1
Picidae:		
Colaptes auratus	Yellow-shafted flicker	2
Melanerpes cruentatus	Little black woodpecker	2

PASSERIFORMES

Scientific name	Common name	Number
Cotingidae:		
Rupicola rupicola	Orange cock-of-the rock	1
Rupicola sanguinolenta	Scarlet cock-of-the rock	1
Tyrannidae:		
Pitangus sulphuratus	Kiskadee flycatcher	1
Alaudidae:		
Alauda arvensis	Skylark	2
Corvidae:		
Cyanocitta cristata	Bluejay	2
Cyanocitta stelleri	Steller's jay	4
Pica pica hudsonica	Magpie	9
Pica nuttalli	Yellow-billed magpie	1
Cissa chinensis	Chinese cissa	1
Urocissa caerulea	Formosan red-billed pie	2
Dendrocitta formosae	Asiatic tree pie	2
Corvus corax principalis	Raven	1
Corvus alba	African white-necked crow	2
Corvus brachyrhynchos	Crow	1
Corvus insolens	Indian crow	2
Cracticidae:		
Gymnorhina hypoleuca	White-backed piping crow	1

BIRDS—Continued

PASSERIFORMES—continued

Scientific name	Common name	Number
Ptilonorhynchidae:		
Ptilonorhynchus violaceus	Satin bowerbird	2
Timaliidae:		
Pomatorhinus horsfieldii	Indian scimitar babbler	1
Pomatorhinus erythrogenys	Rusty-cheeked scimitar babbler	1
Heterophasia capistrata	Black-headed sibia	1
Sittidae:		
Sitta castanea	Chestnut-bellied nuthatch	2
Sitta carolinensis	White-breasted nuthatch	2
Pycnonotidae:		
Pycnonotus cafer	Red-vented bulbul	1
Pycnonotus leucogenys	White-cheeked bulbul	1
Turdidae:		
Turdus grayi	Bonaparte's thrush	1
Turdus migratorius	Albino robin	1
Thamnolaea cinnemomeiventris	Cliff chat	2
Sturnidae:		
Acridotheres tristis	Jungle mynah	1
Lamprocolius purpureus	Burchell's glossy starling	3
Spreo superbus	Tricolored or superb starling	1
Sturnus malabarica	Gray-headed mynah	1
Pastor roseus	Rose-colored pastor	1
Sturnus vulgaris	Starling	1
Gracula religiosa indica	Lesser hill mynah	1
Gracula religiosa robusta	Nias wattled mynah	1
Gracula religiosa	Hill mynah	3
Nectariniidae:		
Nectarinia johnstoni	Dark malachite sunbird	1
Ploceidae:		
Ploceus baya	Baya weaver	9
Ploceus vitellinus	Vitelline masked weaver	3
Quelea quelea	Red-billed weaver	1
Euplectes orix	Red bishop weaver	2
Euplectes afra	Yellow-crowned bishop weaver	6
Diatropura procne	Giant whydah	5
Steganura paradisaea	Paradise whydah	3
Ploceipasser mahali	Mahali weaver	1
Munia oryzivora	Java finch	18
Amadina fasciata	Cut-throat weaver finch	5
Lonchura maja	White-headed nun	9
Estrilda angolensis	Cordon bleu finch	1
Estrilda coerulescens	Lavender finch	2
Estrilda astrild	Red-eared waxbill	1
Estrilda troglodytes	Common waxbill	4
Zosterops palpebrosa	White-eye	2
Estrilda amandava	Strawberry finch	9
Poephila guttata castanotis	Zebra finch	26
Poephila gouldiae	Black-headed Gouldian finch	2
	Gouldian finch	1

BIRDS—Continued

PASSERIFORMES—continued

Scientific name	Common name	Number
Icteridae:		
Xanthornus decumanus	Crested oropendola	1
Psomocolax oryzivora	Rice grackle	1
Tangavius armenti	Colombian red-eyed cowbird	1
Molothrus bonariensis	Silky cowbird	1
Quiscalus quiscula	Purple grackle	1
Icterus galbula	Baltimore oriole	1
Icterus giraudi	Giraud's oriole	1
Icterus icterus	Troupial	1
Agelaius icterocephalus	Yellow-headed marshbird	1
Thraupidae:		
Calospiza ruficapilla	Brown-headed tanager	1
Thraupis leucoptera	White-edged tanager	1
Thraupis cana	Blue tanager	1
Ramphocelus dimidiatus	Crimson tanager	1
Ramphocelus passerinii	Passerini's tanager	2
Cissopis leveriana	Black-and-white tanager	2
Fringillidae:		
Saltator maximus	Buff-throated saltator	1
Paroaria gularis nigro-genis	Black-eared cardinal	2
Paroaria cucullata	Brazilian cardinal	1
Spiza americana	Dickcissel sparrows	7
Hesperiphona vespertina	Evening grosbeak	3
Carpodacus mexicanus frontalis	House finch	1
Sporophila gutturalis	Yellow-billed finch	8
Carduelis carduelis	European goldfinch	4
Carduelis carduelis × *Serinus canarius.*	European goldfinch × canary	1
Serinus canarius	Canary	2
Sicalis luteola	Saffron finch	7
Melospiza melodia	Song sparrow	1

REPTILES

LORICATA

Scientific name	Common name	Number
Crocodylidae:		
Crocodylus niloticus	African crocodile	1
Osteolaemus tetraspis	Broad-nosed crocodile	3
Crocodylus cataphractus	Narrow-nosed crocodile	1
Crocodylus porosus	Salt-water crocodile	1
Crocodylus acutus	American crocodile	2
Alligator mississipiensis	Alligator	15
Alligator sinesis	Chinese alligator	2
Caiman sclerops	Caiman	5
Tomistoma schlegeli	Gavial (false)	1

SAURIA

Scientific name	Common name	Number
Gekkonidae:		
Gecko smithi	Giant gecko	1
Tarentola mauritanica	Gecko	2

REPTILES—Continued

SAURIA—continued

Scientific name	Common name	Number
Chamaeleonidae:		
Chamaeleo melleri	Meller's chameleon	3
Chamaeleo dilepis	Flap-necked chameleon	12
Iguanidae:		
Iguana iguana	Common iguana	2
Anolis carolinensis	American anole	Many
Anolis cristatellus	Little crested anole	1
Phrynosoma cornutum	Texas horned lizard	10
Sceloporus undulatus	Fence lizard	3
Sauromalus obesus	Chuckwalla	1
Ctenosaura acanthura	Spiny-tailed lizard	1
Cyclura stejnegeri	Mona Island iguana	1
Scincidae:		
Mabuya multifasciata	Malayan skink	6
Egernia luctuosa	Mourning skink	2
Egernia whitei	White's skink	7
Eumeces fasciatus	Greater five-lined skink	5
Scincus officinalis	Sand skink	8
Trachysaurus rugosus	Stump-tailed lizard	1
Gerrhosauridae:		
Gerrhosaurus major	Plated lizard	7
Teiidae:		
Tupinambis nigropunctatus	Black tegu	1
Tupinambis teguixin	Yellow tegu	1
Anguidae:		
Gerrhonotus multicarinatus	Alligator lizard	1
Ophisaurus ventralis	Glass lizard	2
Helodermatidae:		
Heloderma suspectum	Gila monster	3
Heloderma horridum	Beaded lizard (black phase)	1
	Mexican beaded lizard	2
Varanidae:		
Varanus salvator	Indian monitor lizard	1
Varanus varius	Australian lace monitor	2
Varanus albigularis	Cape monitor	1
Zonuridae:		
Zonurus giganteus	Spiny lizard	1

SERPENTES

Scientific name	Common name	Number
Boidae:		
Constrictor c. constrictor	Boa constrictor	2
Constrictor constrictor imperator	Emperor boa	1
Eunectes murinus	Anaconda	2
Epicrates cenchria	Rainbow boa	4
Epicrates angulifer	Cuban tree boa	8
Boa enydris enydris	Tree boa	1
Boa enydris cookii	Cook's tree boa	1
Eryx thebaicus	Sharp-tailed sand boa	1
Python regius	Ball python	5

REPTILES—Continued

SERPENTES—continued

Scientific name	Common name	Number
Boidae—Continued		
Python sebae	African python	1
Python molurus	Indian rock python	2
Python reticulatus	Regal python	2
Colubridae:		
Lampropeltis getulus getulus	King snake	2
Lampropeltis getulus holbrooki	Speckled king snake	2
Lampropeltis getulus californiae	California king snake	3
Lampropeltis getulus floridana	Florida king snake	2
Lampropeltis getulus splendida	Sonoran king snake	1
Lampropeltis doliata ssp	Scarlet king snake	1
Lampropeltis doliata triangulum	Milk snake	1
Lampropeltis rhombomaculata	Mole snake	1
Lampropeltis doliata polyzonua	Tropical king snake	1
Thamnophis sirtalis ordinata	Garter snake	6
Thamnophis sirtalis proxima	Ribbon snake	1
Natrix sipedon	Water snake	4
Natrix rhombifera	Diamond-backed water snake	2
Natrix taxispilota	Brown water snake	1
Natrix cyclopion floridana	Green water snake	1
Natrix erythrogaster	Red-bellied water snake	2
Natrix pictiventris	Florida water snake	3
Coluber constrictor constrictor	Northern black racer	1
Drymarchon corais couperi	Indigo snake	1
Elpahe obsoleta obsoleta	Pilot black snake, albino	2
	Pilot black snake	5
Elaphe obsoleta confinis	Southern pilot black snake	1
Elaphe guttata emoryi	Corn snake	2
Elaphe quadrivittata	Chicken snake	4
Elaphe taeniura	Asiatic rat snake	4
Elaphe carinata	Lesser Indian rat snake	1
Abastor erythrogrammus	Rainbow snake	4
Boaedon lineatum	African house snake, or musaga	2
Diadophis punctatus edwardsii	Ring-necked snake	1
Opheodrys major	Formosan green snake	11
Storeria dekayi	DeKay's snake	2
Dryophis prasinus	Grass-green whip snake	1
Ptyas mucosus	Dhaman, or greater Indian rat snake	4
Spilotes pullatus	Black and yellow rat snake	1
Dispholidus typus	Boomslang	1
Simocephalus capensis	File snake	1
Chrysopelea pelias	Twin-barred tree snake	1
Elapidae:		
Naja naja	Indian cobra	4
Naja naja atra	Taiwan cobra	2
Naja melanoleuca	Black cobra	1
Naja haje	Egyptian cobra	3
Bungarus multicinctus	Kraits	3

REPTILES—Continued

SERPENTES—continued

Scientific name	Common name	Number
Viperidae:		
Vipera russellii	Russell's viper	1
Crotalidae:		
Ancistrodon contortrix laticinctus	Broad-banded copperhead	5
Ancistrodon piscivorus	Water moccasin or cottonmouth	4
Ancistrodon piscivorus leucostoma	Western water moccasin	1
Ancistrodon acutus	Asian snorkel viper	3
Trimeresurus wagleri	Pit viper	1
Trimeresurus gramineus	Palm viper	11
Trimeresurus popeorum	Pope's pit viper	1
Trimeresurus elegans	Mamushi, or Asiatic viper	2
Trimeresurus flavoviridis	Habu, or Asiatic viper	4
Trimeresurus okinavensis	Habu, or Asiatic viper	1
Crotalus adamanteus	Eastern diamond-back rattlesnake	1
Crotalus atrox	Western diamond-back rattlesnake	18
Crotalus horridus	Timber rattlesnake	1

CHELONIA

Scientific name	Common name	Number
Chelydridae:		
Chelydra serpentina	Snapping turtle	12
Macroclemys temminckii	Alligator snapping turtle	5
Kinosternidae:		
Sternotherus odoratus	Musk turtle	3
Kinosternon subrubrum	Mud turtle	5
Kinosternum cruentatum	South American mud turtle	4
Emydidae:		
Clemmys guttata	Spotted turtle	1
Clemmys insculpta	Wood turtle	7
Clemmys marmorata marmorata	Pacific pond turtle	1
Cuona amboinensis	Kura kura box turtle	1
Emys orbicularis	European pond turtle	3
Emydura krefftii	Krefft's turtle	3
Emydura macquaria	Murray turtle	8
Terrapene carolina	Box turtle	Many
Terrapene carolina triunguis	Three-toed box turtle	3
Terrapene ornata ornata	Western box turtle	2
Terrapene camlina bauri	Florida box turtle	2
Malaclemys terrapin	Diamondback turtle	4
Graptemys geographica	Map turtle	3
Graptemys barbouri	Barbour's turtle	7
Graptemys pseudogeographica	False map turtle	4
Chrysemys picta	Painted turtle	31
Psuedemys scripta callirostris	South American red-lined turtle	8
Pseudemys scripta troostii	Cumberland turtle	3
Pseudemys scripta elegans	Mobile turtle	12
Pseudemys scripta ssp	Yellow-bellied turtle	24
Pseudemys floridana	Florida water turtle	15
Pseudemys rubriventris	Red-bellied turtle	9
Pseudemys ornata	Central American turtle	2

REPTILES—Continued

CHELONIA—continued

Scientific name	Common name	Number
Emydidae—Continued		
Pseudemys decussata	Cuban water turtle	1
Batagur baska	Indian fresh-water turtle	1
Testudinae:		
Gopherus agassizi	Desert tortoise	1
Testudo pardalis	Leopard tortoise	1
Testudo elephantina	Giant Aldabra turtle	2
Testudo ephippium	Duncan Island turtle	3
Testudo tabulata	South American turtle	4
Testudo vicina	Galápagos turtle	2
Trionychidae:		
Trionyx ferox spinifera	Eastern soft-shelled turtle	3
Trionyx ferox	Florida soft-shelled turtle	2
Trionyx triunguis	African soft-shelled turtle	2
Pelomedusidae:		
Pelomedusa galeata	African water turtle	2
Pelusios nigricans	African black mud turtle	2
Podocnemis unifilis	Amazon spotted turtle	12
Chelidae:		
Chelodina longicollis	Australian side-necked turtle	3
Hydromedusa tectifera	Small side-necked turtle	2
Mesuclemmys gibba	South American gibba turtle	3
Phrynops geoffroyana	Geoffroy's side-necked turtle	1
Phrynops geoffroyana hilarii	Large side-necked turtle	12
Platemys platycephala	Flat-headed turtle	11
Batrachemys nasuta	South American side-necked turtle	2

AMPHIBIANS

CAUDATA

Scientific name	Common name	Number
Amphiumidae:		
Amphiuma means	Congo eel	6
Ambystomidae:		
Ambystoma tigrinum	Tiger salamander	1
Salamandridae:		
Diemictylus pyrrhogaster	Red-bellied or Japanese newt	14
Notopthalmus viridescens	Red-spotted or common newt	11

SALIENTIA

Scientific name	Common name	Number
Bufonidae:		
Bufo americanus	American toad	2
Bufo blombergii	Forest toad	2
Bufo marinus	Giant toad	4
Bufo paracnemis	Rococo toad	1
Bufo peltocephalus	Cuban toad	7
Pipidae:		
Pipa pipa	Surinam toad	29
Leptodactylidae:		
Ceratophrys calcarata	Colombian horned frog	2
Ceratophrys ornata	Argentine horned frog	1

AMPHIBIANS—Continued

SALIENTIA—continued

Scientific name	Common name	Number
Hylidae:		
Hyla cinerea	Green tree frog	1
Hyla versicolor	Gray tree frog	3
Microhylidae:		
Microhyla carolinensis	Narrow-mouthed toad	1
Ranidae:		
Rana adspersa	African bull frog	10
Rana catesbeiana	American bull frog	1
Rana clamitans	Green frog	20
Rana pipiens	Leopard frog	Many
Rhacophoridae:		
Hylambates maculatus	African flash tree frog	4
Dendrobatidae:		
Dendrobates auratus	Black poison-arrow frog	1
Dendrobates tinctorius	Green poisen-arrow frog	1
Dendrobates typographus	Yellow poison-arrow frog	2

ARTHROPODS

DECAPODA

Cenobitidae:		
Coenobita clypeatus	Land hermit crab	35

ARANEAE

Theraphosidae:		
Eurypelma hentzii	Tarantula	1
Theridiidae:		
Latrodectus mactans	Black-widow spider	1

SCORPIONIDA

Vejovidae:		
Vejovis spinigerus	Stripe-tailed scorpion	1

ORTHOPTERA

Blattidae:		
Periplaneta australasiae	Australian cockroach	Many

MOLLUSKS

PULMONATA

Limnaeidae:		
Helisoma trivolvis	Pond snails	Many

FISHES

OSTARIOPHYSI

Characidae:		
Metynnis roosevelti	Metynnis	2
Gymnotidae:		
Sternarchella schotti	African knifefish	2

FISHES—Continued

OSTARIOPHYSI—continued

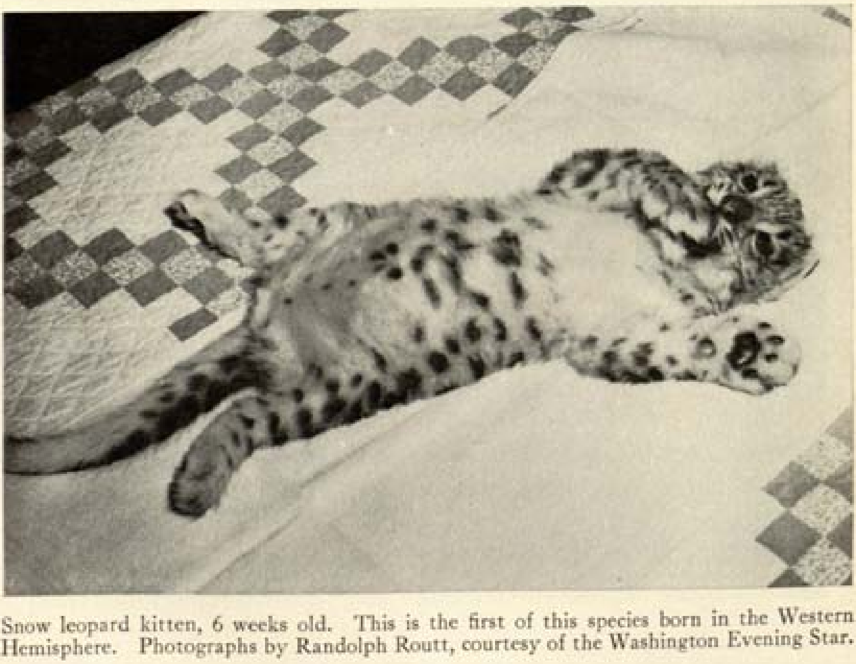
Scientific name	Common name	Number
Cyprinidae:		
Brachydanio rerio	Zebra danio-fish	14
Barbus everetti	Clown barb	1
Tanichthys albonubes	White Cloud Mountain fish	6
Electrophoridae:		
Electrophorus electricus	Electric eel	1
Cobitidae:		
Acanthophthalmus semicinctus	Kuhlii loach	1
Doradidae:		
Acanthodoras spinosissimus	Talking catfish	1
Callichthyidae:		
Plecostomus plecostomus	Armored catfish	2
Corydoras hastatus	Corydoras	2
Corydoras paleatus	Corydoras scavenger catfish	1
CYPRINODONTES		
Poeciliidae:		
Gambusia punctata	Blue gambusia	2
Mollienisia latipinna	Black molly	3
Lebistes reticulatus	Guppy	10
Lebistes reticulatus	Flag-tailed guppy	10
Xiphophorus maculatus	Platys or moonfish	1
LABYRINTHICI		
Anabantidae:		
Trichogaster trichopterus	Blue gourami	1
Anabas testudineus	Climbing perch	4
PERCOMORPHI		
Cichlidae:		
Haplochromis multicolor	Egyptian mouthbreeder	1
Tilapia sparrmani	Peacock cichlid	3
Pterophyllum eimekei	Angelfish	5
PLECTOGNATHI		
Lepidosirenidae:		
Protopterus annectens	African lungfish	1
Lepidosiren paradoxa	South American lungfish	1

GIRAFFES

During the past 20 years, the National Zoological Park has been very successful in breeding giraffes and gaur. A summary of both species is presented here, in order that it may be made a part of the permanent record.

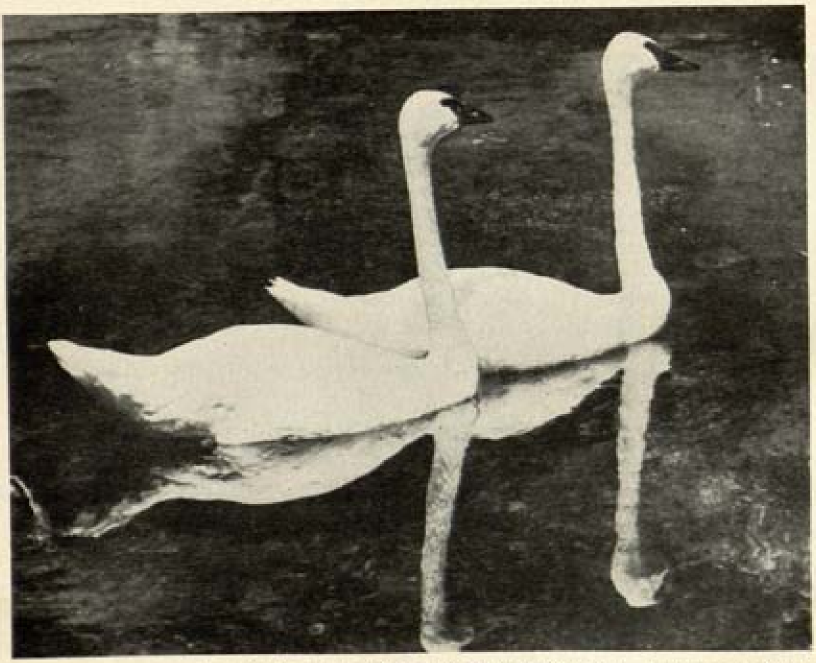
The first giraffes to come to the Zoo were a pair of Nubian giraffes obtained from the Game Department of the Sudan by Dr. William M. Mann on the Smithsonian Institution-Chrysler Expedition to East

Linsang—first one to be exhibited in the Western Hemisphere. Sent to the National Zoological Park by Lt. Col. Robert Traub, Kuala Lumpur, Malaya.



Snow leopard kitten, 6 weeks old. This is the first of this species born in the Western Hemisphere. Photographs by Randolph Routt, courtesy of the Washington Evening Star.

Indian elephant, 14-year-old male, displays his dental braces devised by Keeper Roger McDonald to prevent the tips of the tusks from growing together. Photograph by Francis Routt, courtesy of the Washington Evening Star.



Trumpeter swans, on deposit from the Fish and Wildlife Service. Largest of the swan family, these birds have been saved from extinction in the United States by the careful protection of the Fish and Wildlife Service. Photograph by Wellner Streets, courtesy of the Washington Daily News.

Africa in 1926. Known as Hi-Boy and Dot, they both succumbed to a kidney infection, one after a year, the other 3 months later.

There were no more giraffes in the collection until 1937, when the Smithsonian Institution-National Geographic Society Expedition to the Netherlands East Indies stopped in the Sudan on the way home and acquired four young ones, a pair of dark-spotted and a pair of light-spotted Nubian giraffes. The dark ones became known as Kitty and Bob. Bob died in 1956, but Kitty is still alive in the Zoo. The other pair were named Nicky (after a 10-year-old journalist who had campaigned for "giraffes for the National Zoo") and Nageoma, for National Geographic Magazine. Nicky died in December 1945, and Nageoma in July 1946.

The breeding record follows:

Nicky and Nageoma

March 4, 1945, female, Helen. Named for granddaughter of Dr. Gilbert Grosvenor, President, National Geographic Society. Still in Zoo.

Bob and Kitty

January 4, 1945, female, stillborn.

August 22, 1946, female, Twiga. Still in the Zoo.

October 2, 1948, male, Bedello (named after Walter Bedell Smith, who was the first visitor to see him). Sent to the Zoo in Fort Worth, Tex., April 18, 1952.

September 25, 1950, female. Sent to Taronga Park Zoo, Sydney, Australia, January 3, 1952.

December 29, 1952, female, Harriet. Sent to Honolulu Zoo, Hawaii, May 27, 1953.

February 23, 1955, female, Amelia. Gestation period 450 days. Sent to Catskill Game Farm, Catskill, N.Y., October 6, 1955.

January 12, 1957, male, Doc. Gestation period 454 days. Still in the Zoo.

Bob and Helen

February 3, 1951, female. Died February 9, 1951.

June 17, 1952, male, Harry. Died December 13, 1952.

March 29, 1954, female, Astrid. Gestation period 450 days. Sent to Catskill Game Farm, Catskill, N.Y., July 29, 1954.

September 16, 1956, male, Thomas. Gestation period 459 days. Died March 28, 1957.

Bob and Twiga

December 22, 1951, male, stillborn.

April 28, 1954, male, Frank. Gestation period 446 days. Sent to Catskill Game Farm, Catskill, N.Y., July 29, 1954.

April 25, 1956, female, Marta. Gestation period 451 days. Sent to Catskill Game Farm, Catskill, N.Y., August 20, 1956; now at "Africa U.S.A." Boca Raton, Fla.

A pair of reticulated giraffes about 3 years old were purchased June 21, 1939. The female died April 24, 1942; the male, Rufus, died November 13, 1956. They left no offspring.

GAUR

A pair of gaur were obtained in 1937 from Mysore, India, by the Smithsonian Institution-National Geographic Society Expedition to the East Indies. Their breeding record follows:

March 14, 1940, male. Sent to Philadelphia Zoological Gardens, Philadelphia, Pa., April 25, 1944.
September 3, 1941, male. Died May 31, 1942.
October 20, 1942, female. Died June 16, 1944.
December 23, 1943, male. Died February 19, 1946.
December 23, 1945, female. Died May 7, 1946.
February 10, 1946, male. Died May 4, 1947.
May 10, 1947, female.[1]
July 18, 1948, male.[1]
February 2, 1950, female. Exchanged May 25, 1955.
November 1, 1952, female, offspring of young pair.
August 12, 1953, male. Exchanged May 25, 1955.
August 22, 1954, female. Sent to St. Louis Zoo, St. Louis, Mo., April 26, 1956.
June 13, 1955, male. Sent to St. Louis Zoo, St. Louis, Mo., April 26, 1956.
February 12, 1956, male. Still in the Zoo.
March 5, 1957, female. Offspring of young pair. Died March 7, 1957.
March 18, 1958, male. Offspring of young pair. Still in the Zoo.

The high mortality rate is due, in almost every case, to the excitable temperament of these animals. The old male died on May 26, 1957, apparently of senility. The old female is still living, but she has not accepted the young male.

FINANCES

Funds for the operation of the National Zoological Park are appropriated annually under the District of Columbia appropriation act. The appropriation for the fiscal year 1958 totaled $833,000, which included a supplemental appropriation of $49,000. This was an increase of $113,000 over fiscal year 1957. The increase consisted of $49,000 for the conversion of keeper positions; $36,300, contributions to the Civil Service Retirement Fund; $22,595 to establish seven new positions, and $5,105 to cover costs of reallocations. Of the $833,000 appropriated, $619,165 was for salaries, leaving a balance of $213,835 for the operation of the Zoo. Included in this balance were major operational expenditures amounting to $177,513, consisting of $65,000 for animal food; $20,300 for fuel for heating; $29,325 for materials, building construction and repair; $34,218 for Civil Service Retirement Fund; $12,750 for purchase of animals; $8,900 for electricity; $5,000 for veterinarian equipment and supplies; and $2,000 for Federal Employees Group Life Insurance. The balance of $35,872 in operation funds was expended for other items including freight, tele-

[1] Kept at N. Z. P. for breeding; referred to hereafter as young pair.

phone, telegraph, and postal services, sundry supplies, uniforms, gasoline, road repair, equipment replacement, and purchase of new equipment.

PERSONNEL

After serving as Acting Director for 17 months, Dr. Theodore H. Reed was named Director on March 12, 1958. At the same time, J. Lear Grimmer, who had been Assistant Director, was named Associate Director.

James F. Wright, V.M.D., a graduate of the University of Pennsylvania, was appointed to fill the position of veterinarian. He comes to the Zoo with experience in private veterinary practice as well as service with the Department of Agriculture's Plum Island Animal Disease Laboratory, in Long Island, N.Y. He has a makeshift hospital in the Park, which it is hoped may some day be replaced with a more modern structure. His report for the year may be found on pages 171–174.

As of the beginning of the fiscal year, the animal keepers were converted from the GS classification to Wage Board. They are now on a pay level comparable with other skilled trades, such as carpenters and plumbers. It is believed that the present starting wage will attract good men and that the salary will induce them to stay in the Zoo.

There are 144 authorized positions at the Zoo, divided as follows: Administrative office 13, an increase of one property and supply clerk; animal department 53 (48 keepers, cook, exterminator, 2 laborers, and an increase of 1 storekeeper); police 23, an increase of 2; mechanical department 50, an increase of 2 laborers and 1 storekeeper; grounds department 5.

There has been a reorganization in the animal department. Ralph Norris is now head keeper and Malcolm Davis, who has had 30 years experience in the Zoo, is now associate head keeper. William Widman is senior keeper in the bird division, Charles Thomas in the division of large mammals, Bert Barker in the division of small mammals, and Mario DePrato in the reptile division. In the police department three men were promoted to the rank of Sergeant: Donald B. Bell, Earl A. King, and Aubrey L. Canter. In the mechanical shop, William G. Modena was made assistant superintendent of maintenance and construction.

INFORMATION AND EDUCATION

The Zoo continues to handle a large correspondence with persons all over the world who write for information regarding animals. From every part of this country citizens write to the Zoo as a national institution. Telephone calls come in constantly, asking for identification of animals, proper diets, or treatment of disease. Visitors to the office as well as to the animal exhibits are constantly seeking information.

Because of the ever-increasing demand for information concerning the care of animals in captivity, a series of 11 mimeographed leaflets has been written covering the care and feeding of the various animal families, ranging from invertebrates to primates. The leaflets are used to supplement correspondence and telephone inquiries on pet care and have proved successful in providing better service to the public.

The Associate Director gave five 4-hour sessions of training to six senior Boy and Girl Scouts. These youngsters are now qualified to guide troops of younger Scouts when they visit the Zoo.

The Director spoke before 6 civic clubs, 2 school groups, and 5 church groups; he also appeared on a television program and was interviewed on a radio program. He was coauthor, with Dr. Samuel W. Thompson, of "Toxoplasmosis in a Swamp Wallaby," published in the Journal of the American Veterinary Medical Association, December 15, 1957.

Malcolm Davis, associate head keeper, spoke before four civic clubs on "Penguins and Antarctica" and also showed slides to a school group. He has contributed articles and book reviews to All-Pets Magazine, the Audubon Magazine, the American Racing Pigeon News, the Aviculturist's Gazette, the Sentinel, and the Journal of Mammalogy. A group of rocky islands off Budd Coast, Antarctica, has been named Davis Islets in recognition of a biological survey made there by Mr. Davis in 1948 when he went to the South Pole with the U.S. Navy Expedition.

Mario DePrato made a collecting trip in the Dismal Swamp, Va., bringing back a number of interesting reptiles for the Zoo. William A. Xanten, Jr., a keeper in the reptile house, contributed a number of snakes and turtles obtained while he was on vacation in Florida.

William Widman, senior keeper in the birdhouse, spent 2 weeks in the Philadelphia Zoological Park, studying methods practiced there; and Bernard Gallagher, keeper in the small-mammals division, spent a week of official time in the Detroit Zoo, working and observing.

Ordinarily the Zoo does not conduct guided tours of the Park, but exceptions were made for groups of physically handicapped children who visited the Zoo. One group was from the District of Columbia Health School, whose children were brought by the Kiwanis Club, and another from the Silver Spring Intermediate School. Six children from the Pre-School for the Blind, Alexandria, Va., were brought by the Lions Club and were allowed to feel small animals and harmless reptiles. The District of Columbia Society for Crippled Children brought a group of 30. In all cases police and keepers were assigned to assist in showing the young students the exhibits.

Conducted tours were also given to a group of 211 biology students and 6 faculty members of Randolph-Macon Woman's College, Lynch-

burg, Va., and to 40 boys and girls who were winners in the annual Westinghouse Science Talent Search.

While the Zoo does not conduct a regular research program as such, every effort is made to study the animals and to improve their health, housing, and diet in any way possible.

VETERINARIAN'S REPORT

One of the most important activities of the veterinary department has been the application of the projectile type of syringe as an adjunct to therapy. The original work on this equipment was done at the University of Georgia and the Georgia Fish and Game Commission. They produced a temporary paralysis in wild deer, using nicotine alkaloid either alone or in combination with thiopental sodium. An attempt was made to adapt this method to the zoological collection, but met with very little success except in deer. The apparatus is used with little disturbance to animals in their captive habitat. Its most effective use is in the administration of antibiotics, antiserums, ataraxics (sedatives, narcotics, tranquilizers), and vaccines. With this type of therapy it is not necessary to rope, manhandle, trap, cage, or exhaust either animals or keepers to provide parenteral medication. It is successfully used both inside and outside of buildings and in small lots and large paddocks. As the operator seldom needs other help, considerable saving in man-hours and animals results. The following species have been successfully treated with this projectile type of syringe: elk, zebra, yak, tiger, pygmy hippopotamus, British Park bull, Saiga antelope, camel, elephant, kangaroo, bear, deer, Nile hippopotamus, and giraffe. The full details of these treatments are contained in a paper to be published later.

A severe case of necrotic stomatitis developed in the Zoo's bull elk during the winter, which prevented him from eating the usual rations. Special diet and the use of the projectile syringe are credited with effecting a cure. He is now in excellent health.

The youngest female giraffe was successfully treated with the projectile syringe method for bowel impaction and inappetence of 7 days' duration. Lacking this new equipment, it is doubtful that this animal could have been treated at all.

During the year a major dietary change was instituted by the Associate Director and was enthusiastically supported by the entire animal department. The diets for the carnivores and omnivores were patterned after those developed by the Philadelphia Zoological Park and in use successfully by that organization since 1935. It is too early to draw definite conclusions, but it is felt that these changes have already benefited the animal colonies by increased reproduction

and improved general condition. The technical aspects of the above diets have been published by the Zoological Society of Philadelphia.

A new herbivorous diet was developed by the animal department staff with gratifying results.

The feed for the reptile division is still being obtained from various governmental institutions in the area. Bacteriological isolations from several large snakes lost during the past year indicated that feed rodents may be carriers of reptilian pathogens. Specifically, several isolations of *Paracolobactrum arizonae* were made from medium-sized boas and pythons whose only source of infection could have been feed rats. This particular organism is nonpathogenic to rodents, but it will produce lesions in cold-blooded animals such as lizards and snakes. At the present time the pathogenicity of this particular organism is being investigated. At this writing isolations of this organism have been made from a regal python, an African python, a western diamondback rattlesnake, and the drain of the cage inhabited by the first two snakes. This problem happens to be the most interesting of several in the reptile division. Others are the high percentage of granulomatous lesions found in the organs of reptiles and the persistent remissions and exacerbations of the necrotizing lesions commonly known as "mouth rot."

In January 1958, the king cobra succumbed after less than a year and a half in the collection. At the time of death this individual had attained a length of 11 feet 9½ inches and a weight of 14½ pounds. The snake had been off its feed for almost 3 months, and no amount of coaxing could entice it to eat. Bacteriological cultures were negative for pathogens, but microscopic sections revealed granulomatous lesions in many internal organs. Grossly these lesions showed as white-spotted areas, especially noticeable in the liver. The small intestine contained many cestodes which seemed to be causing the snake no apparent distress.

One *Salmonella typhimurium* was isolated from a 9-foot regal python with ulcerative and necrotic enteritis. It was interesting to note that this individual was taken from the same cage inhabited by those snakes from which two of the aforementioned *arizonae* isolations were made. From at least one snake in this same cage an isolation of *Mycobacterium thamnopheos* has been made. Within a period of less than 2 months 2 regal pythons, 1 African python, 2 anacondas, and 2 emperor boas were lost from this cage.

In November 1957, 8 quokkas (*Setonix brachyurus*) were received from Perth, Australia, all of which seemed to be in good condition. However, a week after their arrival, one quokka was found dead (fighting). From this necropsy these animals were found to be harboring large numbers of *Austrostrongylus minutus* and smaller num-

bers of *Dipetalonema annulipapillata.* Other than these parasites, no gross lesions were recognized in this individual. The remaining animals were given antibiotics and oral anthelmintics (piperazine). A short time later a second quokka died from an intestinal intussusception. It was then noticed that most of the remaining animals were exhibiting exfoliative type of skin lesions, scrapings from which were negative. Necropsy findings on another animal dying at this time were grossly negative, except for the previously mentioned parasitism.

Between February and late May there began a progressive posterior paralysis of the remaining five quokkas. The skin trouble had virtually disappeared and the appetites remained good although sometimes variable. In addition to the vitamin and mineral supplements which these animals had been receiving for several months, injectable forms of vitamin E were administered. During this time all recommended diets had been offered and eaten. Despite the treatments and nutritional changes the paralysis progressed. Two of the animals were euthanized and the remaining ones died. Necropsies were done at the National Institutes of Health and the Armed Forces Institute of Pathology. As yet the preliminary reports from these agencies have shed no light on this peculiar and perplexing syndrome.

Eight albatrosses were received in December 1957 from U. S. Naval Installation at Midway Island. Four were black-footed and four were Laysan albatrosses. All seemed to be adults in good condition, but none would eat voluntarily. Forced feeding with trout and smelt fortified with vitamin capsules was begun, but in 2 weeks a Laysan died. None of the birds was self-feeding at this time and several were noticeably weaker. First necropsy findings were essentially negative except that very large numbers of *Tetrabothrium* cestodes were found in the small intestine.

Before the end of January three Laysan and two black-footed birds had been lost from terminal aspiration pneumonia, probably incurred through regurgitation of their forced feedings. Weakness continued to be prominent along with regurgitation of feedings. In February two more black-footed birds died, one of which was found to have slight pulmonary aspergillosis. The remaining bird was removed to another building with its own water tank, where it was felt that the atmosphere would be more humid. This individual died late in March with lipid pneumonia, probably from the oil on the force-fed fish.

After losing all eight birds it was evident that the necropsy findings were secondary, but what the primary condition had been was not known. Recently it was learned that several albatrosses were being successfully kept at Pennsylvania State University by adding

salt (NaCl) to their diet. Apparently these birds secrete sodium chloride in amounts that require heavy dietary supplementation. In reviewing the Zoo's cases it was noted that the symptoms were consistent with salt depletion.

The Zoo's pair of gorillas developed an intestinal malady caused by a heavy infestation with *Balantidium coli*. Fortunately this condition was quickly checked by daily oral administration of carbasone.

Of the 12 Adelie penguins received in February, 4 remain and seem to be in good health. Deaths in this group were caused by aspergillosis as in the past. The cooperative aspergillosis research program with these birds conducted by Dr. William Sladen of Johns Hopkins University and Dr. C. Herman of Fish and Wildlife Service continued. A new antifungal drug was tried this year for the first time with some degree of success.

The pangolin (*Manis pentadactyla*) received in February from Formosa died in mid-June from grossly undetermined causes. Microscopic findings have not been reported as yet.

Pigeons caught in the Park were sent to Major Thompson at the Fitzsimons Army Hospital in Denver, Colo., for a toxoplasmosis incidence survey, results of which indicate small probability of a reservoir in these birds.

Mechanical injury to the tail of the male cheetah necessitated surgical removal of the terminal 3 inches of the appendage. The combination of ataraxics and short-acting barbiturates proved a desirable anesthetic in this case, and long-acting antibiotics obtained a favorable outcome.

Bacteriological isolations, over 260 in all, were performed by Dr. Francis R. Lucas of Centreville, Md. Dr. Lucas also assisted with histopathological sections, blood analyses, and virus isolation attempts.

Dr. Thomas Peery of the George Washington University has assisted the Zoo with histopathological slides and pathological interpretations. Identification of endoparasites was supplied by Mr. McIntosh and Mrs. Chitwood of the Department of Agriculture.

Following are the statistics for the mortality rates during the past fiscal year and a table of comparison with the past 6 years:

Mortality, fiscal year 1958

	Deaths	Attrition [1]
Mammals	102	14
Birds	181	34
Reptiles	142	77
Total	425	125

Total mortality, past 6 fiscal years

1953	672
1954	648
1955	735
1956	618
1957	549
1958	550

[1] Attrition is term used for those losses due mainly to the trauma of shipment and handling after accession at the Zoo, or before an animal can adapt to cage habitation within the collection.

COOPERATION

At all times special efforts are made to maintain friendly contacts with other Federal and State agencies, private concerns and individuals, and scientific workers for mutual assistance. As a result the Zoo receives much help and advice and many valuable animals, and in turn it furnishes information and, whenever possible, animals it does not need.

Special acknowledgment is due Howard Fyfe, United States Dispatch Agent in New York City, and Stephen E. Lato, Dispatch Agent in San Francisco. They are frequently called upon to clear shipments of animals coming from abroad, often at great personal inconvenience. The animals have been forwarded to Washington without the loss of a single individual.

The food subsidies section, D.C. Department of Food Services, gave 3,400 pounds of wheat flour not salvageable for human consumption. The U.S. Soldiers Home gave 94 sacks of hard wheat flour and 30 sacks of soft wheat flour. The poultry division of the Department of Agriculture gave several thousand day-old chicks, which are good food for many young animals. The National Institutes of Health cooperated in many ways, helping with postmortems, giving valuable advice, and donating surplus laboratory animals, some of which were exhibited and some used as food. Laboratory animals that had served their purpose were also donated by the Army Medical Center and the Navy Medical Center.

In August 1957, owing to an outbreak of botulism among the North American waterfowl, it became necessary to drain and clean the ponds. Both the District of Columbia Fire Department and the District Sanitation Department cooperated in this task, lending the Zoo hoses and other equipment.

Several times during the year the National Zoological Park has lent various small native animals to National Capital Park naturalists for exhibition at special programs. The Zoo has received aid and assistance in exhibition, and several species, from this organization.

In December 1957 eight male deer were lent to the Christmas Pageant of Peace, held annually on the Ellipse grounds in Washington.

VISITORS

Attendance at the Zoo this year reached a total of 4,028,620. In general this figure is based on estimates rather than actual counts.

Estimated number of visitors in fiscal year 1958

July (1957)	566, 720	January (1958)	123, 900
August	425, 700	February	49, 225
September	403, 400	March	339, 500
October	328, 050	April	583, 915
November	197, 500	May	447, 300
December	164, 050	June	399, 350
		Total	4, 028, 620

Number of bus groups

Locality	Number of groups	Number in groups	Locality	Number of groups	Number in groups
Alabama	31	1, 437	Minnesota	3	107
Arkansas	1	36	Mississippi	9	363
California	1	137	Montana	1	38
Connecticut	4	244	Nebraska	2	188
Delaware	11	472	New Hampshire	2	71
District of Columbia	68	2, 867	New Jersey	16	1, 231
			New York	55	8, 271
Florida	16	3, 665	North Carolina	250	13, 341
Georgia	52	10, 035	Ohio	30	1, 541
Illinois	5	224	Pennsylvania	174	12, 306
Indiana	9	374	Rhode Island	1	108
Kansas	1	25	South Carolina	55	2, 567
Kentucky	10	477	Tennessee	56	2, 759
Louisiana	2	101	Texas	2	833
Maine	9	436	U.S.A	3	35
Maryland	380	31, 297	West Virginia	62	4, 554
Massachusetts	11	394	Wisconsin	1	442
Michigan	4	574			
			Total	1, 337	99, 515

Groups from foreign countries

Canada	1	92	Peru	1	51
China	1	18	Puerto Rico	1	140
Denmark	4	44	Sweden	2	19
Formosa	1	5	Spain	1	20
Japan	1	37	Foreign Exchange students	1	800
Mexico	2	45			
Norway	14	341			
Pakistan	1	38	Total	31	1, 650

About 2 p.m. each day the cars then parked in the Zoo are counted and listed according to the State, Territory, or country from which they come. This is, of course, not a census of the cars coming to the

Zoo but is valuable in showing the percentage of attendance by States of people in private automobiles. Many District of Columbia, Maryland, and Virginia cars come to the Zoo to bring guests from other States. The tabulation for the fiscal year 1958 is as follows:

	Percent		Percent
Maryland	30.5	Illinois	0.7
District of Columbia	21.5	South Carolina	0.7
Virginia	19.3	Michigan	0.7
Pennsylvania	4.0	Tennessee	0.6
New York	2.6	Texas	0.6
North Carolina	2.2	Georgia	0.5
New Jersey	1.6	Indiana	0.4
Ohio	1.5	Delaware	0.4
West Virginia	1.2	Minnesota	0.3
Florida	1.1	Wisconsin	0.3
Massachusetts	0.9	Kentucky	0.3
California	0.8		
Connecticut	0.8		94.0

The remaining 6 percent came from other States, Alaska, Bahamas, Belgium, British Columbia, Canada, Canal Zone, Cuba, England, Germany, Guatemala, Hawaii, Honduras, Italy, Japan, Mexico, New Brunswick, Newfoundland, Nova Scotia, Okinawa, Philippine Islands, Saskatchewan, and the West Indies.

On the days of even small attendance there are cars parked in the Zoo from at least 15 States, Territories, the District of Columbia, and foreign countries. On average days there are cars from about 22 States, Territories, the District of Columbia, and foreign countries; and during the periods of greatest attendance the cars represent not less than 34 different States, Territories, and countries.

Parking spaces in the Zoo now accommodate 1,079 cars when the bus parking place is utilized, and 969 cars when it is not used.

GROUNDS, BUILDINGS, AND ENCLOSURES

During the year there were extensive replacements, remodeling, and repairs to paddocks, cages, and water lines. Roofs were repaired and roads and sidewalks patched.

Two zebra paddocks were enlarged, and the old cookhouse was remodeled and refurbished to facilitate the new method of preparing foods. A special experimental cage was constructed behind the bird house for the secluded study of species of birds that do not adapt themselves well to exhibition.

A stationary air compressor has been installed in the shop area.

The basement space under the big tortoises' enclosure in the reptile house was opened up and made into a storage room. An insect-raising room was constructed in the basement of the reptile house, and

the animal department now has centralized and consolidated their mealworm raising.

A new map of the National Zoological Park, showing the location of all buildings and exhibits, was prepared, and copies of it, suitably framed, have been placed at various locations throughout the Park.

Following the tragic death of a little girl who was mauled by a lion in the Zoo on May 16, 1958, a study was begun to eliminate any danger points in the buildings and grounds. Wire mesh has been placed on some of the guard rails, and further precautions will be taken when the report of an independent committee investigating safety measures has been completed. The National Zoological Park has always had a fine record of safety: since 1908, when records were first kept of the number of annual visitors, approximately 115,000,000 people have visited the Zoo without one instance of serious injury. The accident in May resulted in the first fatality.

The work of the gardener's force has been mainly that of removing dead trees, which are a menace to both animals and visitors, and replacing them with young trees. The animal department is furnished with forage which is very beneficial for animals. Heavy logs for the big cats to climb, perches and sawed hollow logs for small mammals, gnawing logs for rodents, and perches for birds are supplied on demand, and tropical plants for indoor cages and the buildings are supplied and cared for.

The accumulation of trash is still a major problem, although the installation of larger trash receptacles and a number of "litter-bug" signs posted at strategic spots have helped in keeping the Park presentable.

With the increase in the number of visitors, the work of the police in maintaining order and protecting the public and the animals is constantly growing. New police officers have been authorized for next year, and temporary men are appointed for the summer months, but the force is still inadequate. The number of visitors who stopped at police headquarters to ask for information or to receive first aid was 7,000.

PLANS FOR THE FUTURE

Owing to lack of appropriated funds, no major improvements were undertaken during the fiscal year. The old buildings continue to deteriorate, and even the newest exhibition building is now 21 years old and needs painting and repairs. Ten enclosures, including the pools for exhibition of aquatic mammals, have been abandoned for nearly 11 years. It is hoped that in the near future funds will be appropriated for the following badly needed new construction and improvements:

Buildings.—A building to house antelopes and other hoofed animals that require a heated building. The present structure, built in 1898 for $3,500, is inadequate, dimly lighted, and poorly ventilated. The building houses a miscellaneous collection of cats, kangaroos, gaur, anoas, and others. The Zoo has made it a policy not to purchase or accept antelopes because of the lack of housing for them.

A new administration building to replace the 153-year-old historic landmark, which is still in use as an office building but is not well adapted for the purpose. Termites destroyed the photographic file last year, and most of the Zoo library has now been moved to the second floor of the building to postpone the day when the invaders will attack this valuable collection of scientific books. A thorough examination of the office was made by the District of Columbia Department of Buildings and Grounds, which recommended that unless extensive repairs are undertaken immediately, the building be condemned as unsafe.

A hospital, which will also serve as a fireproof receiving station for animals shipped in, for quarantining them when necessary, and with facilities for caring for those in ill health. This building should also contain an office and a laboratory for the veterinarian. There is no structure within the National Zoological Park suitable for conversion into an animal hospital. The building now in use is an ancient stone house, formerly used as a hay barn and storage shed, which was hastily cleaned out and sketchily furnished at the time the veterinarian was appointed in 1955.

Enclosures.—Enclosures and pools for beavers, otters, seals, and nutrias, which cannot be adequately cared for or exhibited under existing conditions.

New paddocks for the exhibition of such animals as deer, sheep, goats, and other hoofed animals, to provide for the exhibition of a greater assortment of these attractive and valuable animals.

Installations.—Extensive remodeling of some of the buildings is needed to bring them up to date with the latest techniques of zoological exhibits and make them more pleasing esthetically for the visitors and ecologically for the animals.

Respectfully submitted.

THEODORE H. REED, *Director*.

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Canal Zone Biological Area

SIR: It gives me pleasure to present herewith the annual report on the Canal Zone Biological Area for the fiscal year ended June 30, 1958.

SCIENTISTS, STUDENTS, AND OBSERVERS

Following is the list of 43 scientists, students, and observers who visited the island last year and stayed for several days, in order to conduct scientific research or observe the wildlife of the area:

Name	*Principal interest*
Alexander, Dr. T., University of Miami, Fla.	Tropical research.
Anderson, Eugene, Santa Monica, Calif.	Bird observation.
Bartel, Mr. and Mrs. James, Pomona, Calif.	Wildlife photography and bird observation.
Boyden, Dr. Alan, Rutgers University, N.J.	Studies in comparative serology.
Brooks, Dr. Robert, Williams College, Williamstown, Mass.	Bird observation.
Brown, Mr. and Mrs. W. L., Toronto, Canada.	Bird watching and bird photography.
Bruno, Kent, Ohio State University.	Assistant to Dr. Hartman.
Buren, Dr. William F., Public Health Service, El Paso, Tex.	Study of ants.
Chickering, Dr. A. M., Cambridge, Mass.	Study of spiders.
Cox, George, University of Illinois.	Preparatory visit to arrange research on energy requirements of tropical birds.
Enders, Dr. Robert K., Swarthmore College.	Study of mammals and vegetation of the island.
Fast, Arthur, Arlington, Va.	Bird study and observation.
Groner, Miss Dorothy, Los Angeles, Calif.	Wildlife photography and bird observation.
Hartman, Dr. Frank, Ohio State University.	Muscle studies of birds and adrenal gland.
Henry, Mr. and Mrs. Thomas R., Washington, D.C.	Science writer.
Hughes-Schrader, Dr. Sally, Columbia University.	Insect cytology.

Name	*Principal interest*
Johnson, Dr. M., Rutgers University, N.J.	Research on apical meristems of tropical woody plants.
Keddy, Dr. and Mrs. J. L., Smithsonian Institution.	Inspection of facilities and wildlife observation.
Kendeigh, S. Charles, University of Illinois.	Preparatory visit to arrange research on energy requirements of tropical birds.
Kessler, Dietrich, University of Wisconsin.	Wildlife observation.
Klingener, David, Swarthmore College.	Research on fungus-growing ants and their fungi.
Loomis, Mr. and Mrs. H. F., Miami, Fla.	Collection of millipeds.
Pearson, Dr. Paul, Rutgers University, N.J.	Studies in comparative serology.
Prescott, G. W., Michigan State University.	Supplementary collections of plankton from Gatun Lake.
Snow, Dr. David, New York Zoological Society.	Bird observation.
Snyder, Miss Dorothy, Peabody Museum, Salem, Mass.	Bird observation.
Stultz, Mr. and Mrs. O. M., El Monte, Calif.	Wildlife photography and bird observation.
Taabor, Dr. Henry J., San Francisco, Calif.	Wildlife observation and collection of plants and insects.
Usinger, Dr. R. L., University of California.	Main interest is ectoparasites, especially bedbugs and polyctenids on birds and bats.
Walch, Miss Carolyn, Johns Hopkins University.	Wildlife observation.
Weber, Dr. Neal A., Swarthmore College.	Research on fungus-growing ants and their fungi.
Weil, Mrs. Gertrude W., University of California	Wildlife observation.
Weil, John, University of California	Wildlife observation.
Wetmore, Dr. and Mrs. Alexander, Washington, D.C.	Bird observation.
Woodring, Dr. W. P., Washington, D.C.	The stratigraphic relations of fossiliferous beds of early Tertiary age in the Gatun Lake area near Barro Colorado Island.
Wyse, Gordon B., Swarthmore College.	Wildlife observation.

Research and observations were also conducted by some 75 other individuals who spent one day and night on the island.

VISITORS

Approximately 570 visitors were permitted to visit the island for the day. Most of them came on Tuesdays and Saturdays, when they were conducted on guided tours through the jungle.

RAINFALL

During the dry season (January through April) of the calendar year 1957, rains of 0.01 inch or more fell during 20 days (33 hours) and amounted to 1.20 inches, as compared to 12.53 inches during 1956. During the wet season of 1957 (May through December), rains of 0.01 inch or more fell on 176 days (647 hours) and amounted to 96.77 inches, as compared to 101.42 inches during 1956. Total rainfall for

TABLE 1.—*Annual rainfall, Barro Colorado Island, C. Z.*

Year	Total inches	Station average	Year	Total inches	Station average
1925	104. 37	----------	1942	111. 10	108. 55
1926	118. 22	113. 56	1943	120. 29	109. 20
1927	116. 36	114. 68	1944	111. 96	109. 30
1928	101. 52	111. 35	1945	120. 42	109. 84
1929	87. 84	106. 56	1946	87. 38	108. 81
1930	76. 57	101. 51	1947	77. 92	107. 49
1931	123. 30	104. 69	1948	83. 16	106. 43
1932	113. 52	105. 76	1949	114. 86	106. 76
1933	101. 73	105. 32	1950	114. 51	107. 07
1934	122. 42	107. 04	1951	112. 72	107. 28
1935	143. 42	110. 35	1952	97. 68	106. 94
1936	93. 88	108. 98	1953	104. 97	106. 87
1937	124. 13	110. 12	1954	105. 68	106. 82
1938	117. 09	110. 62	1955	114. 42	107. 09
1939	115. 47	110. 94	1956	114. 05	107. 30
1940	86. 51	109. 43	1957	97. 97	106. 98
1941	91. 82	108. 41			

TABLE 2.—*Comparison of 1956 and 1957 rainfall, Barro Colorado Island* (inches)

Month	Total		Station average	Years of record	1957 excess or deficiency	Accumulated excess or deficiency
	1956	1957				
January	*5.57*	*0.56*	*2.14*	*33*	*−1.58*	*−1.58*
February	*2.11*	*0.57*	*1.22*	*33*	*−0.65*	*−2.23*
March	*2.24*	*0.02*	*1.15*	*33*	*−1.13*	*−3.36*
April	*2.61*	*0.05*	*2.94*	*33*	*−2.89*	*−6.25*
May	16.55	6.37	10.87	33	−4.50	−10.75
June	6.85	5.97	10.95	33	−4.98	−15.73
July	19.55	10.86	11.78	33	−0.92	−16.65
August	9.48	21.90	12.48	33	+9.42	−7.23
September	11.27	12.40	10.04	33	+2.36	−4.87
October	18.64	17.22	14.00	33	+3.22	−1.65
November	12.37	17.96	18.79	33	−0.83	−2.48
December	6.81	4.09	10.62	33	−6.53	−9.01
Year	114.05	97.97	106.98			−9.01
Dry season	12.53	1.20	7.45	----------	----------	−6.25
Wet season	101.52	96.77	99.53	----------	----------	−2.76

the year was 97.97 inches. During 33 years of record the wettest year was 1935 with 143.42 inches, and the driest year was 1930, with only 76.57 inches. March was the driest month of 1957 (0.02 inch) and August the wettest (21.90 inches). The maximum records for short periods were: 5 minutes 1.30 inches; 10 minutes 1.65 inches; 1 hour 4.11 inches; 2 hours 4.81 inches; 24 hours 10.48 inches.

BUILDINGS, EQUIPMENT, AND IMPROVEMENTS

Special attention was paid during the year to the improvement and expansion of existing facilities.

The library on the island was greatly enlarged and altered and was moved to the lower floor of the new building to make it more accessible and provide space for improved arrangement of books. A great many new books and journals have been received, more will be added, and many old books and journals have been bound or rebound. A temporary librarian was engaged to catalog the whole collection, which should make it much more useful to visiting scientists and students. Air-conditioning was installed in the new library room in order to preserve the books and to provide greater comfort for persons using the library facilities.

Two large aviaries and many smaller cages were built, and many species of Panamanian birds are now being kept in captivity on the island for experimental and observational purposes. New insect cages and vivaria have been ordered. Eight hygrothermographs were ordered making it possible to keep extensive records of temperature and humidity conditions in different parts of the island. An Ampex 201 sound recorder, with accessories, and a Kodak K–100 turret camera were bought. A portable canvas blind was constructed for use in the field; and various minor items of trapping and laboratory equipment, including mist nets, an ultraviolet lamp, new dissecting kits, and thermometers were also purchased.

A new 30-hp. Mercury outboard motor was bought to provide a means of rapid communication with the mainland in case of emergencies and also to facilitate fieldwork in the more remote regions of Gatun Lake and the Chagres River. A 4-hp. Dragonfly air-drive outboard motor was purchased to facilitate research work along the shoreline of the island and the adjacent mainland. Large tents, cots, and gasoline stoves were also obtained and will be available to scientists and students wishing to camp for a few days on the far side of the island.

Many new items of office equipment, including two new typewriters, lamps, desks, tables, and chairs were purchased for use in the Balboa office at Diablo Heights and in the laboratory and library on the island.

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A reinforced 12,000-gallon concrete water tank was built back of the old laboratory. This will assure a steady water supply for the expanding needs of the station.

Barbour House was provided with new toilet and shower facilities, additional dry-closet space, and a concrete septic tank. The old Zetek House was divided into two sections, one of which is being used as living quarters and the other as a storeroom and office. A new Caterpillar generator was installed on the island and has greatly improved the electricity situation.

Other routine repair and maintenance activities included the repainting of the outside and inside of all the station buildings, small repairs to the gasoline winch engine, rebuilding the dock on the island, rebuilding the Frijoles dock site, and repairing the trackway from the Frijoles railroad station to the dock.

The labor situation on the island has been greatly improved by the hiring of three additional temporary laborers, and another office assistant was engaged to take care of increased office work in Balboa and on the island.

OTHER ACTIVITIES

A program was initiated to encourage promising young scientists to come to the Canal Zone Biological Area to conduct special research projects. The first of these temporary assistants was C. F. Bennett, Jr., of the Department of Geography at the University of California at Los Angeles, who is studying temperature and humidity gradients in the forest during the rainy season.

The National Science Foundation has provided financial support for two research projects to be conducted or supervised by the Resident Naturalist. The first will be a 3-year study of the behavior and evolution of certain neotropical birds, and the second will be a 6-month study of certain behavior patterns of sphingid and saturniid moths. This program will be carried out by a research assistant, Dr. A. D. Blest, of University College, London.

PLANS AND REQUIREMENTS

As it seems probable that there will be an increasing number of scientists and students coming to the Canal Zone Biological Area in future years, remaining for longer periods of time and bringing their families with them, somewhat more comfortable and more private living quarters are urgently required.

It is planned to remodel the second floor of the old laboratory building, to make available separate rooms and additional washing and toilet facilities. Chapman House is in a very bad state of repair, having been heavily infested with termites in previous years and should

be remodeled or replaced to provide more private living quarters and more work space.

Because the problem of storing materials on the island is becoming acute, it is planned to build a separate storage shed.

Plans for relocating the island dock have been abandoned, as there is no convenient alternative site available where the silting problem would not be equally serious. It has been decided, therefore, to have the old channel beside the present dock redredged, and arrangements for this work have already been made.

It is also planned to replace the old winch as well as the launch U.S. *Moon*, which is beginning to show signs of deterioration.

In connection with the research projects of the station staff, more facilities for keeping animals in captivity and conducting experimental work under suitable conditions will be constructed.

Several other projects supported by the National Science Foundation, including a study of the energy requirements of tropical birds by Dr. S. Charles Kendeigh and George Cox of the University of Illinois and a life-history study of the coati by John H. Kaufmann of the University of California, may also require more cages and constant-temperature chambers.

The program of graduate assistantships will be continued, and every effort will be made to provide all the facilities which future assistants may need in their work.

The expansion of the library will continue.

It is also hoped to extend the field of research by the station staff to some part of the mainland. The island itself is, of course, almost completely covered by heavy mature forest. This is extremely valuable; but it would also be useful to be able to do intensive, long-term, and undisturbed work in other areas of different ecology. An attempt will be made to obtain access to some area of grassland, or mixed grassland and brush, on the mainland near Gamboa. This will provide ecologists and students of animal behavior with a much greater range of opportunities.

FINANCES

Trust funds for maintenance of the island and its living facilities are obtained by collections from visitors and scientists, table subscriptions, and donations.

The following institutions continued their support to the laboratory through the payment of table subscriptions:

Eastman Kodak Co	$1,000.00
New York Zoological Society	300.00
Smithsonian Institution	300.00

C. M. Goethe's donations during the year are gratefully acknowledged.

ACKNOWLEDGMENTS

The Canal Zone Biological Area can operate only with the excellent cooperation of the Canal Zone Government and the Panama Canal Company. Thanks are due especially to the Executive Secretary Paul Runnestrand and his staff, the Customs and Immigration officials, and the Police Division. The technical advice and assistance provided by P. Alton White, chief of the Dredging Division, and members of his staff, by C. W. Soper of the Eastman Kodak Co., and by Lt. K. E. McCall and other members of the Signal Corps Meteorological Team No. 2, were also invaluable.

Respectfully submitted.

MARTIN H. MOYNIHAN,
Resident Naturalist.

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the International Exchange Service

SIR: I have the honor to submit the following report on the activities of the International Exchange Service for the fiscal year ended June 30, 1958:

The Smithsonian Institution is the official United States agency for the exchange with other nations of governmental, scientific, and literary publications. The International Exchange Service, initiated by the Smithsonian Institution in the early years of its existence for the interchange of scientific publications between learned societies and individuals in the United States and those of foreign countries, serves as a means of developing and executing in part the broad and comprehensive objective, "the diffusion of knowledge." It was later designated by the United States Government as the agency for the transmission of official documents to selected depositories throughout the world, and it continues to execute the exchanges pursuant to conventions, treaties, and other international agreements.

The number of packages of publications received for transmission during the year was 1,094,798, a decrease of 110,241 packages under the previous fiscal year. The weight of the packages received was 743,329 pounds, a decrease of 84,568 pounds. During the current year 19 Government depository sets were assembled for transmission abroad as compared to 21 sets assembled during the previous fiscal year. The reduction in the number of Government sets assembled, together with the use of corrugated cardboard boxes in place of wood boxes for packing the Government sets for transmission, accounted for 14,000 pounds of the decrease in weight. One Government department transmitted during the previous fiscal year 71,500 pounds of publications that had accumulated during World War II and transmitted only 258 pounds of backlog publications during the current year.

The average weight of the individual package decreased to 10.86 ounces as compared to the 10.99-ounce average for the fiscal year of 1957.

The publications received from foreign sources for addressees in the United States and from domestic sources for shipment abroad are classified as shown in the following table:

Classification	Packages		Weight	
	Number	*Number*	*Pounds*	*Pounds*
United States parliamentary documents sent abroad	590,366		225,365	
Publications received in return for parliamentary documents		8,226		13,385
United States departmental documents sent abroad	221,460		187,605	
Publications received in return for departmental documents		7,219		16,742
Miscellaneous scientific and literary publications sent abroad	198,141		199,968	
Miscellaneous scientific and literary publications received from abroad for distribution in the United States		69,386		100,264
Total	1,009,967	84,831	612,938	130,391
Grand total	1,094,798		743,329	

The packages of publications are forwarded to the exchange bureaus of foreign countries by freight or, where shipment by such means is impractical, to the foreign addressees by direct mail. Distribution in the United States of the publications received through the foreign exchange bureaus is accomplished primarily by mail, but by other means when more economical. The number of boxes shipped to the foreign exchange bureaus was 3,082, or 50 less than for the previous year. Of these boxes 999 were for depositories of full sets of United States Government documents, these publications being furnished in exchange for the official publications of foreign governments which are received for deposit in the Library of Congress. The weight of packages forwarded by mail and by means other than freight was 271,560 pounds.

There was allocated to the International Exchange Service for transportation $31,800. With this amount it was possible to effect the shipment of 818,887 pounds, which was 40,184 pounds less than was shipped in the previous year. However, approximately 6,891 pounds of the full sets of United States Government documents accumulated during the year because the Library of Congress had requested suspension of shipment to certain foreign depositories.

During the year, ocean freight rates per cubic foot continued at the 1957 level. However, on November 5, 1957, a number of carriers filed a special rate for hauling books and periodicals to the Baltimore piers amounting to about a 20 percent reduction.

With the exception of those to Taiwan, no shipments are being made to China, North Korea, Outer Mongolia, and Communist-controlled area of Viet-Nam, or Communist-controlled area of Laos.

FOREIGN DEPOSITORIES OF GOVERNMENTAL DOCUMENTS

The number of sets of United States official publications received by the Exchange Service for transmission abroad in return for the official publications sent by foreign governments for deposit in the Library of Congress is now 106 (63 full and 43 partial sets), listed below. Changes that occurred during the year are shown in the footnotes.

DEPOSITORIES OF FULL SETS

ARGENTINA: División Biblioteca, Ministerio de Relaciones Exteriores y Culto, Buenos Aires.
AUSTRALIA: Commonwealth Parliament and National Library, Canberra.
NEW SOUTH WALES: Public Library of New South Wales, Sydney.
QUEENSLAND: Parliamentary Library, Brisbane.
SOUTH AUSTRALIA: Public Library of South Australia, Adelaide.
TASMANIA: Parliamentary Library, Hobart.
VICTORIA: Public Library of Victoria, Melbourne.
WESTERN AUSTRALIA: State Library, Perth.[1]
AUSTRIA: Administrative Library, Federal Chancellery, Vienna.
BELGIUM: Bibliothèque Royale, Bruxelles.
BRAZIL: Biblioteca Nacional, Rio de Janeiro.
BULGARIA: Bulgarian Bibliographical Institute, Sofia.[2]
BURMA: Government Book Depot, Rangoon.
CANADA: Library of Parliament, Ottawa.
MANITOBA: Provincial Library, Winnipeg.
ONTARIO: Legislative Library, Toronto.
QUEBEC: Library of the Legislature of the Province of Quebec.
CEYLON: Department of Information, Government of Ceylon, Colombo.
CHILE: Biblioteca Nacional, Santiago.
CHINA: National Central Library, Taipei, Taiwan.
National Chengchi University, Taipei, Taiwan.
COLOMBIA: Biblioteca Nacional, Bogotá.
COSTA RICA: Biblioteca Nacional, San José.
CUBA: Ministerio de Estado, Canje Internacional, Habana.
CZECHOSLOVAKIA: University Library, Prague.
DENMARK: Institut Danois des Échanges Internationaux, Copenhagen.
EGYPT: Bureau des Publications, Ministère des Finances, Cairo.
FINLAND: Parliamentary Library, Helsinki.
FRANCE: Bibliothèque Nationale, Paris.
GERMANY: Deutsche Staatsbibliothek, Berlin.
Free University of Berlin, Berlin-Dahlem.
Parliamentary Library, Bonn.
GREAT BRITAIN:
ENGLAND: British Museum, London.
LONDON: London School of Economics and Political Science. (Depository of the London County Council.)
HUNGARY: Library of Parliament, Budapest.[3]
INDIA: National Library, Calcutta.
Central Secretariat Library, New Delhi.
Parliament Library, New Delhi.[3]

[1] Changed from Public Library of Western Australia, Perth.
[2] Shipment suspended.
[3] Added during the year.

INDONESIA: Ministry for Foreign Affairs, Djakarta.

IRELAND: National Library of Ireland, Dublin.

ISRAEL: State Archives and Library, Hakirya, Jerusalem.

ITALY: Ministerio della Pubblica Istruzione, Rome.

JAPAN: National Diet Library, Tokyo.[4]

MEXICO: Secretaria de Relaciones Exteriores, Departmento de Información para el Extranjero, México, D. F.

NETHERLANDS: Royal Library, The Hague.

NEW ZEALAND: General Assembly Library, Wellington.

NORWAY: Utenriksdepartmentets Bibliothek, Oslo.

PERU: Sección de Propaganda y Publicaciones, Ministerio de Relaciones Exteriores, Lima.

PHILIPPINES: Bureau of Public Libraries, Department of Education, Manila.

POLAND: Bibliothèque Nacionale, Warsaw.[2]

PORTUGAL: Biblioteca Nacional, Lisbon.

SPAIN: Biblioteca Nacional, Madrid.

SWEDEN: Kungliga Biblioteket, Stockholm.

SWITZERLAND: Bibliothèque Centrale Fédérale, Berne.

TURKEY: National Library, Ankara.[5]

UNION OF SOUTH AFRICA: State Library, Pretoria, Transvaal.

UNION OF SOVIET SOCIALIST REPUBLICS: All-Union Lenin Library, Moscow.

UNITED NATIONS: Library of the United Nations, Geneva, Switzerland.

URUGUAY: Oficina de Canje Internacional de Publicaciones, Montevideo.

VENEZUELA: Biblioteca Nacional, Caracas.

YUGOSLAVIA: Bibliografski Institut, Belgrade.[4]

DEPOSITORIES OF PARTIAL SETS

AFGHANISTAN: Library of the Afghan Academy, Kabul.

BOLIVIA: Biblioteca del Ministerio de Relaciones Exteriores y Culto, La Paz.

BRAZIL:

MINAS GERAIS: Directoria Geral de Estatistica em Minas, Belo Horizonte.

BRITISH GUIANA: Government Secretary's Office, Georgetown, Demerara.

CANADA:

ALBERTA: Provincial Library, Edmonton.

BRITISH COLUMBIA: Provincial Library, Victoria.

NEW BRUNSWICK: Legislative Library, Fredericton.

NEWFOUNDLAND: Department of Provincial Affairs, St. John's.

NOVA SCOTIA: Provincial Secretary of Nova Scotia, Halifax.

SASKATCHEWAN: Legislative Library, Regina.

DOMINICAN REPUBLIC: Biblioteca de la Universidad de Santo Domingo, Ciudad Trujillo.

ECUADOR: Biblioteca Nacional, Quito.

EL SALVADOR:

Biblioteca Nacional, San Salvador.

Ministerio de Relaciones Exteriores, San Salvador.

GREECE: National Library, Athens.

GUATEMALA: Biblioteca Nacional, Guatemala.

HAITI: Bibliothèque Nationale, Port-au-Prince.

[4] Receives two sets.

[5] Changed from Department of Printing and Engraving, Ministry of Education, Istanbul.

HONDURAS:

Biblioteca Nacional, Tegucigalpa.[6]

Ministerio de Relaciones Exteriores, Tegucigalpa.

ICELAND: National Library, Reykjavik.

INDIA:

BOMBAY: Secretary to the Government, Bombay.

BIHAR: Revenue Department, Patna.

UTTAR PRADESH:

University of Allahabad, Allahabad.

Secretariat Library, Lucknow.

WEST BENGAL: Library, West Bengal Legislative Secretariat, Assembly House, Calcutta.

IRAN: Imperial Ministry of Education, Tehran.

IRAQ: Public Library, Baghdad.

JAMAICA:

Colonial Secretary, Kingston.

University College of the West Indies, St. Andrew.

LEBANON: American University of Beirut, Beirut.

LIBERIA: Department of State, Monrovia.

MALAYA: Federal Secretariat, Federation of Malaya, Kuala Lumpur.

MALTA: Minister for the Treasury, Valletta.

NICARAGUA: Ministerio de Relaciones Exteriores, Managua.

PAKISTAN: Central Secretariat Library, Karachi.

PANAMA: Ministerio de Relaciones Exteriores, Panamá.

PARAGUAY: Ministerio de Relaciones Exteriores, Sección Biblioteca, Asunción.

PHILIPPINES: House of Representatives, Manila.

SCOTLAND: National Library of Scotland, Edinburgh.

SIAM: National Library, Bangkok.

SINGAPORE: Chief Secretary, Government Offices, Singapore.

SUDAN: Gordon Memorial College, Khartoum.

VATICAN CITY: Biblioteca Apostolica Vaticana, Vatican City.

INTERPARLIAMENTARY EXCHANGE OF THE OFFICIAL JOURNAL

There are now being sent abroad 80 copies of the Federal Register and 91 copies of the Congressional Record. This is an increase over the preceding year of 3 copies of the Federal Register and of 2 copies of the Congressional Record. The countries to which these journals are being forwarded are given in the following list:

DEPOSITORIES OF CONGRESSIONAL RECORD AND FEDERAL REGISTER

ARGENTINA:

Biblioteca de la H. Legislatura de Mendoza, Mendoza.[8 7]

Biblioteca del Poder Judicial, Mendoza.[8]

Boletín Oficial de la República Argentina, Ministerio de Justica e Instrucción Pública, Buenos Aires.

Cámara de Diputados Oficina de Información Parlamentaria, Buenos Aires.

[6] Changed from Biblioteca y Archivo Nacionales.

[7] Congressional Record only.

[8] Federal Register only.

AUSTRALIA:

Commonwealth Parliament and National Library, Canberra.

NEW SOUTH WALES: Library of Parliament of New South Wales, Sydney.

QUEENSLAND: Chief Secretary's Office, Brisbane.

VICTORIA: Public Library of Victoria, Melbourne.[8]

WESTERN AUSTRALIA: Library of Parliament of Western Australia, Perth.

BRAZIL: Secretaria de Presidencia, Rio de Janeiro.[7]

BRITISH HONDURAS: Colonial Secretary, Belize.

CANADA:

Library of Parliament, Ottawa.

Clerk of the Senate, Houses of Parliament, Ottawa.

CEYLON: Ceylon Ministry of Defense and External Affairs, Colombo.[7]

CHINA:

Legislative Yuan, Taipei, Taiwan.[7]

Taiwan Provincial Government, Taipei, Taiwan.

CUBA:

Biblioteca del Capitolio, Habana.

Biblioteca Pública Panamericana, Habana.[8]

CZECHOSLOVAKIA: Ceskoslovenska Akademie Ved, Prague.[7]

EGYPT: Ministry of Foreign Affairs, Egyptian Government, Cairo.[7]

FRANCE:

Bibliothèque Assemblée Nationale, Paris.

Bibliothèque Conseil de la République, Paris.

Library, Organization for European Economic Cooperation, Paris.[7]

Research Department, Council of Europe, Strasbourg.[7]

Service de la Documentation Étrangère, Assemblée Nationale, Paris.[7]

GERMANY:

Amerika-Institut der Universität München, München.[7]

Archiv, Deutscher Bundestag, Bonn.

Bibliothek der Instituts für Weltwirtschaft an der Universität Kiel, Kiel-Wik.

Bibliothek Hessischer Landtag, Wiesbaden.[7]

Der Bayrische Landtag, Munich.[7, 8]

Deutschen Institiut fur Rechtswissenschaft, Potsdam-Babelsberg II.[8]

Deutscher Bundesrat, Bonn.[7]

Deutscher Bundestag, Bonn.[7]

Hamburgisches Welt-Wirtschafts-Archiv, Hamburg.

GHANA: Chief Secretary's Office, Accra.[7]

GREAT BRITAIN:

Department of Printed Books, British Museum, London.

House of Commons Library, London.[7]

N. P. P. Warehouse, H. M. Stationery Office, London.[8, 9, 10]

Printed Library of the Foreign Office, London.

Royal Institute of International Affairs, London.[7]

GREECE: Bibliothèque, Chambre des Députés Hellénique, Athens.

GUATEMALA: Biblioteca de la Asamblea Legislativa, Guatemala.

HAITI: Bibliothèque Nationale, Port-au-Prince.

HONDURAS: Biblioteca del Congreso Nacional, Tegucigalpa.

HUNGARY: National Library, Budapest.

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[9] Three copies.

[10] Two copies.

INDIA:
- Civil Secretariat Library, Lucknow, United Provinces.[8]
- Indian Council of World Affairs, New Delhi.[7]
- Jammu and Kashmir Constituent Assembly, Srinagar.[7]
- Legislative Assembly, Government of Assam, Shillong.[7]
- Legislative Assembly Library, Lucknow, United Provinces.
- Legislative Assembly Library, Trivandrum.[7]
- Madras State Legislature, Madras.[7]
- Parliament Library, New Delhi.
- Servants of Indian Society, Poona.[7]

IRELAND: Dail Eireann, Dublin.

ISRAEL: Library of the Knesset, Jerusalem.

ITALY:
- Biblioteca Camera dei Deputati, Rome.
- Biblioteca del Senato della Republica, Rome.
- Periodicals Unit, Food and Agriculture Organization of the United Nations, Rome.[8]
- International Institute for the Unification of Private Law, Rome.[8]

JAPAN:
- Library of the National Diet, Tokyo.
- Ministry of Finance, Tokyo.

JORDAN: Parliament of the Hashemite Kingdom of Jordan, Amman.[7]

KOREA: Secretary General, National Assembly, Seoul.

LUXEMBOURG: Assemblée Commune de la C. E. C. A., Luxembourg.

MEXICO:
- Dirección General Information, Secretaría de Gobernación, Mexico, D. F.
- Biblioteca Benjamin Franklin, México, D. F.
- AGUASCALIENTES: Gobernador del Estado de Aguascalientes, Aguascalientes.
- BAJA CALIFORNIA: Gobernador del Distrito Norte, Mexicali.
- CAMPECHE: Gobernador del Estado de Campeche, Campeche.
- CHIAPAS: Gobernador del Estado de Chiapas, Tuxtla Guitiérrez.
- CHIHUAHUA: Gobernador del Estado de Chihuahua, Chihuahua.
- COAHUILA: Periódico Oficial del Estado de Coahuila, Palacio de Gobierno, Saltillo.
- COLIMA: Gobernador del Estado de Colima, Colima.
- GUANAJUATO: Secretaría General de Gobierno del Estado, Guanajuato.[8]
- JALISCO: Biblioteca del Estado, Guadalajara.
- MÉXICO: Gaceta del Gobierno, Toluca.
- MICHOACÁN: Secretaría General de Gobierno del Estado de Michoacán, Morelia.
- MORELOS: Palacio de Gobierno, Cuernavaca.
- NAYARIT: Gobernador de Nayarit, Tepic.
- NUEVO LEÓN: Biblioteca del Estado Monterrey.
- OAXACA: Periódico Oficial, Palacio de Gobierno, Oaxaca.[8]
- PUEBLA: Secretaría General de Gobierno, Puebla.
- QUERÉTARO: Secretaría General de Gobierno, Sección de Archivo, Querétaro.
- SINALOA: Gobernador del Estado de Sinaloa, Culiacán.
- SONORA: Gobernador del Estado de Sonora, Hermosillo.
- TAMAULIPAS: Secretaría General de Gobierno, Victoria.
- VERACRUZ: Gobernador del Estado de Veracruz, Departamento de Gobernación y Justicia, Jalapa.
- YUCATÁN: Gobernador del Estado de Yucatán, Mérida.

NETHERLANDS: Koninklijke Bibliotheek, The Hague.[9]
NEW ZEALAND: General Assembly Library, Wellington.
NORWAY: Library of the Norwegian Parliament, Oslo.
PANAMA: Biblioteca Nacional, Panama City.[7]
PHILIPPINES: House of Representatives, Manila.[3]
POLAND: Kancelaria Rady, Panstwa, Biblioteka Sejmova, Warsaw.
PORTUGUESE TIMOR: Repartição Central de Administração Civil, Dili.[9]
SWITZERLAND: Bibliothèque, Bureau International du Travail, Geneva.[9]
International Labor Office, Geneva.[9, 10]
Library, United Nations, Geneva.
UNION OF SOUTH AFRICA:
CAPE OF GOOD HOPE: Library of Parliament, Cape Town.
TRANSVAAL: State Library, Pretoria.
UNION OF SOVIET SOCIALIST REPUBLICS: Fundamental'niia Biblioteka Obschestvennykh Nauk, Moscow.
URUGUAY: Diario Oficial, Calle Florida 1178, Montevideo.

FOREIGN EXCHANGE SERVICES

Exchange publications for addresses in the countries listed below are forwarded by freight to the exchange services of those countries. Exchange publications for addresses in other countries are forwarded directly by mail.

LIST OF EXCHANGE SERVICES

AUSTRIA: Austrian National Library, Vienna.
BELGIUM: Service des Échanges Internationaux, Bibliothèque Royale de Belgique, Bruxelles.
CHINA: National Central Library, Taipei, Taiwan.
CZECHOSLOVAKIA: Bureau of International Exchanges, University Library, Prague.
DENMARK: Institut Danois des Échanges Internationaux, Bibliothèque Royale, Copenhagen.
EGYPT: Government Press, Publications Office, Bulaq, Cairo.
FINLAND: Delegation of the Scientific Societies, Helsinki.
FRANCE: Service des Échanges Internationaux, Bibliothèque Nationale, Paris.
GERMANY (Eastern): Deutsche Staatsbibliothek, Berlin.
GERMANY (Western): Deutsche Forschungsgemeinschaft, Bad Godesberg.
HUNGARY: National Library, Széchényi, Budapest.
INDIA: Government Printing and Stationery, Bombay.
INDONESIA: Minister of Education, Djakarta.
ISRAEL: Jewish National and University Library, Jerusalem.
ITALY: Ufficio degli Scambi Internazionali, Ministero della Pubblica Istruzione, Rome.
JAPAN: Division of International Affairs, National Diet Library, Tokyo.
NETHERLANDS: International Exchange Bureau of the Netherlands, Royal Library, The Hague.
NEW SOUTH WALES: Public Library of New South Wales, Sydney.
NEW ZEALAND: General Assembly Library, Wellington.

NORWAY: Service Norvégien des Échanges Internationaux, Bibliothèque de l'Université Royale, Oslo.

PHILIPPINES: Bureau of Public Libraries, Department of Education, Manila.

POLAND: Service Polonais des Échanges Internationaux, Bibliothèque Nationale, Warsaw.

PORTUGAL: Secção de Trocas Internacionais, Biblioteca Nacional, Lisbon.

QUEENSLAND: Bureau of International Exchange of Publications, Chief Secretary's Office, Brisbane.

RUMANIA: International Exchange Service, Biblioteca Centrala de Stat, Bucharest.

SOUTH AUSTRALIA: South Australian Government Exchanges Bureau, Government Printing and Stationery Office, Adelaide.

SPAIN: Junta de Intercambio y Adquisición de Libros y Revistas para Bibliotecas Públicas, Ministerio de Educación Nacional, Madrid.

SWEDEN: Kungliga Biblioteket, Stockholm.

SWITZERLAND: Service Suisse des Échanges Internationaux, Bibliothèque Centrale Fédérale, Palais Fédéral, Berne.

TASMANIA: Secretary of the Premier, Hobart.

TURKEY: National Library, Ankara.

UNION OF SOUTH AFRICA: Government Printing and Stationery Office, Cape Town.

UNION OF SOVIET SOCIALIST REPUBLICS: Bureau of Book Exchange, State Lenin Library, Moscow.

VICTORIA: Public Library of Victoria, Melbourne.

WESTERN AUSTRALIA: State Library, Perth.

YUGOSLAVIA: Bibliografski Institut FNRJ, Belgrade.

Dan G. Williams, Jr., who was employed by the Smithsonian Institution on February 25, 1946, and who was promoted to Chief, International Exchange Service, on August 22, 1948, transferred to the Department of Health, Education, and Welfare, Birmingham, Ala., on March 7, 1958. The undersigned was appointed Chief of the Service on March 10, 1958.

Respectfully submitted.

J. A. COLLINS, *Chief*.

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the National Gallery of Art

SIR: I have the honor to submit, on behalf of the Board of Trustees, the twenty-first annual report of the National Gallery of Art, for the fiscal year ended June 30, 1958. This report is made pursuant to the provisions of section 5 (d) of Public Resolution No. 14, 75th Congress, first session, approved March 24, 1937 (50 Stat. 51).

ORGANIZATION

The statutory members of the Board of Trustees of the National Gallery of Art are the Chief Justice of the United States, the Secretary of State, the Secretary of the Treasury, and the Secretary of the Smithsonian Institution, ex officio. The five general trustees continuing in office during the fiscal year ended June 30, 1958, were Chester Dale, Ferdinand Lammot Belin, Duncan Phillips, Paul Mellon, and Rush H. Kress. On May 1, 1958, Chester Dale was reelected by the Board of Trustees to serve as President of the Gallery and Ferdinand Lammot Belin was reelected Vice President.

The executive officers of the Gallery as of June 30, 1958, are as follows:

Huntington Cairns, Secretary-Treasurer.
John Walker, Director.
Ernest R. Feidler, Administrator.
Huntington Cairns, General Counsel.
Perry B. Cott, Chief Curator.

The three standing committees of the Board, as constituted at the annual meeting on May 1, 1958, were as follows:

EXECUTIVE COMMITTEE

Chief Justice of the United States, Earl Warren, Chairman.
Chester Dale, Vice Chairman.
Ferdinand Lammot Belin.
Secretary of the Smithsonian Institution, Leonard Carmichael.
Paul Mellon.

FINANCE COMMITTEE

Secretary of the Treasury, Robert B. Anderson, Chairman.
Chester Dale, Vice Chairman.
Ferdinand Lammot Belin.
Secretary of the Smithsonian Institution, Leonard Carmichael.
Paul Mellon.

ACQUISITIONS COMMITTEE

Ferdinand Lammot Belin, Chairman.
Duncan Phillips.
Chester Dale.
Paul Mellon.
John Walker.

PERSONNEL

On June 30, 1958, full-time Government employees on the staff of the National Gallery of Art numbered 317 as compared with 313 employees as of June 30, 1957. The United States Civil Service regulations govern the appointment of employees paid from appropriated public funds.

Negotiations with the Civil Service Commission which had extended over several years finally resulted in raising the grade level of the guard staff one full grade. In addition, 18 other positions were reclassified upward, including the Curator of Education, the Curator of the Index of American Design, and the Curator of Graphic Arts.

APPROPRIATIONS

For the fiscal year ended June 30, 1958, Congress in the regular annual appropriation for the National Gallery of Art provided $1,645,000 to be used for salaries and expenses in the operation and upkeep of the Gallery, the protection and care of works of art acquired by the Board of Trustees, and all administrative expenses incident thereto, as authorized by Joint Resolution of Congress approved March 24, 1937 (20 U.S.C. 71–75; 50 Stat. 51). Congress also included in a supplemental appropriation act $31,580 to cover pay increases authorized by P.L. 85–462, approved June 20, 1958. The total appropriation for the fiscal year was $1,676,580. The following expenditures and encumbrances were incurred:

Personal services	$1, 360, 824. 00
Other than personal services	315, 756. 00
Total	1, 676, 580. 00

ATTENDANCE

There were 913,481 visitors to the Gallery during the fiscal year 1958, as compared to 942,196 for the fiscal year 1957. The average daily number of visitors was 2,516.

ACCESSIONS

There were 1,730 accessions by the National Gallery of Art as gifts, loans, or deposits during the fiscal year.

Gifts

The following 6 paintings and 1,310 bronzes were given to the National Gallery of Art by the Samuel H. Kress Foundation in exchange for 26 paintings and 6 pieces of sculpture:

Artist	*Title*
Van Dyck	Dona Polyxena Spinola Guzman de Leganes.
Rubens	Decius Mus Addressing the Legions.
Titian	Vincenzo Capello.
El Greco	Christ Cleansing the Temple.
Andrea del Sarto	Charity.
Titian	St. John the Evangelist on Patmos.
Florentine School, XVI Century.	Lion (bronze).
Sienese School, XV Century	The Capitoline Wolf (bronze).
Francesco di Giorgio	Winged Figure with Cornucopia (bronze).
Warin	Cardinal Richelieu (bronze).
Various	1,306 small bronzes.

Col. and Mrs. E. W. Garbisch gave "Mount Auburn Cemetery, Cambridge," by Thomas Chambers, in exchange for two portraits by Erastus Field which they had previously given to the Gallery.

During the year the following gifts or bequests were also accepted by the Board of Trustees:

PAINTINGS

Donor	*Artist*	*Title*
Chester Dale	Stuart	Sir Robert Liston.
Eugene S. Pleasonton	Neagle	Colonel Augustus James Pleasonton.
Lewis Einstein	Veronese	Agostino Barberigo.
Clarence Y. Palitz	Lucas Cranach the Elder.	Nymph of Spring.
Mrs. Mary E. Carnegie	Sargent	Mrs. Joseph Chamberlain.
Gen. Charles L. Lindemann.	Courbet	La Grotte de la Loue.
Col. and Mrs. E. W. Garbisch.	Unknown	Mr. Willson.
Col. and Mrs. E. W. Garbisch.	Badger	Captain Isaac Foster.
Col. and Mrs. E. W. Garbisch.	Badger	Mrs. Isaac Foster.
Col. and Mrs. E. W. Garbisch.	Badger	Dr. Isaac Foster, Jr.
Col. and Mrs. E. W. Garbisch.	Badger	Dr. William Foster.
Col. and Mrs. E. W. Garbisch.	Chipman	Melons and Grapes.
Col. and Mrs. E. W. Garbisch.	Unknown	Aurora—Goddess of the Morning.
Col. and Mrs. E. W. Garbisch.	Coe	Henry W. Houston.
Col. and Mrs. E. W. Garbisch.	Unknown	The Dog.

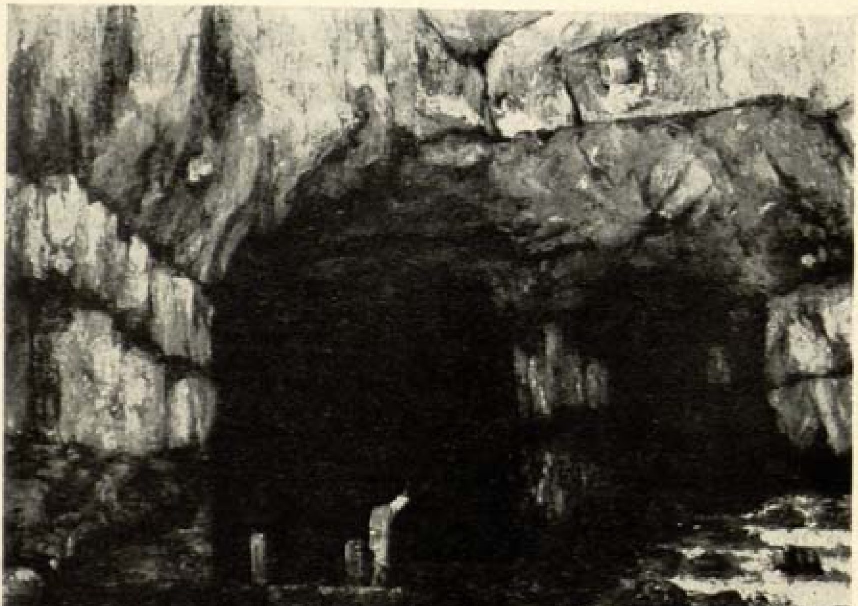
DECORATIVE ARTS

George D. Widener and Mrs. Eleanor W. Dixon.	French-Eighteenth Century.	Paneled Room with Appointments.

St. John the Evangelist on Patmos: Titian. Samuel H. Kress Collection, National Gallery of Art.

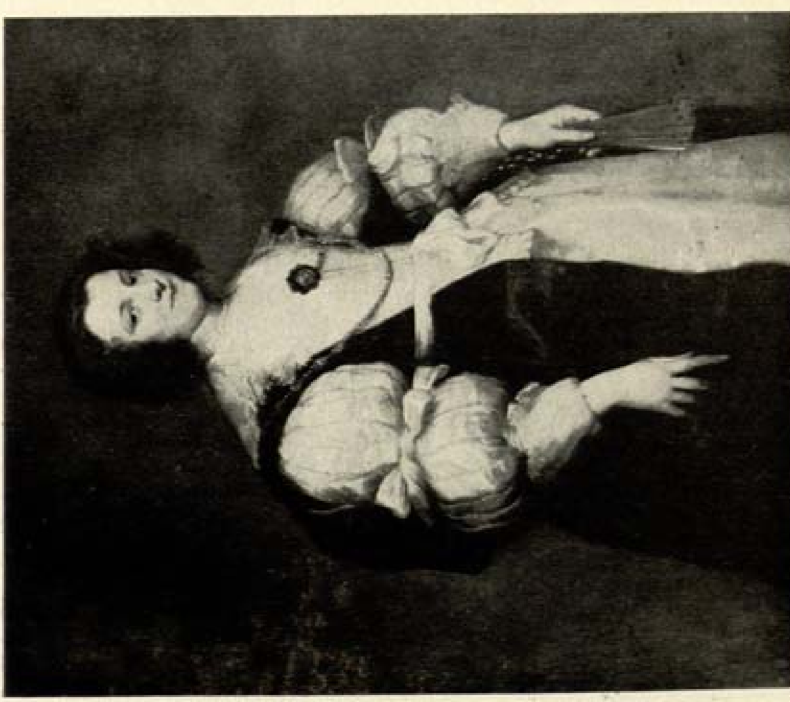
Christ Cleansing the Temple: El Greco. Samuel H. Kress Collection, National Gallery of Art.

Decius Mus Addressing the Legions: Peter Paul Rubens. Samuel H. Kress Collection, National Gallery of Art.



La Grotte de la Loue: Gustave Courbet. Gift of Charles L. Lindemann to the National Gallery of Art.

Charity: Andrea del Sarto. Samuel H. Kress Collection, National Gallery of Art.



Dona Polyxena Spinola Guzman: Van Dyck. Samuel H. Kress Collection, National Gallery of Art.

Sir Robert Liston: Gilbert Stuart. Chester Dale Collection, National Gallery of Art.

Vincenzo Capello: Titian. Samuel H. Kress Collection, National Gallery of Art.

PRINTS AND DRAWINGS

Donor	*Artist*	*Title*
Lessing J. Rosenwald	Burgkmair	The Battle of Padua.
Lessing J. Rosenwald	Master of Cologne Arms.	Christ and the Woman of Samaria.
Lessing J. Rosenwald	Anonymous German.	Calvary.
(Purchased from Print Purchase Fund).	Homer	30 wood engravings.
(Purchased from Print Purchase Fund).	Homer	2 lithographs.

WORKS OF ART ON LOAN

The following works of art were received on loan by the Gallery:

From:	*Artist*
Chester Dale, New York, N.Y.:	
The Seine at Giverny	Monet.
Blue Morning	Bellows.
Samuel H. Kress Foundation, New York, N.Y.:	
Bronze Andiron (Mars)	Sansovino.
Bronze Andiron (Venus)	Sansovino.
Altar Candlestick	Briosco.
Madonna and Child	French School, First Half XIV Century.
Saint Mary Cleophas and Her Family	Strigel.
Col. and Mrs. Edgar W. Garbisch, New York, N.Y.:	
Twenty-three early American paintings.	
Robert Woods Bliss, Washington, D.C.:	
Seven objects of Pre-Columbian art.	
Mrs. Eugene Meyer, Washington, D.C.:	
Still Life	Manet.
Chateau Noir	Cezanne.
Vase of Flowers	Cezanne.
The Sailor	Cezanne.
Still Life	Cezanne.
Still Life	Dufresne.
Nude	Renoir.
Man Lying on a Sofa	Renoir.

WORKS OF ART ON LOAN RETURNED

The following works of art on loan were returned during the fiscal year:

To:	*Artist*
Robert Woods Bliss, Washington, D.C.:	
Twelve objects of Pre-Columbian art.	
Col. and Mrs. Edgar W. Garbisch, New York, N.Y.:	
Twenty-four early American paintings.	
Mr. and Mrs. Charles B. Wrightsman, Palm Beach, Fla.:	
La Causette	Pissarro.
Sketch for the Staircase Ceiling in Wurzburg	Tiepolo.

To:	*Artist*
Mrs. Eugene Meyer, Washington, D.C.:	
Still Life	Manet.
Chateau Noir	Cezanne.
Vase of Flowers	Cezanne.
The Sailor	Cezanne.
Still Life	Cezanne.
Still Life	Dufresne.
Nude	Renoir.
Man Lying on a Sofa	Renoir.

WORKS OF ART LENT

During the fiscal year the Gallery lent the following works of art for exhibition purposes:

To:	*Artist*
American Embassy, Paris:	
America (tapestry)	17th Century Brussels.
The Flight into Egypt (drawing)	Tiepolo.
Design for Fresco for a Ceiling (drawing).	Tiepolo.
American Embassy, Brussels:	
Apollo and Daphne (tapestry)	Gobelins, French School.
Carnegie Institute, Pittsburgh, Pa.:	
Siegfried and the Rhine Maidens	Ryder.
The White Girl	Whistler.
Connecticut Historical Society, Hartford, Conn.:	
Girl in Pink Dress	Unknown.
Lady with Plumed Headdress	Unknown.
Charles Adams Wheeler	Unknown.
Father and Son	Buddington.
Brooklyn Museum, Brooklyn, N.Y.:	
Mrs. Richard Yates	Stuart.
New York State Historical Association, Cooperstown, N.Y.:	
Alice Slade	Unknown.
Joseph Slade	Unknown.
International Exhibition, Brussels:	
Miss Van Alen	Attributed to P. Vanderlyn.
Flowers and Fruit	Unknown.
Flax Scutching Bee	Park.
Benjamin Reber's Farm	Hofman.
The Trotter	Unknown.
Baltimore Museum of Art, Baltimore, Md.:	
Right and Left	Homer.
Woodlawn Plantation, Mt. Vernon, Virginia:	
General Washington at Princeton	Polk.
Alexander Hamilton Bicentennial Commission, Washington, D.C.:	
Alexander Hamilton	Trumbull.
Virginia 350th Anniversary, Jamestown Festival, Williamsburg, Va.:	
Pocahontas	British School.

EXHIBITIONS

The following exhibitions were held at the National Gallery of Art during the fiscal year 1958:

"One Hundred Years of Architecture in America," exhibition celebrating the Centennial of the American Institute of Architects. Continued from previous fiscal year, through July 14, 1957.

American Primitive Paintings from the Collection of Edgar William and Bernice Chrysler Garbisch—a selection of the outstanding works from the first two exhibitions of this Collection at the National Gallery of Art. July 24, 1957, through September 16, 1957.

American Paintings from the Collection of the National Gallery of Art. August 1, 1957, through September 15, 1957.

The Art of William Blake—commemorating the 200th anniversary of the birth of the artist. October 19, 1957, through December 1, 1957.

Exhibition of Masterpieces of Korean Art, sponsored by the Government of the Republic of Korea. December 15, 1957, through January 12, 1958.

Illuminated Manuscript Pages from the Rosenwald Collection, and North Italian Engravings from the Rosenwald Collection and Gifts from W. G. Russell Allen. December 21, 1957, through February 12, 1958.

The Fantastic, the Occult, and the Bizarre in Prints from the Rosenwald Collection. March 15, 1958, through May 11, 1958.

Exhibition of Photographs by Alfred Stieglitz. March 16, 1958, through April 27, 1958.

American Paintings from the Collection of the National Gallery of Art. May 16, 1958, to continue into the next fiscal year.

TRAVELING EXHIBITIONS

Rosenwald Collection.—Special exhibitions of prints from the Rosenwald Collection were circulated to the following places during the fiscal year 1958:

Achenbach Foundation for Graphic Arts, California Palace of the Legion of Honor, San Francisco, Calif.:

"The Printmaker 1450–1950," 26 prints______ September 1957.

Los Angeles County Museum, Los Angeles, Calif.:

"Jacques Callot," 59 prints______ September 17–October 20, 1957.

Smithsonian Traveling Exhibition Service, Washington, D.C.:

"Contemporary German Prints" (exhibition tour).

Extended from October 1957 through the spring of 1958.

American Federation of Arts, New York, N.Y.:

"The Life of Christ in Prints," a circulating exhibition of 50 prints.

Indiana University Art Gallery, Bloomington, Ind.:	
"Baudelaire and the Graphic Arts," 10 prints and drawings	October 25–November 17, 1957.
Whitechapel Art Gallery, London, England:	
S. W. Hayter, 2 prints	November 1957.
Cosmopolitan Club of Philadelphia, Philadelphia, Pa.:	
Blake, 10 prints and 1 drawing	November 1957, last 3 weeks.
Smith College Museum of Art, Northhampton, Mass.:	
Special study exhibition of Renaissance art, 16 prints	November 18–December 20, 1957.
Currier Gallery of Art, Manchester, N.H.:	
Christmas Exhibition, 20 prints	November 27–December 29, 1957.
Philadelphia Museum of Art, Philadelphia, Pa.:	
Large retrospective Picasso Exhibition, 15 prints	December 1957.
University of Minnesota, Duluth Branch, Duluth, Minn.:	
Christmas Exhibition, 1 print	December 1957.
Fine Arts Gallery of San Diego, San Diego, Calif.:	
"The Madonna in Art," 3 prints	December 6–29, 1957.
Columbia Museum of Art, Columbia, S.C.:	
Picasso, "Sculptor's Studio," 46 prints	February 1–28, 1958.
Art Department, Notre Dame University, Notre Dame, Ind.:	
Lenten Exhibition (Passion of Christ), 3 sets of Dürer prints (63 prints in all)	February 26–April 5, 1958.
Philadelphia Museum of Art, Philadelphia, Pa.:	
"Original Pieces of Sculpture by Aristide Maillol," 2 prints, 2 drawings (to show with above exhibition)	April 15–May 15, 1958.
Barber-Scotia College, Concord, N.C.:	
Festival of Fine Arts. 30 prints	May 1–17, 1958.
Smithsonian Traveling Exhibition Service, Washington, D. C.:	
Exhibition, "George Bellows—Prints and Drawings," 19 prints	Extended from May 1958 through December 1958.
Museum of Art of Ogunquit, Ogunquit, Maine:	
Mary Cassatt, 14 prints and drawings	June 15, through first week in September 1958.

Index of American Design.—During the fiscal year 1958, 18 traveling exhibitions (including 870 plates) with 26 bookings were circulated in the following States:

State	*Number of exhibitions*	*State*	*Number of exhibitions*
California	1	Pennsylvania	9
Colorado	1	Tennessee	2
Connecticut	2	Texas	2
New Jersey	1	Utah	7
New York	1		

Two traveling exhibitions (including 71 plates) with 14 bookings in 11 States were circulated by the Smithsonian Traveling Exhibition Service.

Four traveling exhibitions (including 110 plates) with 7 bookings in Virginia were circulated by the Virginia Museum of Fine Arts.

One traveling exhibition (including 80 plates) was circulated by the United States Information Agency in Germany.

CURATORIAL ACTIVITIES

The curatorial department accessioned 1,383 gifts to the Gallery during the fiscal year 1958. Advice was given regarding 341 works of art brought to the Gallery for expert opinion and nine visits to collections were made by members of the staff in connection with offers of gifts or for expert opinion. About 2,150 inquiries requiring research were answered verbally and by letter.

Dr. Perry B. Cott, chief curator, was a guest of the Federal Republic of Germany for a 4-week tour of German museums with a group of American museum officials. Dr. Cott gave the following lectures during the year: "Some German Art Centers Revisited—1957" before the Municipal Art Society of Baltimore, Md., and "Observations on Italian and Spanish Painting in the Samuel H. Kress Collection" at the Museum of Fine Arts, Houston, Tex. He also spoke on "Business and the Arts" on the occasion of the opening of the Samuel H. Kress Collection in the Brooks Memorial Art Gallery, Memphis, Tenn. Dr. Erwin O. Christensen, curator of decorative arts, gave seven lectures to USIA groups and two lectures to National Education Association schoolteachers on the Index of American Design. Miss Elizabeth Mongan, curator of graphic arts, spoke on Blake at the Cosmopolitan Club in Philadelphia, Pa. Dr. Hereward Lester Cooke, museum curator, spoke on the Gallery LecTour at the annual meeting of the American Association of Museums in Charleston, S.C. Dr. Katharine Shepard, assistant curator of graphic arts, gave a talk on print techniques to a group of young women from the Washington area. Miss Elizabeth Benson, assistant registrar, spoke to a group of women from the Washington area on "Venice in Painting."

William P. Campbell, curator of painting, assisted in the judging of art exhibitions sponsored by the National League of American Pen Women and the Delmarva Chicken Festival, Denton, Md. Thomas P. Baird, museum curator, assisted in the judging of exhibitions for the Christmas Greens on Capitol Hill, the Arts Club of Washington, St. John's Church, Georgetown, Church of the Blessed Sacrament, Chevy Chase, and an exhibition held in The Plains, Va.

Miss Mongan served on the selection committee for the Exhibition of French Drawings from American collections to be held at the Boymans Museum, Rotterdam, and at the Orangerie in Paris. She also served on the board of directors of the Print Council of America and on its executive committee, and is on the American Jury of Selection of the International Graphic Society, Inc. Dr. Shepard served as secretary of the Washington Society of the Archaeological Institute of America, and on the local committee of arrangements for the general meeting of the Archaeological Institute of America. Mr. Baird served on the committee for the annual meeting of the College Art Association held in Washington, D.C.

The Richter Archives received and cataloged over 2,000 photographs on exchange from museums here and abroad, and 3,610 photographs were purchased for the Richter Archives.

RESTORATION

Francis Sullivan, resident restorer of the Gallery, made regular and systematic inspection of all works of art in the Gallery, and periodically removed dust and bloom as required. He relined 9 paintings and gave special treatment to 46 paintings and 3 pieces of sculpture. Thirty-two paintings were X-rayed as an aid in research. Experiments were continued with the application of 27H and other synthetic varnishes developed by the National Gallery of Art Fellowship at the Mellon Institute of Industrial Research, Pittsburgh, Pa. Mr. Sullivan consulted with artists and engineers in New York on a new type of fluorescent incandescent light. Subsequently, 10 units of these fixtures were installed in the restoration studio. Technical advice on condition and the care of paintings was given when works of art were brought to the Gallery, and such technical information as could be given when requested by the public. He inspected all Gallery paintings on loan in Government buildings in Washington, and also gave advice on and special treatment to works of art belonging to other Government agencies, including the White House, the Freer Gallery of Art, the Capitol, the Treasury, and the Smithsonian Institution.

PUBLICATIONS

Dr. Fern Rusk Shapley, assistant chief curator, wrote an article for the magazine *Art in America*, Fall 1957, entitled "Old Masters." Dr. Christensen contributed the following articles for magazines: "Opportunities for Research through the Index of American Design and Related Washington Institutions" for the *College Art Journal*, Fall of 1957; "Pennsylvania German Folk Arts" for *Art in America*, Fall of 1957; and "A Study of Body Design" for *Ford Times*, September 1957. He also wrote "American Folk Sculpture" for *A Concise*

Encyclopedia of American Antiques, vols. 1 and 2, 1958, published by Hawthorne Books. John Pancoast, registrar, reviewed "Museum Registration Methods" for the *Museum News*. Dr. Cooke wrote an article on George Bellows for the *America* magazine. Members of the curatorial staff assisted in the installation of the exhibitions and publication of the catalogs for the Korean, Blake, and Stieglitz exhibitions.

During the past fiscal year the Publications Fund published 2 new 11-by-14-inch color reproductions, 3 new color and 8 new black-and-white postcards. Four additional large collotype reproductions of paintings on exhibition were produced by outside publishers and placed on sale by the fund.

The A. W. Mellon Lecture in the Fine Arts by Dr. Étienne Gilson, entitled "Painting and Reality," published in book form, was placed on sale. The following additional books related to the collection or with text by a staff member were made available: Pre-Columbian Art, A Guide to Art Museums in the U. S.—East Coast, and Three Hundred Years of American Painting. A revised second edition of Looking at Italian Pictures in the National Gallery of Art was published by the Fund.

Other new items made available during the year include the recording of Richard Bales's cantata, "The Union," on sculpture reproduction, and playing cards reproducing two National Gallery paintings.

EDUCATIONAL PROGRAM

The program of the Educational Office was carried out under the supervision of the curator in charge of educational work and his staff who lectured and conducted guided tours in the Gallery on the works of art in its collection.

The attendance for the general tours, Congressional tours, "Tours of the Week," and "Pictures of the Week" totaled 43,983, while that of the auditorium lectures on Sunday afternoons was approximately 12,914 during the fiscal year 1958.

Tours, lectures, and conferences were arranged by special appointment for 284 groups and individuals. The total number of people served in this manner was 8,097, an increase over last year of 457 persons. These special appointments were made for such groups as the various governmental agencies, educators (foreign and American), religious groups, heads of museums, radio and television representatives, and convention groups.

The program of training volunteer docents continued during the fiscal year. Seventy-four ladies were given special instruction under the general supervision of the curator in charge of educational work. By special arrangement with the school systems of the District of

Columbia and surrounding counties of Maryland and Virginia these ladies assisted in conducting tours for 1,101 classes, with a total of 32,548 children, an increase over last year of 9,987.

The staff of the Educational Office delivered 20 lectures in the auditorium on Sunday afternoons. Twenty-four lectures were given by guest speakers, and during March and April Sir Anthony Blunt delivered the Seventh Annual Series of six A. W. Mellon Lectures in the Fine Arts on the theme "Poussin and French Classicism."

The Educational Department has nine sets of traveling exhibitions which are circulated to schools, libraries, universities, clubs, etc., throughout the United States, and were viewed by approximately 20,000 persons. Sixteen copies of the film "Your National Gallery of Art" are on permanent loan in distribution centers throughout the country, and a new film on the Gallery "Art in the Western World" is available for local viewers. The Educational Office continued the slide-strip sale and during the year a total of 37 sets of strips containing about 300 slides each were placed in Educational Institutions. The sales of the filmstrip "The Art of the Florentine Golden Age in the National Gallery of Art" totaled 64.

During the past year 235 persons borrowed a total of 7,239 slides from the slide lending collection.

Members of the staff prepared leaflets on works of art in individual galleries, and prepared mimeographed material for school tours; prepared and recorded 20 radio broadcasts for use during intermission periods of the National Gallery of Art concerts broadcast each Sunday evening, and for circulation through audio-visual centers throughout the country.

A printed Calendar of Events announcing all the National Gallery activities was prepared and distributed by the Educational Office to a mailing list of approximately 5,700 names.

Dr. Stites visited museums, monuments, important houses and landmarks, for the purpose of photographing for a new filmstrip on American painting. He held meetings with religious and cultural groups, and judged art shows for embassies, Government agencies, and others. He recorded talks for the Voice of America, gave the commencement address at Montgomery Junior College, and attended cultural awards dinner of the Scholastic Magazine. Dr. Evans judged art shows for the Navy and for community activities groups, gave a slide lecture to the National Convention of Penwomen and set up a teachers' aids exhibition for the Arlington County schools. Dr. Evans also made an 8-day survey tour of eastern audio-visual centers, for the National Gallery's extension program. Dr. Bouton wrote articles on various artists for the Encyclopaedia Britannica and attended a meeting of the Washington Committee of Educational Television. Mrs. Michel-

son consulted with educators of the Fairfax County schools, judged art shows at the Hecht Company and at the National Collection of Fine Arts, where she also exhibited. She delivered a lecture at the National Housing Center.

LIBRARY

The most important acquisitions to the Library this year were 621 books, pamphlets, periodicals, and subscriptions, and 3,610 photographs which were purchased from private funds. A total of 34 books and subscriptions were purchased from Government funds made available for this purpose. Gifts to the library included 1,024 books and pamphlets; 836 books, pamphlets, and periodicals were received on exchange from other institutions. More than 490 visits were made by other than National Gallery staff to the Library for study and research during this year, and approximately 1,600 telephone requests for information were handled in the Library.

The Library is the depository for photographs of the works of art in the collections of the National Gallery of Art. A stock of reproductions is maintained for use in research by the curatorial and other departments of the Gallery, for dissemination of knowledge to qualified sources, for exchange with other institutions, and for sale at the request of any interested individual. Approximately 5,400 photographs were received in the Library and processed for the Library's stock in this fiscal year of 1958. Approximately 1,100 requests were handled of which 1,059 orders were actually filled, 373 by mail and 686 over the counter. Sales to the general public amounted to $1,156.33 covering approximately 1,500 photographs. There were 295 permits for reproduction of 778 subjects processed in the Library.

INDEX OF AMERICAN DESIGN

The work of the Index continued as usual and in addition included, this year, the processing for preservation of some 17,200 renderings. Approximately 533 persons studied Index material for research purposes, and to gather material for publication and design. The circulation of traveling exhibitions of Index renderings continued during the year (see exhibitions); and approximately 146 slides were lent for lecture and study purposes.

The curator of the Index continued to take part in the orientation program of the USIA personnel, and delivered seven lectures on the purpose of the Index and on folk arts and crafts in the United States.

The curator of the Index is also curator of decorative arts, and in that capacity undertook preparation of a guide on "Objects of Medieval Art." The work of labeling the Chinese porcelains was also begun.

MAINTENANCE OF THE BUILDING AND GROUNDS

Throughout the fiscal year the Gallery building, its equipment, and its grounds have been maintained at the established standards.

The conversion of the elevator in the west wing of the Gallery building from manual control to automatic operation was completed in January 1958. Accordingly, for the first time since the opening of the Gallery in 1941, this elevator is regularly available to the general public.

In the outer lobby of the Constitution Avenue entrance two new marble benches were installed. It is believed that these are more in keeping with the general appearance of the Gallery than the wood benches they replaced.

In March 1958 the shipping door at the northeast moat was replaced with an aluminum door more easily opened and closed than the door which has served the Gallery since its inception.

In January 1958 the installation of LecTour, an electronic guide system, was completed in 10 galleries. The device was made available to the public the first Monday in February. From that time to the end of the fiscal year 24,651 persons used this guide service.

For the Korean exhibition, the Gallery staff, working in conjunction with designers from the Smithsonian Institution, created an unusual installation, using special designs in vertical cases, wall cases, and special bases. The installation was unique in its field and was unusually well received by the public.

The expansion of the Gallery's horticultural program continued during the year, and the current annual production of plants and flowers for the garden courts, special exhibitions, etc., is valued at $24,000, compared to less than $6,000 before the greenhouse and coldhouse were made available to the Gallery's horticulturist late in 1954. Additionally, it is now estimated that in the greenhouse and growing beds for future use there are plant materials having a value in excess of $40,000.

OTHER ACTIVITIES

Forty Sunday evening concerts were given during the fiscal year in the East Garden Court. The National Gallery of Art Orchestra, conducted by Richard Bales, played nine concerts in the Gallery, two of which were made possible by the Music Performance Trust Fund of the American Federation of Musicians. A string orchestra conducted by Mr. Bales furnished music during the opening of the Korean Exhibition on December 14, 1957, and at the opening of the Stieglitz Exhibition on March 15, 1958. A special concert was given on June 15, 1958, in the Lecture Hall for representatives of radio and television stations in the East. The National Gallery Orchestra with the Church of the Reformation Choir presented Mr. Bales's two

cantatas "The Confederacy" and "The Union" in Constitution Hall in October 1957. Early in 1958 Columbia Records released its recording of "The Union." During March 1958 Mr. Bales appeared as guest conductor at the Eleventh Annual Folk Music Festival in Wilmington, Ohio, in performance of one of his compositions. Five Sunday evenings during May and June 1958 were devoted to the Gallery's Fifteenth American Music Festival. All the concerts were broadcast in their entirety by WGMS–AM and FM in Washington. The intermissions during Sunday evening concerts featured discussions by members of the Educational Office staff and Mr. Bales.

During the fiscal year 3,104 copies of 12 press releases were issued in connection with Gallery activities. One hundred twenty-eight permits to copy paintings and 166 permits to photograph in the Gallery were also issued.

The Photographic Laboratory of the Gallery produced 11,680 prints, 733 black-and-white slides, 733 color slides, 1,811 black-and-white negatives, 70 color-separation negatives, 171 color transparencies, 63 infrareds, 33 ultraviolets, and 103 enlargements.

During the fiscal year a program was undertaken to distribute sets of 500 color slides (2″ x 2″) to a number of educational institutions. The first distribution was made in groups of 100 slides to 103 institutions. Subsequent sets will be shipped in groups of 100 each until the project is completed.

OTHER GIFTS

Gifts of money were made during the fiscal year 1958 by the Old Dominion Foundation, Avalon Foundation, George M. and Pamela A. Humphrey Fund, Miss Anita Rattner, Howell Foreman, and Mrs. Oma Jeane Rauh.

AUDIT OF PRIVATE FUNDS OF THE GALLERY

An audit of the private funds of the Gallery will be made for the fiscal year ended June 30, 1958, by Price Waterhouse & Co., public accountants, and the certificate of that company on its examination of the accounting records maintained for such funds will be forwarded to the Gallery.

Respectfully submitted.

HUNTINGTON CAIRNS, *Secretary.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Library

Sir: I have the honor to submit the following report on the activities of the Smithsonian library for the fiscal year ended June 30, 1958:

Of the 53,274 publications received in the library, 1,394 were books and periodicals that could not be obtained in exchange. Extra funds made available during the year for the purchase of books and periodicals made it possible to fill in gaps in some fields. Back issues of periodicals and some of the much-needed out-of-print reference materials are being acquired even though in many instances they are difficult to locate.

The backbone of the library's collection was enriched by the continual flow of journals and monographs from scientific, cultural, and technical societies and organizations all over the world, which were received in exchange for the Smithsonian publications. New exchanges arranged this year totaled 128 and are to be added to the vast number already established. There were 788 special requests sent to issuing organizations or societies for back issues of publications to fill gaps in the library's collections.

In addition, the library is greatly indebted to numerous organizations and individuals for special gifts. Outstanding among these were the 6,659 pieces from the Melville collection on philately released by the Library of Congress. From Stack's in New York came 18 volumes on numismatics. From the library of the late Dr. Raymond C. Shannon there were received 2,697 books and reprints chiefly on Diptera. From Dr. Mason E. Hale, Jr., came 22 parts of Rabenhorst's Kryptogamen Flora.

There were 11,442 publications sent to the Library of Congress, plus 5,176 books and periodicals, to be added to the Smithsonian Deposit. The others not individually recorded in the library, were documents, doctoral dissertations, and miscellaneous publications of no immediate concern to the Institution. To the National Library of Medicine were sent 1,325 periodicals and dissertations, to the U.S. Book Exchange 3,334 publications, and to other agencies 502 items.

The circulation of books and periodicals in the reference and circulation section totaled 11,447. Added to this, 9,526 new publications were sent to sectional libraries for intramural circulation and filing. Since no record is kept of the use of the library's collections in the sectional libraries, no accurate numerical estimate can be made of the

actual use of books throughout the Institution. In all, 959 books were lent to 100 other libraries. Two outstanding loans were for the Theodore Roosevelt Centennial Exhibit at the Library of Congress. In addition the library's services were increased by 4,012 loans from other libraries, chiefly the Library of Congress, Department of Agriculture, Geological Survey, and the National Library of Medicine.

The 11,394 reference queries answered shows only a portion of the identifying, checking, searching, and locating required to supply the right answers to the many complex questions that are asked daily by the library's users. Of the 8,583 persons who came to the library, 3,500 used the resources of the division of insects library. The lack of adequate reading areas in the main library is not conducive to quiet study and discourages users from availing themselves of the library's research facilities.

The catalog section classified and cataloged 4,463 books and pamphlets, entered 25,253 periodicals, and filed 26,768 cards. The staff of the catalog section participated in the west-stacks moving project in spite of the current work load which had to be met. Cards for all cataloged material that was discarded had to be taken out. Also there were 1,000 or more volumes pulled from the west stacks to be cataloged and added to the permanent collection. A painstaking search of the card catalog and the library shelves had to be made before any of the duplicate material could be discarded. Steady progress is being made on the cataloging of material in the department of science and technology.

The catalog section prepared 9,000 volumes for binding or rebinding. Through a waiver from the Government Printing Office, the work was done by a commercial binder under contract. The fresh new buckram bindings not only preserve valuable research material but also add to the appearance of the shelves. In addition, 536 volumes requiring special handling by a skilled binder were repaired or rebound in the library.

David Ray, a foreign-language specialist in the catalog section, translated 190 letters from other languages, including Russian, and provided reference assistance to staff members of the Institution on translations of obscure words and phrases. In April a class in scientific Russian, taught by Mr. Ray, was started for 25 members of the curatorial staff of the Natural History Museum to aid them in acquiring a reading knowledge of Russian scientific publications.

The special project, started a year ago, of weeding out and removing the library's collections in the Smithsonian and Arts and Industries Buildings was almost completed at the end of the year. The duplicate and special collections which had been stored in the west stacks in the Smithsonian Building for the past 50 years have now all been

cleared from this area. Some of this material was kept for the Institution's use, the rest disposed of to various sources including the U.S. Book Exchange, the Library of Congress, and other Government agencies. The Watts de Peyster collection of about 5,000 volumes, including a valuable collection of Napoleona, was deposited with the library of Franklin and Marshall College at Lancaster, Pa.

The Bureau of American Ethnology library, after the discarding of some 6,750 items plus about 5,000 reprints, was shifted into this west-stack area. The east stacks and office library were both weeded for duplicates and no-longer-needed material, and the entire collections from both areas were moved to other locations. The Astrophysical Observatory library, which had been in the Smithsonian Building, was shifted to the Arts and Industries Building. This east-stack area, which housed some 60,000 volumes, was entirely cleared of the library's collections and has been made available for other uses.

The library housed on the second floor of the Arts and Industries Building has been undergoing a cleanup program since last summer. Here again duplicates and no-longer-needed publications have been pulled and discarded. A special crew hired for this project washed all shelves with soap and water, and all books are being cleaned with a vacuum cleaner. Altogether, 158,182 books, pamphlets, and periodicals (bound and unbound) were disposed of as a part of this project.

The working collections in these two library-stack areas are now easily accessible, and shelving space has been made available for current accessions. Plans are in progress for the development of library facilities for the Museum of History and Technology.

A similar project of weeding and discarding in the library at the National Zoological Park was undertaken to provide space for its working collection of books. In all, 750 volumes and pamphlets have been disposed of, and progress is being made on cataloging this collection.

Most important of the changes on the library's staff during the year was the retirement of Mrs. Leila F. Clark as librarian on August 31, 1957, after more than 29 years' service. Serving first as assistant librarian in charge of the National Museum library, she was appointed Smithsonian librarian on February 2, 1942. During her administration the library contributed its efforts to the war activities, providing reference and research materials to the Institution's staff as well as to other Government agencies. The consolidation of the National Museum library with the Smithsonian library on November 2, 1951, resulted in better and more economical library service to the whole Institution.

On September 23, 1957, Miss Ruth Blanchard, who had been chief of the catalog section, was appointed librarian. Another important change was the retirement on September 30, 1957, of Mrs. Elisabeth H. Gazin, chief of the reference and circulation section. Miss Janice S. Brown was appointed March 17, 1958, to fill this position.

The librarian and the chief of the reference and circulation section attended the Special Libraries Association convention in Chicago, Ill., where they took advantage of the varied activities provided by the Association's museum division.

SUMMARIZED STATISTICS

ACCESSIONS

	Volumes	Total recorded volumes, 1958
Smithsonian Deposit at the Library of Congress	22	586,722
Smithsonian main library (including former office and Museum libraries)	7,890	316,503
Astrophysical Observatory (including Radiation and Organisms)	91	15,036
Bureau of American Ethnology	366	37,716
National Air Museum	61	558
National Collection of Fine Arts	61	14,140
National Zoological Park	1	4,218
Total	8,492	974,893

Unbound volumes of periodicals and reprints and separates from serial publications, of which there are many thousands, have not been included in these totals.

EXCHANGES

New exchanges arranged	128
Specially requested publications received	788

CATALOGING

Volumes cataloged	4,463
Catalog cards filed	26,768

PERIODICALS

Periodical parts entered	25,253

5,154 were sent to the Smithsonian Deposit.

CIRCULATION

Loans of books and periodicals	11,447

Circulation in sectional libraries is not counted except in the division of insects.

BINDING AND REPAIR

Volumes sent to the bindery	9,000
Volumes repaired in the library	536

Respectfully submitted.

RUTH E. BLANCHARD, *Librarian.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on Publications

SIR: I have the honor to submit the following report on the publications of the Smithsonian Institution and its branches for the year ended June 30, 1958:

The publications of the Smithsonian Institution are issued partly from federally appropriated funds (Smithsonian Reports and publications of the National Museum, the Bureau of American Ethnology, and the Astrophysical Observatory) and partly from private endowment funds (Smithsonian Miscellaneous Collections, publications of the Freer Gallery of Art, and some special publications). The Institution also edits and publishes under the auspices of the Freer Gallery of Art the series Ars Orientalis, which appears under the joint imprint of the University of Michigan and the Smithsonian Institution. The second volume in this series appeared during the year. In addition, the Smithsonian publishes a guide book, a picture pamphlet, postcards and a postcard folder, a color-picture album, color slides, a filmstrip on Smithsonian exhibits, a coloring book for children, and popular publications on scientific and historical subjects related to its important exhibits and collections for sale to visitors. Through its publication program the Smithsonian endeavors to carry out its founder's expressed desire for the diffusion of knowledge.

During the year the Institution published 13 papers and title page and contents of 2 volumes in the Miscellaneous Collections; 1 Annual Report of the Board of Regents and separates of 18 articles in the General Appendix of the Report; 1 Annual Report of the Secretary; 4 special publications and reprints of 1 of the series of mathematical tables and of 1 special publication.

The United States National Museum issued 1 Annual Report, 2 Bulletins, 17 Proceedings papers, and 8 papers in the series Contributions from the United States National Herbarium.

The Bureau of American Ethnology published 1 Annual Report and 4 Bulletins.

The Astrophysical Observatory published 6 numbers in the series Smithsonian Contributions to Astrophysics.

The National Collection of Fine Arts published 1 catalog, and the Smithsonian Traveling Exhibition Service, under the National Collection of Fine Arts, issued 1 catalog.

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The Freer Gallery of Art issued 1 publication, and a reprint of 1 pamphlet.

There were distributed 530,662 copies of publications and miscellaneous items. Publications: 14 Contributions of Knowledge, 30,752 Miscellaneous Collections, 8,709 Annual Reports and 19,418 pamphlet copies of Report separates, 1,060 War Background Studies, 40,857 special publications, 152 reports of the Harriman Alaska Expedition, 54,317 publications of the National Museum, 28,131 publications of the Bureau of American Ethnology, 21,635 publications of the National Collection of Fine Arts, 589 publications of the Freer Gallery of Art, 12,897 publications of the Astrophysical Observatory, 5,012 reports of the American Historical Association, and 2,006 publications not issued by the Smithsonian Institution. Miscellaneous items: 13 sets of North American Wildflowers and 1 Pitcher Plant volume, 46,039 guide books, 16,933 picture pamphlets, 172,114 postcards and postcard folders, 16,796 color slides, 52,138 information leaflets, 57 New Museum of History and Technology pamphlets. There were also distributed 208 statuettes, 10 Viewmaster reels, and 10 filmstrips and 5 filmstrip records.

The 1958 allotment from Government funds of $158,500 for printing and binding was entirely obligated at the close of the year.

SMITHSONIAN MISCELLANEOUS COLLECTIONS

In this series, under the immediate editorship of Ruth B. MacManus, there were issued title page and table of contents of volumes 131 and 134, 4 papers in volume 134, 8 papers in volume 135, and whole volume 133, as follows:

Volume 131

Title page and table of contents. (Publ. 4310.) [January] 1958.

Volume 133

Araucanian child life and its cultural background, by Sister M. Inez Hilger. 439 pp., 90 pls., 10 figs. (Publ. 4297.) December 10, 1957. ($7.00.)

Volume 134

No. 9. The birds of Isla Coiba, by Alexander Wetmore. 105 pp., 4 pls., 15 figs. (Publ. 4295.) July 8, 1957. ($1.30.)

No. 10. The medical and veterinary importance of cockroaches, by Louis M. Roth and Edwin R. Willis. 147 pp., 7 pls. (Publ. 4299.) December 19, 1957. ($1.25.)

No. 11. Anatomy and taxonomy of the mature naiads of the genus *Plathemis* (Odonata: Libellulidae), by Harvey R. Levine. 28 pp., 25 figs. (Publ. 4301.) September 25, 1957. (30 cents.)

No. 12. Permian brachiopods from central Oregon, by G. Arthur Cooper. 79 pp., 12 pls., 2 figs. (Publ. 4302.) December 9, 1957. ($1.30)

Title page and table of contents. (Publ. 4311.) [February] 1958.

Volume 135

No. 2. Morphology and taxonomy of the foraminiferal genus *Pararotalia* Le Calvez, 1949, by Alfred R. Loeblich, Jr., and Helen Tappan. 24 pp., 5 pls., 5 figs. (Publ. 4304.) December 3, 1957. (45 cents.)

No. 3. Geology of Barro Colorado Island, Canal Zone, by W. P. Woodring. 39 pp., 3 pls., 3 figs. (Publ. 4304.) February 11, 1958. (65 cents.)

No. 4. A new theory on Columbus's voyage through the Bahamas, by Edwin A. Link and Marion C. Link. 45 pp., 5 pls., 2 charts. (Publ. 4306.) January 20, 1958. (90 cents.)

No. 5. Mineralogical studies on Guatemalan jade, by William F. Foshag. 60 pp., 4 pls., 2 figs. (Publ. 4307.) December 3, 1957. (80 cents.)

No. 6. A revised interpretation of the external reproductive organs of male insects, by R. E. Snodgrass. 60 pp., 15 figs. (Publ. 4309.) December 3, 1957. (60 cents.)

No. 7. The anatomy of the Labrador duck, *Camptorhynchus labradorius* (Gmelin), by Philip S. Humphrey and Robert S. Butsch. 23 pp., 5 pls., 9 figs. (Publ. 4334.) May 28, 1958. ($1.00.)

No. 8. Miscellaneous notes on fossil birds, by Alexander Wetmore. 11 pp., 5 pls. (Publ. 4335.) June 26, 1958. (30 cents.)

No. 10. Periodicities in ionospheric data, by C. G. Abbot. 5 pp., 1 fig. (Publ. 4338.) May 28, 1958. (15 cents.)

SMITHSONIAN ANNUAL REPORTS

Report for 1956.—The complete volume of the Annual Report of the Board of Regents for 1956 was received from the printer December 6, 1957:

Annual Report of the Board of Regents of the Smithsonian Institution showing the operations, expenditures, and condition of the Institution for the year ended June 30, 1956. ix+580 pp., 105 pls., 64 figs. (Publ. 4272.)

The general appendix contained the following papers (Publs. 4273–4290):

The edge of the sun, by Donald H. Menzel.

The mystery of Mars, by H. P. Wilkins.

The story of cosmic rays, by W. F. G. Swann.

Atmospheric pollution in growing communities, by François N. Frenkiel.

Hurricanes, by R. C. Gentry and R. H. Simpson.

Plantlike features in thunder-eggs and geodes, by Roland W. Brown.

Exploration for the remains of giant ground sloths in Panama, by C. Lewis Gazin.

The Kitimat story, by Angela Croome.

Sewage treatment—how it is accomplished, by C. E. Keefer.

Pioneer settlement in eastern Colombia, by Raymond E. Crist and Ernesto Guhl.

The sources of animal behavior, by G. P. Wells.

Rivers in the sea, by F. G. Walton Smith.

A narrative of the Smithsonian-Bredin Caribbean Expedition, 1956, by Waldo L. Schmitt.

Man as a maker of new plants and new plant communities, by Edgar Anderson.

Project Coral Fish looks at Palau, by Frederick M. Bayer and Robert R. Harry-Rofen.

Archeological work in Arctic Canada, by Henry B. Collins.

The Cherokees of North Carolina: Living memorials of the past, by William H. Gilbert, Jr.

Dried meat—early man's travel ration, by Edward N. Wentworth.

Report for 1957.—The Report of the Secretary, which will form part of the Annual Report of the Board of Regents to Congress, was issued January 17, 1958:

Report of the Secretary and financial report of the Executive Committee of the Board of Regents for the year ended June 30, 1957. x+204 pp., 9 pls. (Publ. 4308.)

SPECIAL PUBLICATIONS

The history of entomology in World War II, by Emory C. Cushing. vi+117 pp., 9 pls., 2 figs. (Publ. 4294.) [August] 1957. ($2.00.)

The story of transportation, by E. John Long. 36 pp., illus. (Publ. 4312.) [June] 1958. (50 cents.)

Adventures in science at the Smithsonian, by E. John Long and George Weiner. 44 pp., illus. (Publ. 4341.) [May] 1958. (25 cents.)

Coloring book of the Smithsonian Institution. 50 pp. (Publ. 4342.) [June] 1958. (50 cents.)

REPRINTS

Smithsonian mathematical formulae and tables of elliptic functions, by Edwin P. Adams and R. L. Hippisley. Third reprint. Smithsonian Misc. Coll., vol. 74, No. 1, Publ. 2672, 314 pp. [October] 1957. ($4.00.)

The Smithsonian Institution. 49 pp., 29 illus. (Spec. Publ. 4145) [October] 1957. (50 cents.)

PUBLICATIONS OF THE UNITED STATES NATIONAL MUSEUM

The editorial work of the National Museum has continued during the year under the immediate direction of John S. Lea, assistant chief of the division. The following publications were issued:

REPORT

The United States National Museum annual report for the year ended June 30, 1957. Pp. vi+137, illus., January 17, 1958.

BULLETINS

211. Life histories of North American blackbirds, orioles, tanagers, and allies, by Arthur Cleveland Bent. Pp. ix+549, 37 pls., February 27, 1958.

215. Studies in Foraminifera, by Alfred R. Loeblich, Jr., and collaborators. Pp. vi+323, December 30, 1957.

PROCEEDINGS

Volume 105

Title page, table of contents, and index. Pp. i–iv, 585–618, June 16, 1958.

Volume 107

No. 3381. Some littoral barnacles from the Tuamotu, Marshall, and Caroline Islands, by Dora Priaulx Henry. Pp. 25–38, 3 pls., October 21, 1957.

No. 3382. A new species of *Calanopia* (Copepoda: Calanoida) from the Caribbean Sea, by Thomas E. Bowman. Pp. 39–45, 3 figs., September 4, 1957.

No. 3383. The frogfishes of the family Antennariidae, by Leonard P. Schultz. Pp. 47–105, 8 figs., 14 pls., November 1, 1957.

No. 3384. New American cynipid wasps from oak galls, by Lewis H. Weld. Pp. 107–122, 1 pl., October 23, 1957.

No. 3385. The foraminiferal genus *Halyphysema* and two new tropical Pacific species, by Alfred R. Loeblich, Jr. Pp. 123–126, 1 pl., January 9, 1958.

No. 3386. The leafhopper tribe Alebrini (Homoptera, Cicadellidae), by David A. Young, Jr. Pp. 127–277, 39 figs., December 4, 1957.

No. 3387. Two additional Miocene porpoises from the Calvert Cliffs, Maryland, by Remington Kellogg. Pp. 279–337, 30 pls., December 9, 1957.

No. 3388. Studies of seven siderites, by Edward P. Henderson and Stuart H. Perry. Pp. 339–403, 6 figs., 22 pls., January 31, 1958.

No. 3389. New Neotropical wasps of the family Braconidae (Hymenoptera) in the U.S. National Museum, by C. F. W. Muesebeck. Pp. 405–461, 4 figs., January 27, 1958.

No. 3390. North American copepods of the family Notodelphyidae, by Paul L. Illg. Pp. 463–649, 19 figs., April 28, 1958.

Volume 108

No. 3391. *Pycnaspis splendens*, new genus, new species, a new ostracoderm from the upper Ordovician of North America, by Tor Ørvig. Pp. 1–23, 5 figs., 3 pls., April 10, 1958.

No. 3392. *Branchinecta cornigera*, a new species of anostracan phyllopod from the State of Washington, by James E. Lynch. Pp. 25–37, 16 figs., April 15, 1958.

No. 3393. Type specimens of lice (order Anoplura) in the United States National Museum, by Phyllis T. Johnson. Pp. 39–49, May 27, 1958.

No. 3394. A new North American bird-flea, by F. G. A. M. Smit. Pp. 51–57, 10 figs., May 15, 1958.

No. 3396. A redefinition of the butterfly genera *Tatochila*, *Phulia*, *Piercolias*, and *Baltia*, with descriptions of related genera and subgenera, by William D. Field. Pp. 103–131, 40 figs., June 9, 1958.

No. 3397. The systematic position of the bird genus *Apalopteron*, by H. G. Deignan. Pp. 133–136, 1 pl., June 16, 1958.

CONTRIBUTIONS FROM THE U. S. NATIONAL HERBARIUM

Volume 29

Title page and table of contents. Pp. i–vi, November 15, 1957.

Part 12. Notes on some Brazilian and other Leguminosae, by Arturo Burkhart. Pp. 545–551, November 15, 1957.

Volume 30

Title page and table of contents. Pp. i–v, November 15, 1957.

Volume 31

Title page and table of contents. Pp. i-v, February 4, 1958.

Part 3. The Acanthaceae of Colombia, III, by Emery C. Leonard. Pp. x+323–781, figs. 119–274, February 4, 1958.

Volume 32

Part 3. A revision of the genus *Chaetocalyx*, by Velva E. Rudd. Pp. iii+207–245, 13 figs., February 6, 1958.

Volume 33

Whole volume. The Bromeliaceae of Colombia, by Lyman B. Smith. Pp. i–v+311, 88 figs., December 24, 1957.

Volume 34

Part 1. Diagnostic characteristics of the fruits and florets of economic species of North American *Sporobolus*, by Vera Lyola Colbry. Pp. iii+24, 2 figs., 4 pls., December 17, 1957.

PUBLICATIONS OF THE BUREAU OF AMERICAN ETHNOLOGY

The editorial work of the Bureau continued under the immediate direction of Mrs. Eloise B. Edelen. The following publications were issued during the year:

ANNUAL REPORT

Seventy-fourth Annual Report of the Bureau of American Ethnology, 1956–1957. ii+28 pp., 2 pls. 1958.

BULLETINS

Bulletin 164. Anthropological Papers Nos. 49–56. x+356 pp., 75 pls., 5 figs., 15 maps. December 2, 1957.

- No. 49. The Ormond Beach Mound, east-central Florida, by Jesse D. Jennings, Gordon R. Willey, and Marshall T. Newman.
- No. 50. Hair pipes in Plains Indian adornment, a study in Indian and White ingenuity, by John C. Ewers.
- No. 51. Observations on some nineteenth-century pottery vessels from the Upper Missouri, by Waldo R. Wedel.
- No. 52. Revaluation of the Eastern Siouan problem, with particular emphasis on the Virginia branches—the Occaneechi, the Saponi, and the Tutelo, by Carl F. Miller.
- No. 53. An archeological reconnaissance in southwestern Mexico, by Matthew W. Stirling.
- No. 54. Valladolid Maya enumeration, by John P. Harrington.
- No. 55. Letters to Jack Wilson, the Paiute Prophet, written between 1908 and 1911, edited by Grace M. Dangberg.
- No. 56. Factionalism at Taos Pueblo, New Mexico, by William N. Fenton.

Bulletin 165. Music of Acoma, Isleta, Cochiti, and Zuñi Pueblos, by Frances Densmore. xii+118 pp., 6 pls. August 15, 1957.

Bulletin 166. River Basin Surveys Papers, No. 8. Excavations in the McNary Reservoir Basin near Umatilla, Oregon, by Douglas Osborne. With appendixes by Marshall T. Newman, Arthur Woodward, W. J. Kroll, and B. H. McCleod. x+258 pp., 40 pls., 6 figs., 19 maps. December 31, 1957.

Bulletin 167. Archeological investigations at the mouth of the Amazon, by Betty J. Meggers and Clifford Evans. xxviii+664 pp., 112 pls. 206 figs. December 31, 1957.

PUBLICATIONS OF THE ASTROPHYSICAL OBSERVATORY

The editorial work of the Smithsonian Astrophysical Observatory continued under the immediate direction of Ernest E. Biebighauser. The year's publications are as follows:

SMITHSONIAN CONTRIBUTIONS TO ASTROPHYSICS

Volume 2

No. 5. Geomagnetism and the emission-line corona, 1950–1953, by Barbara Bell and Harold Glazer. Pps. 51–107, 35 figs., November 27, 1957.

No. 6. A new catalog of ancient novae, by Hsi Tsê-tsung. Pp. 109–130. Historical records of meteor showers in China, Korea, and Japan, by Susumu Imoto and Ichiro Hasegawa. Pp. 131–144. February 12, 1958.

No. 7. Distribution of meteoritic debris about the Arizona meteorite crater, by John S. Rinehart. Pp. 145–160, 9 figs., January 28, 1958.

No. 8. Sunspots and geomagnetism, by Barbara Bell and Harold Glazer. Pp. 161–179, 12 figs, March 13, 1958.

No. 9. On two parameters used in the physical theory of meteors, by Luigi G. Jacchia. Pp. 181–187, 3 figs., June 18, 1958.

No. 10. Orbital data and preliminary analyses of satellites 1957 Alpha and 1957 Beta, by various authors. Pp. iii–vii+189–347, May 23, 1958.

PUBLICATIONS OF THE NATIONAL COLLECTION OF FINE ARTS

A retrospective exhibition of sculpture by Paul Manship. With foreword, "An Appreciation," by Thomas M. Beggs. 31 pp., illus. 1958.

Smithsonian Institution Traveling Exhibitions, 1958–1959. 32 pp. 1958.

PUBLICATIONS OF THE FREER GALLERY OF ART

Ars Orientalis, vol. 2. vii+639 pp., 224 pls., 123 fgs. (Publ. 4298.) 1957. ($31.00.)

REPRINT

The Freer Gallery of Art of the Smithsonian Institution. 16 pp., 8 pls., 3 figs. (Publ. 4185.) 1958.

REPORTS OF THE AMERICAN HISTORICAL ASSOCIATION

The annual reports of the American Historical Association are transmitted by the Association to the Secretary of the Smithsonian Institution and are by him communicated to Congress, as provided in

the act of incorporation of the Association. The following reports were issued during the year:

Annual Report of the American Historical Association for the year 1954. Vol. 2. Writings on American History, 1952. 1958.

Annual Report of the American Historical Association for the year 1956. Vol. 1. Proceedings. 1957.

REPORT OF THE NATIONAL SOCIETY, DAUGHTERS OF THE AMERICAN REVOLUTION

The manuscript of the Sixtieth Annual Report of the National Society, Daughters of the American Revolution, was not received until after the end of the period covered by this report.

Respectfully submitted.

PAUL H. OEHSER,
Chief, Editorial and Publications Division.

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report of the Executive Committee of the Board of Regents of the Smithsonian Institution

For the Year Ended June 30, 1958

To the Board of Regents of the Smithsonian Institution:

Your executive committee respectfully submits the following report in relation to the funds of the Smithsonian Institution, together with a statement of the appropriations by Congress for the Government bureaus in the administrative charge of the Institution.

SMITHSONIAN INSTITUTION

PARENT FUND

The original bequest of James Smithson was £104,960 8s 6d—$508,318.46. Refunds of money expended in prosecution of the claim, freight, insurance, and other incidental expenses, together with payment into the fund of the sum of £5,015, which had been withheld during the lifetime of Madame de la Batut, brought the fund to the amount of $550,000.

The gift of James Smithson was "lent to the United States Treasury, at 6 per centum per annum interest" (20 USC 54), and by the Act of March 12, 1894 (20 USC 55), the Secretary of the Treasury was "authorized to receive into the Treasury, on the same terms as the original bequest of James Smithson, such sums as the Regents may, from time to time see fit to deposit, not exceeding, with the original bequest the sum of $1,000,000."

The maximum of $1,000,000 which the Smithsonian Institution was authorized to deposit in the Treasury of the United States was reached on January 11, 1917, by the deposit of $2,000.

Under the above authority the amounts shown below are deposited in the United States Treasury and draw 6 percent interest:

	Unrestricted funds	*Income*
James Smithson	$727,640	$43,658.40
Avery	14,000	840.00
Habel	500	30.00
Hamilton	2,500	150.00
Hodgkins (general)	116,000	6,960.00
Rhees	590	35.40
Sanford	1,100	66.00
Total	862,330	51,739.80

	Restricted funds	*Income*
Hodgkins (specific)	$100,000	$6,000.00
Poore	26,670	1,600.20
Reid	11,000	660.00
Total	137,670	8,260.20
Grand total	1,000,000	60,000.00

In addition to the $1,000,000 deposited in the Treasury of the United States there has been accumulated from income and bequests the sum of $3,556,079.86 which has been invested and is carried on the books of the Institution as the Consolidated Fund, a policy approved by the Regents at their meeting on December 14, 1916.

CONSOLIDATED FUND

(Income for the unrestricted use of the Institution)

Fund	Investment 1958	Income 1958
Abbott, W. L., special	$19,928.57	$1,030.98
*Avery, Robert S. and Lydia	52,835.57	2,733.44
Gifts, royalties, gain on sale of securities	369,334.71	19,107.35
Hachenberg, George P. and Caroline	5,379.61	278.32
*Hamilton, James	539.96	27.93
Henry, Caroline	1,617.74	83.69
Henry, Joseph and Harriet A	65,571.48	1,724.83
*Hodgkins, Thomas G. (general)	40,520.10	2,096.26
Morrow, Dwight W	103,437.53	5,351.29
Olmsted, Helen A	1,071.70	55.45
Porter, Henry Kirke	383,089.72	19,818.91
*Rhees, William Jones	632.85	32.75
*Sanford, George H	1,190.73	61.59
*Smithson, James	1,633.01	84.50
Witherspoon, Thomas A	172,621.90	8,930.49
Total	1,219,405.18	61,417.78

*In addition to funds deposited in the United States Treasury.

CONSOLIDATED FUND

(Income restricted to specific use)

Fund	Investment 1958	Income 1958
Abbott, William L., for investigations in biology	$139,695.42	$7,208.60
Arthur, James, for investigations and study of the sun and annual lecture on same	53,496.50	2,767.63
Bacon, Virginia Purdy, for traveling scholarship to investigate fauna of countries other than the United States	67,016.55	3,467.04
Baird, Lucy H., for creating a memorial to Secretary Baird	32,206.06	1,666.18
Barney, Alice Pike, for collection of paintings and pastels and for encouragement of American artistic endeavor	38,365.53	1,984.85

CONSOLIDATED FUND—Continued

Fund	Investment 1958	Income 1958
Barstow, Frederick D., for purchase of animals for Zoological Park	$1,337.32	$69.19
Canfield Collection, for increase and care of the Canfield collection of minerals	51,160.58	2,646.75
Casey, Thomas L., for maintenance of the Casey collection and promotion of researches relating to Coleoptera	16,766.55	867.38
Chamberlain, Francis Lea, for increase and promotion of Isaac Lea collection of gems and mollusks	37,668.47	1,948.78
Dykes, Charles, for support in financial research	57,595.87	2,979.38
Eickemeyer, Florence Brevoort, for preservation and exhibition of the photographic collection of Rudolph Eickemeyer, Jr	14,539.82	752.23
Hanson, Martin Gustav and Caroline Runice, for some scientific work of the Institution, preferably in chemistry or medicine	11,891.41	615.18
Higbee, Harry, Memorial Fund, for general use of the Institution after the period of ten years from date of gift (1957)	673.94	34.69
Hillyer, Virgil, for increase and care of Virgil Hillyer collection of lighting objects	8,791.18	454.81
Hitchcock, Albert S., for care of the Hitchcock Agrostological Library	2,110.71	109.22
Hrdlička, Aleš and Marie, to further researches in physical anthropology and publication in connection therewith	54,980.81	2,704.49
Hughes, Bruce, to found Hughes alcove	25,604.12	1,324.60
Loeb, Morris, for furtherance of knowledge in the exact sciences	116,578.66	6,031.11
Long, Annette and Edith C., for upkeep and preservation of Long collection of embroideries, laces, and textiles	726.31	37.57
Maxwell, Mary E., for care and exhibition of Maxwell collection	26,237.15	1,357.35
Myer, Catherine Walden, for purchase of first-class works of art for use and benefit of the National Collection of Fine Arts	27,018.91	1,397.81
Nelson, Edward W., for support of biological studies	29,747.18	1,475.56
Noyes, Frank B., for use in connection with the collection of dolls placed in the U.S. National Museum through the interest of Mr. and Mrs. Noyes	1,285.12	66.46
Pell, Cornelia Livingston, for maintenance of Alfred Duane Pell collection	9,915.16	512.97
*Poore, Lucy T. and George W., for general use of the Institution when principal amounts to $250,000	215,574.10	10,480.28
Rathbun, Richard, for use of division of U.S. National Museum containing Crustacea	14,227.05	736.02
*Reid, Addison T., for founding chair in biology, in memory of Asher Tunis	23,965.96	1,232.06
Roebling Collection, for care, improvement, and increase of Roebling collection of minerals	161,436.71	8,351.86
Roebling Solar Research	40,635.92	2,102.31
Rollins, Miriam and William, for investigations in physics and chemistry	171,753.27	7,969.83
Smithsonian employees' retirement	33,113.34	1,743.13
Springer, Frank, for care and increase of the Springer collection and library	23,987.59	1,240.96
Strong, Julia D., for benefit of the National Collection of Fine Arts	13,374.30	691.92
Walcott, Charles D. and Mary Vaux, for development of geological and paleontological studies and publishing results of same	640,318.28	33,251.23
Walcott, Mary Vaux, for publications in botany	77,429.21	4,005.76
Younger, Helen Walcott, held in trust	94,180.80	4,792.15
Zerbee, Frances Brinckle, for endowment of aquaria	1,268.82	65.66
Total	2,336,674.68	119,143.20

*In addition to funds deposited in the U.S. Treasury.

FREER GALLERY OF ART FUND

Early in 1906, by deed of gift, Charles L. Freer, of Detroit, gave to the Institution his collection of Chinese and other Oriental objects of art, as well as paintings, etchings, and other works of art by Whistler, Thayer, Dewing, and other artists. Later he also gave funds for construction of a building to house the collection, and finally in his will, probated November 6, 1919, he provided stocks and securities to the estimated value of $1,958,591.42, as an endowment fund for the operation of the Gallery. The fund now amounts to $8,118,055.02.

SUMMARY OF ENDOWMENTS

Invested endowment for general purposes	$2,081,735.18
Invested endowment for specific purposes other than Freer endowment	2,474,344.68
Total invested endowment other than Freer	4,556,079.86
Freer invested endowment for specific purposes	8,118,055.02
Total invested endowment for all purposes	12,674,134.88

CLASSIFICATION OF INVESTMENTS

Deposited in the U.S. Treasury at 6 percent per annum, as authorized in the U.S. Revised Statutes, sec. 5591		$1,000,000.00
Investments other than Freer endowment (cost or market value at date acquired):		
Bonds	$1,189,444.34	
Stocks	2,328,183.81	
Real estate and mortgages	5,801.00	
Uninvested capital	32,650.71	
		3,556,079.86
Total investments other than Free endowment		4,556,079.86
Investments of Freer endowment (cost or market value at date acquired):		
Bonds	$4,597,684.90	
Stocks	3,504,511.46	
Uninvested capital	15,858.66	
		8,118,055.02
Total investments		12,674,134.88

ASSETS

Cash:			
United States Treasury current account	$768,885.37		
In banks and on hand	311,289.87		
	1,080,175.24		
Less uninvested endowment funds	48,509.37		
		$1,031,665.87	
Travel and other advances		4,981.00	
Cash invested (U.S. Treasury notes)		1,330,197.74	
			$2,366,844.61
Investments—at book value:			
Endowment funds:			
Freer Gallery of Art:			
Stocks and bonds	$8,102,196.36		
Uninvested cash	15,858.66		
		8,118,055.02	
Investments—at book value—other than Freer:			
Stocks and bonds (Consolidated Fund)	3,422,123.26		
Uninvested cash	32,650.71		
Special deposit in U.S. Treasury at 6 percent interest	1,000,000.00		
Other stocks and bonds	95,504.89		
Real estate and mortgages	5,801.00		
		4,556,079.86	
			12,674,134.88
Total			15,040,979.49

UNEXPENDED FUNDS AND ENDOWMENT

Unexpended funds:			
Income from Freer Gallery of Art endowment			$605,688.43
Income from other endowments:			
Restricted		$391,551.38	
General		389,166.45	
			780,717.83
Gifts and contributions			980,438.35
			2,366,844.61
Endowment funds:			
Freer Gallery of Art	$8,118,055.02		
Other:			
Restricted	2,474,344.68		
General	2,081,735.18		
			12,674,134.88
Total			15,040,979.49

CASH BALANCES, RECEIPTS, AND DISBURSEMENTS DURING FISCAL YEAR 1958[1]

	Restricted Funds		Unrestricted Funds	Gifts and Grants	Total
	General	Freer			
Receipts:					
Income from investments:					
Freer Fund		$389,152.67			$389,152.67
Consolidated Fund	$95,431.56		$61,936.05		157,367.61
Loan to U.S. Treasury	8,260.20		51,739.80		60,000.00
Real estate and mortgages	3,068.84				3,068.84
Special Funds—stocks and bonds	5,050.15		34,235.42		39,285.57
Publications	913.18	8,928.54	80,427.22	$1,817.58	92,086.52
Research grant income			35,231.72		35,231.72
Special gifts and fees:					
Gifts and contributions		16,000.00	65,929.29		81,929.29
Special service fees		86.68	6,134.87	59,536.57	65,758.12
Refund of advances			10,489.00		10,489.00
Employees withholdings (net)			(3,793.90)		(3,793.90)
Other	100.00		9,197.47		9,297.47
Reinvestment (required by provision of 2 donors)	19,346.10				19,346.10
Gifts and grants				[2]1,427,935.38	1,427,935.38
Total income	132,170.03	414,167.89	351,526.94	1,489,289.53	2,387,154.39
Endowment Funds—					
Sales of securities:					
Freer Fund					1,544,434.59
Less amounts purchased					1,529,467.94
					14,966.65
Consolidated Fund					424,317.14
Less amounts purchased					527,177.03
					(102,859.89)
Other stocks and bonds					21,170.53
Less amounts purchased					18,643.61
					2,526.92
Total receipts					2,301,788.07
Disbursements:					
Administrative salaries			81,684.76		81,684.76
Other salaries	12,473.29	143,229.79			155,703.08
Purchases for collections	17,916.27	175,937.51			193,853.78
Research and explorations and related administrative expense:					
Salaries			33,997.33	[2]670,847.22	704,844.55
Travel	10,267.34	11,739.68	8,436.78		30,443.80
Equipment and supply			11,968.47		11,968.47
Other	1,965.06		926.36	[2]1,411,455.91	1,414,347.33
Publications	10,810.10	21,309.67	49,556.28		81,676.05
Buildings, equipment, and grounds:					
Buildings and installations		10,435.31	980.65		11,415.96
Court and grounds maintenance		2,061.18			2,061.18
Furniture and fixtures			159.20		159.20
Technical laboratory		1,097.62			1,097.62
Contractual services:					
Custodian and legal fees	7,705.17	11,232.90	958.75		19,896.82

See footnotes at end of table.

CASH BALANCES, RECEIPTS, AND DISBURSEMENTS DURING FISCAL 1958 [1]—Continued

	Restricted Funds		Unrestricted Funds	Gifts and Grants	Total
	General	Freer			
Disbursements—Continued					
Other supplies and expenses:					
Meetings, special exhibits		$5,215.08	$6,026.23		$11,241.31
Lectures		1,390.06			1,390.06
Photographs and reproductions		5,121.51	915.76		6,037.27
Library		3,216.39	965.81		4,182.20
Stationery and office supply			266.62		266.62
Postage, telephone and telegraph			446.40		446.40
Stamp machines			1,849.80		1,849.80
Total disbursements	61,137.23	391,977.70	199,148.20	$2,082,303.13	2,734,566.26
Excess of disbursements over receipts (see note)					(432,778.19)
Cash balance June 30, 1957					1,904,072.19
					1,471,294.00
Investment of current funds in United States Government bonds:					
Purchases					831,138.74
Sold or redeemed					440,019.98
					(391,118.76)
Cash balance June 30, 1958					1,080,175.24

[1] This statement does not include Government appropriations under administrative charge of the Institution.

[2] Includes receipts for IGY program.

[3] Includes disbursements for IGY program.

Note: This figure reflects expenditures of grants for specific purposes received in 1957 for required expenditure in 1958, largely under the IGY program.

The practice of maintaining savings accounts in several of the Washington banks and trust companies has been continued during the past year, and interest on these deposits amounted to $8,926.14.

Deposits are made in banks for convenience in collection of checks, and later such funds are withdrawn and deposited in the United States Treasury. Disbursement of funds is made by check signed by the Secretary of the Institution and drawn on the U.S. Treasury.

The Institution gratefully acknowledges gifts and grants from the following:

Albion College, gift to defray expenses of Dr. Leonard P. Schultz in connection with travel to Albion College.

American Institute of Biological Sciences, grant to defray expenses of Dr. Leonard P. Shultz in connection with attendance at a symposium dealing with basic research approaches to the development of shark repellents in New Orleans.

American Institute of Biological Sciences, grant to defray expenses of Dr. Herbert Friedmann in connection with attendance at the 15th Zoological Congress in London.

American Pharmaceutical Association, grant to support historical research and attendance at international scientific meetings by George Griffenhagen.

American Philosophical Society, grant for archeological investigations on the coast of Ecuador.

American Philosophical Society, grant to defray expenses of Dr. T. Dale Stewart in connection with travel to the Iraq Museum in Baghdad.

Atomic Energy Commission, additional grant for the study of specific biological indicators of ionizing radiation and the mechanism of the action of such radiation.

Atomic Energy Commission, additional grant for the purpose of conducting a biochemical investigation of photomorphogenesis in green plants.

Bredin, Mrs. J. Bruce, additional gift for the Smithsonian-Bredin Expeditions Fund.

Buchanan, Wiley T., gift to establish the Buchanan Fund for Purchase of Historical Objects.

Carter Oil Company, additional grant for a research project on echinoid spines.

Clark, Mrs. Leila F., gift to the Library.

Colp, Dr. Ralph, gift to the Northern Mexico Archeological Fund.

Cornell University, gift to defray expenses of Dr. G. A. Cooper in connection with delivering the Gurley Lecture.

Creole Foundation, grant for the purpose of testing carbon samples for radioactive carbon in order to obtain dates from archeological horizons in the Orinoco Basin of Venezuela.

Department of the Air Force, grant for research directed toward the study of the rate of accretion of interplanetary matter by the earth.

Department of the Air Force, grant for research entitled "Study of Atmospheric Entry and Impact of High Velocity Meteorites."

Guggenheim, John Simon, Memorial Foundation, grant to cover the costs of making and printing two or more colored plates for inclusion in a manuscript entitled "The Parasitic Weaverbirds" by Herbert Friedmann.

Harvard University, gift for the Peabody Museum, Harvard University-Smithsonian Institution Kalahari Expedition.

Henry, Miss Caroline, bequest to establish the "Joseph Henry and Harriet A. Henry Fund."

Kevorkian, H., gift to Freer Gallery of Art.

Link, E. A., additional gift for historical research (marine archeology).

Link Foundation, grant for special publications dealing with aviation and Smithsonian Institution collections.

May, Mrs. M. Merriweather Post, gift to purchase wooden Indian Princess.

National Geographic Society, grant to cover the preparation of technical drawings of fishes for illustration in the report on the collection of fishes made during the Arnhem Land Expedition.

National Geographic Society, additional grant to complete the excavations and related work at the archeological site in Jackson County, Alabama.

National Science Foundation, grant for the support of a research entitled "Studies of Type Specimens of Ferns."

National Science Foundation, additional grant for research on recent Foraminifera from Ifaluk Atoll.

National Science Foundation, grant for the support of research entitled "Monographic Studies of Tingidae and Presmidae (Hemiptera)."

National Science Foundation, additional grants for an optical tracking and scientific analysis program for the U.S. Earth Satellite Program.

National Science Foundation, additional grants for research on "Taxonomy of the Bamboos."

National Science Foundation, additional grants for research entitled "Taxonomic Study of the Phanerogams of Colombia."

National Science Foundation, grant for the support of research entitled "Metabolic Aspects of the Digestion of Wax."

National Science Foundation, additional grant for the support of research entitled "Monograph of Fresh-water Calanoid Copepods."

National Science Foundation, grant for the support of research entitled "Reconstruction of Migration Routes."

National Science Foundation, grant for the support of research entitled "Lichens of West Virginia."

National Science Foundation, grant for the support of research entitled "Studies of Cassiduloida (Echinoidea)."

National Science Foundation, grant to assist in defraying travel expenses of Dr. Martin H. Moynihan from Panama to Helsinki, Finland, and return, for the purpose of attending the 12th International Ornithological Congress.

National Science Foundation, additional grant for the support of research entitled "Photoregulation of Growth in Plants."

National Science Foundation, grant for the support of research entitled "Behavior of Neotropical Lepidoptera."

National Science Foundation, grant for the support of research entitled "Comparative Analysis of Behavior in Tropical Birds."

Naval Research, Office of, additional grant to perform psychological research studies.

Naval Research, Office of, additional grant to perform aeronautical research studies.

Naval Research, Office of, additional grant to assist work in progress on the preparation of a synoptic catalog of the mosquitoes of the world.

Naval Research, Office of, grant to provide expert consultants to advise the Navy Research Advisory Committee.

Nelson, R. Leiland, additional gift for biological studies.

Norris, Mrs. Ernest Eden, gift to the Smithsonian Astrophysical Observatory.

United States Commissioner General, grant for preparation of an exhibition of American Folk and Primitive Art for participation in the Brussels Universal and International Exhibition of 1958.

University of Michigan, gift to Freer Gallery of Art.

University of Pennsylvania, gift to defray expenses of Dr. Henry B. Collins in connection with travel to Denmark.

West Texas Geological Society, gift to defray expenses of Dr. G. A. Cooper in connection with travel to West Texas.

For support of the Bio-Sciences Information Exchange:

Atomic Energy Commission.
Department of the Air Force.
Department of the Army.
Department of the Navy.
National Science Foundation.
Public Health Service.
Veterans Administration.

Included in the above list of gifts and contributions are reimbursable contracts.

The foregoing report relates only to the private funds of the Institution.

The following appropriations were made by Congress for the Government bureaus under the administrative charge of the Smithsonian Institution for the fiscal year 1958:

Salaries and expenses	$6,102,319.00
National Zoological Park	840,650.00
National Zoological Park (1958/59)	16,000.00
Additions to the Natural History Building	800,000.00

The appropriation made to the National Gallery of Art (which is a bureau of the Smithsonian Institution) was $1,676,580.00.

In addition, funds were transferred from other Government agencies for expenditure under the direction of the Smithsonian Institution as follows:

Working funds, transferred from the National Park Service, Interior Department, for archeological investigations in river basins throughout the United States	$175,624.00

The Institution also administers a trust fund for partial support of the Canal Zone Biological Area, located on Barro Colorado Island in the Canal Zone.

AUDIT

The report of the audit of the Smithsonian Private Funds follows:

WASHINGTON, D.C., *August 25, 1958.*

THE BOARD OF REGENTS,
SMITHSONIAN INSTITUTION, *Washington 25, D.C.*

We have examined the statement of private funds of Smithsonian Institution as of June 30, 1958 and the related statement of private funds cash receipts and disbursements (but excluding the National Gallery of Art and other departments, bureaus or operations administered by the Institution under Federal appropriations) for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Land, buildings, furniture, equipment, works of art, living and other specimens and certain sundry property are not included in the accounts of the Institution.

In our opinion, the accompanying statements present fairly the financial position of Smithsonian Institution at June 30, 1958 arising from cash transactions and revenues collected and expenses disbursed by it (and changes in proprietary interest and fund balances where reflected in cash basis statements) during the year then ended, on a basic consistent with that of the preceding year.

We have reported as above on the appended financial statements (Exhibits A and B). The accompanying schedules, though not considered necessary for a fair presentation of the financial position and results of operation, are presented mainly for supplementary analysis purposes. While our examination was made primarily for the purpose of formulating our opinion on the current year's basic financial statements, the additional data have been subjected to the same audit procedures and, in our opinion, are stated fairly in all material respects when considered in conjunction with the financial statements taken as a whole.

PEAT, MARWICK, MITCHELL & CO.

Respectfully submitted.

ROBERT V. FLEMING
CLARENCE CANNON
CARYL P. HASKINS
Executive Committee.

GENERAL APPENDIX

to the

SMITHSONIAN REPORT FOR 1958

ADVERTISEMENT

The object of the GENERAL APPENDIX to the Annual Report of the Smithsonian Institution is to furnish brief accounts of scientific discovery in particular directions; reports of investigations made by staff members and collaborators of the Institution; and memoirs of a general character or on special topics that are of interest or value to the numerous correspondents of the Institution.

It has been a prominent object of the Board of Regents of the Smithsonian Institution from a very early date to enrich the annual report required of them by law with memoirs illustrating the more remarkable and important developments in physical and biological discovery, as well as showing the general character of the operations of the Institution; and, during the greater part of its history, this purpose has been carried out largely by the publication of such papers as would possess an interest to all attracted by scientific progress.

In 1880, induced in part by the discontinuance of an annual summary of progress which for 30 years previously had been issued by well-known private publishing firms, the Secretary had a series of abstracts prepared by competent collaborators, showing concisely the prominent features of recent scientific progress in astronomy, geology, meteorology, physics, chemistry, mineralogy, botany, zoology, and anthropology. This latter plan was continued, though not altogether satisfactorily, down to and including the year 1888.

In the report of 1889, a return was made to the earlier method of presenting a miscellaneous selection of papers (some of them original) embracing a considerable range of scientific investigation and discussion. This method has been continued in the present report for 1958.

Reprints of the various papers in the General Appendix may be obtained, as long as the supply lasts, on request addressed to the Editorial and Publications Division, Smithsonian Institution, Washington 25, D.C.

The Sun's Energy[1]

By Farrington Daniels

Department of Chemistry
University of Wisconsin

Life without the sun is unthinkable. Modern civilization with its ever-increasing demands for energy is completely dependent on the solar energy of the past, in the form of fossil fuels, as well as on the solar energy of the present. Many ancient peoples worshiped the sun. Why have we gathered together here this week from the four corners of the earth in the name of the sun? Not to *worship* the sun, but to try, through science and technology, to obtain still more useful energy from it. We rebel against the old adage that "there is nothing new under the sun."

AWAKENED INTEREST IN SOLAR ENERGY

But why this *new* and almost explosive interest in utilizing solar energy? The sun has always been with us. I am delighted to see this new appreciation of solar energy—but I am worried, also. For 7 years I have been actively urging scientists and engineers throughout the world to turn more of their research activities toward greater, direct utilization of this enormous, neglected source of energy—and now the idea has caught on like a delayed-action fuse. Too many people are beginning to expect too much too soon. There is no sudden era of solar prosperity just around the corner. There is much to be done yet by scientists, inventors and engineers, and philanthropists, before it is time for investors to become excited. The producers of conventional power through coal, petroleum, water power, and electricity have nothing to worry about. None of our present engines and generators will be rendered obsolete by solar energy. Atomic energy and solar energy, each in its own way, will merely supplement the *new* additions to our power-producing machinery. Atomic energy will come in large, multimillion-dollar central power stations near

[1] Published by permission of the Stanford Research Institute from Proceedings of the World Symposium on Applied Solar Energy, 1955.

cities and towns. In fact, it is already here. The critical mass of uranium, the elaborate controls and shielding and the disposal of radioactive waste, all work against small atomic units. Emphasis is being placed on 100,000-kilowatt atomic power units and larger, with some consideration of 5,000-kilowatt units for special purposes. Undoubtedly, the successes of atomic power have had an influence on solar energy. They have weaned us away from thinking only in terms of conventional combustion fuels.

Unlike atomic energy, solar energy has no critical mass, no health hazards (except sunburn), and no waste products to dispose of. Anyone can go out in his yard and run a toy steam engine with free sunshine. There is no power limit. Laboratory research and even pilot-plant operation for solar energy is comparatively inexpensive.

Solar-energy utilization will probably start with small units costing not millions of dollars, but only thousands of dollars. They will find their first practical uses in rural, nonindustrialized areas. I do not mean to imply that the deserts of Arizona may not bloom with huge solar powerplants—but they won't be important this year.

Let me ask again why do we sense this upsurge of interest in the utilization of solar energy now, and why has the direct use of the sun's energy been neglected so long? There are many reasons. Life has been too easy with concentrated energy in the form of coal, petroleum, natural gas, and waterpower. "Necessity is the mother of invention" and the scientists and engineers most capable of developing devices for making direct use of the sun have lived in industrialized countries where there has been no necessity for developing solar energy. These countries would not be industrialized unless they had plenty of fuel. Dollarwise, competition with cheap fossil fuels has been unattractive, and "social-conscious-wise" there has been no demand in the industrialized countries that could not be met with conventional sources of energy.

But these conditions are changing and there are several factors which are contributing to our new interest in solar energy. We realize, as never before, that our fossil fuels—coal, oil, and gas—will not last forever. Several careful studies have been published in the last few years which point out that the depletion of our reserves will come sooner than we think. In the fuel-rich United States, the problem may be one for our grandchildren, but some countries already are feeling the pinch of a decrease in high-grade, easily minable coal. Moreover, the population of the world is increasing rapidly and the demands for abundant energy are increasing still faster. Any estimates of the life of fuel reserves based on consumption at past rates are utterly unrealistic.

An occasional catastrophe has shown the helplessness of industrialized cities when the electricity goes off. Every year it becomes more difficult for them to exist without abundant power. The people could not spread out to the farms and live at a subsistence level. The farms are mechanized, too. I have recently had a survey conducted by V. Stoikov who found that for every calorie obtained from food in the United States, we put a little more than a calorie from fossil fuel into producing the food.

Another important factor in our rising interest in the sun is the realization of the great need for more mechanical power in the nonindustrialized areas of the world. Transportation and communication have improved so much that we are acutely aware, as never before, of the need to give technical help to our friends on the other side of the world and to the south of us.

I was privileged to attend a solar-energy symposium in 1954 in New Delhi, as a guest of the Indian Government and UNESCO. The Indian Government took us on a study tour of the semiarid regions. We saw, among other things, four bullocks and two men working diligently and skillfully for long hours irrigating farmland. Every minute two bullocks pull up by rope 250 pounds of water from a depth of 50 feet. One of the men collapses the water bag made from hide and the water flows over the land. The second operator drives the bullocks and a second team of bullocks pulls up the next 250 pounds of water. This work done by the four bullocks and two men is reckoned to be equivalent to one-third of a horsepower. And the four bullocks cost $600 and have a life of only about 6 years. Moreover, they have to eat and they must consume a considerable portion of the crops that they help to grow. The project seemed to be barely self-supporting—but the water has to be raised. If the bullocks' walkway were covered with a solar heat collector which activated a crude engine working at only 5-percent efficiency, a 1-horsepower pump could be operated. Five-percent efficiency should not be impossible. The challenge to replace these bullocks with solar engines seems more important to me now than some of the theoretical researches in which I have been engaged. (Of course, the bullocks are used for plowing and transportation as well as for irrigation.) We also saw a camel walking around a well and pulling up water by a rotating mechanism. We saw a man getting water with the help of a counterweight, and a woman walking back and forth on a balanced beam to pull up pails of water. Solar engines certainly cannot compete yet with coal, oil, and electricity where these are abundant, but I believe that it should be possible to compete right now with manpower and animalpower, in areas where fuels are available only at high prices.

The economics of solar energy does not look very attractive as yet in fuel-rich, highly industrialized areas, but it should be attractive

now in nonindustrialized areas. High efficiency of the conversion of expensive fuel into work and low labor requirements have been the technological goals in industrialized countries. But sunshine is almost free and so efficiency of conversion is less important. Low capital investment and small repair requirements are much more important than engine efficiency and low labor costs.

The need for new sources of power was clearly brought out at the Geneva Conference on Atoms for Peace in 1955. It seemed clear that atomic power can be produced on a large scale, in the future, for only a few tenths of a cent per kilowatt hour more than coal-generated power. It seemed clear, too, that atomic power can be provided in small units very soon at a price considerably higher than that of coal-generated electricity. The price is not interesting in the United States, but it was interesting to some of the nonindustrialized nations. It was pointed out that to build conventional powerplants in remote, nonindustrialized areas requires large capital investments such as the building of railroads and freight cars and engines, and the installation of coal-mining machinery. Atomic power requires much less of these capital costs and so a higher price can be paid for atomic power. The same considerations apply to solar energy. Because the costs of fuel and transportation of fuel are negligible and because heavy capital investments for combustion fuel accessories are eliminated, it is possible to pay more for sun-generated electricity than the industrialized countries are accustomed to pay for coal- and oil-generated electricity.

The difference in labor costs between industrialized and nonindustrialized areas should be considered also in the development of solar energy. Adjusting mirrors to face the sun at frequent intervals and dusting them off could perhaps be done for less than a dollar a day by a bullock driver, turned solar operator. Operators in industrialized countries might cost more than ten times as much. Hand operation then may be cheaper and simpler than automatic operation in nonindustrialized countries, and it can permit a large reduction in the cost of the equipment. In places where electricity is not available, housewives would probably be glad to turn a wheel by hand at frequent intervals in order to preserve the family's food in a simple solar-operated refrigerator.

Still another factor in our awakened interest in solar energy is the development of new materials. Large areas of solar collectors are required for the utilization of solar energy, and large areas of any material are expensive. Machinery, metals, glass, and concrete cost thousands of dollars per acre. We live in an age of plastics; and thin plastics are now available which cost only hundreds of dollars per acre. Here is a new frontier where we may have a chance of cutting costs and making solar devices more economical.

There is much more to solar-energy utilization than the development of solar engines. House heating, house cooling, refrigeration, cooking, distillation of salt water are all parts of the picture which is being suggested now and elaborated throughout this volume. Even in the development of solar power for operating machines the long-range hope lies not so much in heat engines as in photochemistry and photoelectricity. But first let us see how much solar energy we need and how much we have.

ABUNDANCE OF SOLAR ENERGY

In considering any new development, it is well to consider first whether it is theoretically possible, next whether it is technically feasible, and finally whether it is economically sound and socially useful. The symposium was organized to discuss these questions. Answering the first question, the total energy of the sun falling on the earth is far more than is needed to do the world's work and it is an ever-continuing source of energy. To carry on the energy-rich civilization of the United States, this country used, in 1952, 164,000 kilocalories of fuel energy or 190 kilowatt-hours of heat per person per day. The per capita consumption of fuel by all the people of the world was 24,000 kilocalories per day. The total energy from the sun striking the land area of the United States is of the order of 270 million kilocalories, or 313,000 kilowatt-hours, per person per day. The theoretically available supply far exceeds the need, but at present there is no direct utilization of it because it is in the form of low-temperature heat which is difficult to convert into work, and difficult to store and transport.

These figures are based on an arbitrary assumption that the solar radiation amounts to about one small calorie per minute per square centimeter. It is more than this in Arizona and much less than this in some other parts of the country, particularly in the wintertime. This unit is too small to visualize. Earlier, I suggested a new unit of solar radiation—the "roof," which is a "million calories per minute." It is the solar radiation received by 100 square meters of flat surface at the rate of 1,000 kilocalories per minute, or 60,000 kilocalories per hour or 500,000 kilocalories, or 580 kilowatt-hours of heat per 500-minute day. This 100-square-meter area is 1,075 square feet, about the flat area of the roof of a square house which is 10 meters or 33 feet on a side. A "roof-day" of 500,000 kilocalories is approximately equivalent to two million B.t.u., which is the amount of heat evolved by burning 150 pounds (about a man's weight) of coal or 15 gallons (almost an automobile tankful) of gasoline. If all the solar radiation were used with 100 percent efficiency, a "roof-day" of radiation would evaporate about 860 liters or 230 gallons of water.

If the solar energy could be converted into electricity through a heat engine and dynamo, or through a photovoltaic cell with an efficiency of 10 percent, one "roof" of radiation would generate about 7 kilowatts while the sun is shining at the rate of a million calories per minute. If this electrical work is produced throughout 8 hours of sunshine, but averaged over the whole 24-hour day, the roof would produce at the rate of 2.3 kilowatts. A 5-percent efficiency would lead to 3.5 kilowatts during sunshine and 1.2 kilowatts for the day's average. The limits of 5 and 10 percent for conversion of heat into useful electricity give an optimistic but not an impossible range.

SOCIAL IMPLICATIONS

Solar-energy utilization holds out special hope for improving the standard of living in areas which have not yet become industrialized. In marginal agricultural areas human labor can be conserved and work animals with their high food consumption reduced—if some expert is able to come up with a sufficiently practical and inexpensive solar engine. Pumping of water for agriculture, for household use, and for sanitation is the most obvious use of solar energy. There is no way to make the sun shine at night and the intermittency of solar energy is a powerful deterrent to its use. Water pumping is not handicapped by this intermittency. Electric lights for homes and villages might come next in importance, but for this purpose some system of power storage must be provided, possibly for only a few hours. Village industries, weaving, wood turning, furniture making, and machine work might be encouraged with solar engines of 1 to 100 horsepower. Solar refrigeration could conserve food and make possible the use of additional protein materials with a resulting improvement in nutrition.

Solar heating and cooking are definite possibilities if the units are cheap enough.

I have a letter from Mexico telling me that the women of the village spend much of their time walking to the hills 6 miles away to collect firewood for their cooking and heating. The letter goes on to say, "We have plenty of sunshine all around. Can't you do something to help us?" Maybe we can. Let's try! The challenge is not only to save time and labor for the housewife, but to conserve the soil against erosion caused by removing the grass and shrubs for firewood. In some areas the cow and camel dung now used for cooking fuel might be saved for use as fertilizer.

Possibly the solar distillation of salt water and the solar heating and cooling of houses might open up new land areas to settlement and thus tend to relieve some of the world's population pressures.

In some undeveloped and uninhabited areas, a premium price could undoubtedly be paid for electricity, for pumping of water, and for

distilled fresh water. In tackling the economic problems of solar energy, let us not be tied to the economic patterns and practices of the highly industrialized countries. There may be places where people would be glad to pay not 5 mils per kilowatt-hour for electricity, but 5 cents, because the whole economy and standard of living would be raised.

We must not become too enthusiastic, however. There are many places in the world with long, dark Arctic winters, or with cloud-shrouded climates where the sun cannot help. It is well to remember, though, that in a given area the heritage of sunlight is the same on all the land. The same amount of solar energy falls on an acre of land, whether it is city real estate costing thousands of dollars, rich farm land costing hundreds of dollars, grazing lands costing tens of dollars, or wasteland costing almost nothing.

In looking around for large areas of unused land to be occupied with solar collectors, we might consider the rights-of-way at the sides of our railroads and highways—perhaps a "roof" equivalent for every 10 or 20 feet.

Solar energy is primarily for the countryside and not for the cities. When people are piled deep in multiple family apartments and there is no vacant land, demands for power per square meter of sunlight cannot possibly be met. No wonder a report on solar energy by a committee of scientists in London was rather pessimistic.

Arizona is indeed a favored place with optimum sunshine throughout the year and plenty of great open spaces. It should be an excellent proving ground for industrial solar energy. The Bell solar battery has shown that we may expect rapid progress through fundamental research, perhaps in apparently unrelated fields. Let's all join in the fun of pushing back the frontiers of solar-energy research and engineering.

DEVICES AND DIFFICULTIES

I would like to give you an introduction to some of the opportunities that may lie ahead, and some of the devices and difficulties with which we are all concerned. I hope that many new ideas for the utilization of solar energy will be brought forth which will lead to a chain reaction of additional ideas all over the world. I trust, too, that there are many experts who will evaluate these approaches to solar-energy utilization technically and economically and criticize them relentlessly. There are plenty of fertile fields for solar exploration to be worked, and the few active workers should not ordinarily waste their efforts in unpromising areas. Early criticism may serve to direct our limited research resources into more useful channels.

Let me divide the future development of solar energy into short range and long range. About half the solar energy is light and half

heat. The light half, of course, can be used as heat also. Thus all the energy is available as heat. We can start at once developing heat uses. The principles are well known. The difficulty is in economics. Some say just wait for new technological developments and new materials. The technological ceiling will certainly rise. Yes, but it rises only because a few pioneers like to bump their heads against the ceiling. Let's start now on large-scale experimentation and pilot plants using the heat of the sun for heating, cooling, distillation, and for solar-heat engines. Let's accelerate our fundamental research in trying to use the light of the sun. We are a long way behind in competing with agriculture, but agriculture in turn utilizes only a small fraction of the solar energy which it could theoretically utilize. The greatest long-range hope lies in photochemistry and photoelectricity.

Intensive research and development should be directed toward utilizing solar heat to help the nonindustrialized countries now and toward utilizing the solar light at some later time.

SOLAR ENGINES

Solar engines require a higher temperature than is ordinarily needed for house heating, absorption refrigeration, or for distillation of salt water. This higher temperature can be achieved through concentration of the light onto a small area with the help of parabolic or parabolic-cylindrical mirrors; or by heat traps with multiple glass plates which allow sunlight to pass through, but which minimize the loss of heat in the form of long infrared radiation from the heated receiver. The focusing type of engine has the advantage of reducing the area of the boiler and this, in turn, reduces the heat losses and the cost of equipment. It is, however, nearly useless except in direct sunshine. The flat plate collectors will continue some operation on cloudy days. The focusing type may well be more suitable for sunny climates and the flat plate collectors more suitable for regions in which the direct sunlight is frequently cut off by clouds. In either case, the important problem is to keep the capital cost low. Large areas of reflectors or glass plates are expensive.

STORAGE OF POWER

Intermittency is one of the handicaps of solar energy. There is no way by which the sun can be made to shine at night. There are many ways in which mechanical or electrical power can be stored. The question is the economic cost. An engine can pump water up to an elevated reservoir, and as the water falls back to ground level it can do work in a water turbine. The difficulty with this method is the high cost of a reservoir which has appreciable capacity. One kilowatt-hour of heat is equivalent to 4,100 cubic feet of water or

116,000 liters falling through a height of 10 feet. If a hydroelectric plant or an abandoned mine or a large diving bell in a lake or ocean is available the cost may not be so great. At Austin, Tex., a steam powerplant pumps water back from a low reservoir to a high reservoir when electricity is not much in demand and then the full hydroelectric power is available for peak loads.

Standard electric power grids are well suited to help overcome the intermittent nature of solar energy. When the sun is shining the coal supply or the dammed-up water supply can be conserved. The demand for air conditioning is creating new problems with the peak loads of electrical power systems. The sun is usually shining brightest when the air conditioning is needed most.

Power can be stored also in the form of high-temperature heat. One kilowatt-hour of heat is equivalent to 860 kilocalories which is equivalent to a 10-degree C. drop in the temperature of 86 liters of water. Heat to run a steam engine for a while after sundown might be stored in a large insulated hot-water tank or in fused material such as urea with its melting point of 125 degrees C. and its heat of fusion of 50 calories per gram. Huttig has proposed to store heat for operating an engine in an iron sphere heated electrically to a high temperature. The ratio of heat storage to radiating surface is comparatively low. It must be remembered that 1 kilowatt-hour of heat gives only about 0.1 kilowatt-hour or less of work in a small heat engine.

The electrolysis of water and storage of the hydrogen and oxygen in underground gas tanks with water seals offer possibilities. The gases may be combined to operate a high-temperature gas turbine. One kilowatt-hour of heat is equivalent to the heat of combustion of about 10 cubic feet of hydrogen. The stored hydrogen and oxygen may be used directly to operate a hydrogen-oxygen "fuel cell" with nickel electrodes in a fused salt bath at a high temperature. Good laboratory progress is being made in obtaining efficiencies up to 60 and 70 percent with fuel cells.

HOUSE HEATING

House heating is one of the theoretically simple uses of solar energy because the temperature does not have to be high. Flat plate collectors give satisfactory heat traps and focusing devices are not necessary. However, large surfaces are necessary and architectural difficulties arise. The storage of heat may be accomplished with pebble beds, hot-water storage tanks, or chemicals which undergo fusion or transition in crystal form. Competition of solar heating against cheap coal, oil, and gas is difficult, but inasmuch as about one-third of the fuel consumption in the United States goes for

space heating it is clear that there are important conservation aspects to solar house heating. In northern climates the capital cost of large heat-storage capacities is so great that it seems wise to use small auxiliary plants operating on conventionel fuel in addition to the solar heating plant.

In those areas where fuel is expensive and wood and shrubbery need to be conserved in order to minimize soil erosion, there is a special need for solar house heating. In areas of greatest need there is likely to be both a scarcity of fuel and an absence of electricity What then is to be used in the solar heating plant for circulating air or water through the heat storage bins? Circulation by natural convection is usually not enough. Efforts should be made to develop an inexpensive, solar-operated device for circulating air or water.

When ample electricity is available the use of a heat pump offers attractive possibilities with a reservoir of heat produced by solar radiation.

REFRIGERATION AND HOUSE COOLING

Household refrigeration is one of the most urgent fields for the utilization of solar energy. Nutritional deficiencies among people living in tropical areas could be reduced by providing cheap refrigerators for preserving proteins and other foods. The potential market all over the world for refrigerators and house cooling is tremendous.

In the United States with its abundant supply of electricity, refrigeration developments have followed mechanical refrigeration with moving parts powered by electric motors. The absorption and desorption of ammonia in water and other similar types of refrigeration are probably simpler and more efficient. Intensive research on small solar-operated cooling systems should include not only absorption and desorption of gases in solutions, but also adsorption and desorption of gases on solid surfaces and dehydration systems in which the dissolved water is driven out of a solution with solar heat and the dry high-boiling liquid is then ready to absorb more water vapor.

DISTILLATION OF SEA WATER

A million calories per minute or 500,000 kilocalories per day of solar energy striking an area of 100 square meters could theoretically support enough heat to vaporize about a milion grams of water, which is a layer of water 1 centimeter or 0.4 inch deep. Practically, of course, the efficiency would be low and solar distillation would normally correspond to less than 0.2 inch of rain. Multiple stills are possible in which some of the heat of condensation of the water

is used to vaporize fresh water, but the cost of such stills is very high. Premium prices can be paid in some areas for domestic and household water and for drinking water for animals. Here the solar distillation of salt water is particularly attractive. Egypt, Asia, Australia, and parts of the United States have significant regions for practical tests.

Solar-distilled water cannot easily compete with irrigation water because the investment costs of the necessarily large areas of water-containing vessels and glass or plastic are so high. New cheap, weather-resistant plastics are needed which are impervious to water vapor, but are wetted by liquid water and able to withstand years of bright sunlight. Also needed is a solar-operated circulating fan which will circulate air where electrical power is not available.

PHOTOCHEMISTRY

The long-range hope for the direct utilization of solar energy lies in photochemistry and photoelectricity. The research goal in photochemistry is to find a suitable reaction which can be produced by sunlight with the absorption of energy, and then allowed to reverse itself at will in the dark with the evolution of energy. Many endothermic photochemical reactions reverse themselves so rapidly that they merely convert light energy into heat and are not suitable for storing energy. There is a chance that some of the photoproducts will give up electrons to a wire and thus produce an electric current. Most photochemical reactions are spontaneous reactions in which the light merely accelerates the reaction rate, and the reaction does not reverse itself in the dark. Again, many of the promising endothermic reactions respond only to ultraviolet light, which does not exist in sunlight to an appreciable extent. The photochemical challenge is a difficult one.

The fact that photosynthesis exists and carbon dioxide and water combine photochemically in the presence of chlorophyll in the growing plant gives encouragement to those who are trying to use the sun photochemically. The end products of photosynthesis are carbohydrates and other organic materials which, on combustion, will give back the carbon dioxide and water and release the stored energy. The first chemical step in photosynthesis is the release of hydrogen atoms. In trying to copy and improve on nature, it may be easier to store the solar energy in hydrogen rather than in carbohydrates and other products produced by further reduction of the carbon dioxide. Although hydrogen cannot be used for food, it can readily be used for fuel.

Photosynthesis is a remarkable process which we are just beginning to understand. In the laboratory under special conditions it can be

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made efficient. Thirty percent of the light energy absorbed (corresponding to 8 photons per molecule) can be stored and released at a later time by combustion. In agriculture only a small fraction of one percent of the annual solar energy is stored. There are many reasons for this low efficiency. The half of the solar radiation which is in the infrared is ineffective; the growing season lasts for only a third of a year and the ground is entirely covered with green leaves for only a part of this time; the carbon dioxide of the air is too low in concentration; and, most important of all, the sunlight is much too bright for maximum efficiency. As a result of all these handicaps agriculture in the temperate zones of the world ordinarily grows only about 2 tons of dry organic material per acre per year.

The mass culture of algae can probably produce about ten times as much organic material, but a heavy capital investment is required for water tanks, carbon dioxide enrichment, fertilizers, cooling equipment, and harvesting machinery. Research to reduce these costs should be encouraged. One of the best approaches is the development of algae which will grow in hot water and thus eliminate the need for artificial cooling.

The Bell Telephone Co.'s solar battery is one of the most hopeful developments in photochemistry. It was the result of fundamental research in solid-state physics—a field supposedly far removed from that of solar energy. The single crystals of silicon which form the battery are too expensive now, but intensive research should be encouraged in an attempt to find substitutes. Perhaps very cheap electroplated films and vaporized films of semiconducting material should be explored to see if they cannot be made pure enough and similar enough in properties to those of a single crystal.

CONCLUSIONS

I would like to make two suggestions. We work in a heretofore neglected field with no adequate means of publication. Let's start now an international "Journal of Solar Energy Research and Engineering." Science develops exponentially when its scientists can build on the work of others. Rapid publication of results is the life blood of a vigorous science. No single scientific journal is now in existence which is read alike by the many types of engineers and scientists which make up this group. Lack of a proper medium for publishing their research has been a deterrent to young scientists on the threshold of a professional career and who might go into the development of solar energy.

You have heard of the Geophysical Year sponsored by the United Nations through ICSU which in turn appoints committees and solicits support from national governments. Perhaps we can have a Solar

Decade, if we want it. Shall we ask ICSU for an international committee on solar energy?

What can industry do to accelerate the utilization of solar energy? Among the most obvious aids would be mass production of large parabolic mirrors of aluminum pressed out with dies, or of plastics with vaporized metallic films. Small, low-pressure steam turbines or steam engines, die-cast and produced in mass could help greatly to relieve human labor in some of the nonindustrialized areas. One- to ten- or fifty-horsepower engines of sufficiently low cost could find an immediate and large foreign market with some domestic demand, even if the engines are quite inefficient. The development of thin plastics is needed for collectors of solar energy and particularly for the distillation of salt water. Special characteristics are needed such as wetting by water and opaqueness in the far infrared, but the chief demands are for low cost and ability to withstand years of exposure to bright sunlight.

Storage batteries at less than one-tenth the cost of automobile batteries are needed, but they do not need to be small and portable. While laboratory research goes on for new ideas and new methods, studies of mass production of new materials and new machines by industry may well lead to rapid advances in the utilization of the sun's energy.

Solar-energy utilization is rapidly coming of age. Many people have become interested and steady progress will be made. But don't expect miracles. We must go back to our laboratories and roll up our sleeves with ideas newly stimulated and try to extract more value from our sunshine. It is there for us, if we can be smart enough to find it.

But I am confident that the scientists and engineers can and will bring a new era of prosperity and peace to the whole world. The "Atoms for Peace" conference of the United Nations in 1955 opened up a great new hope for atomic power. Perhaps Arizona's "Sun for Man's Use" conference will be just as important. The first half of our century may go down in history as the period of great wars, and it is not impossible that the second half of the century may come to be known as the beginning of a peaceful, power-abundant era in man's evolution. We know now that through research there is a chance that we can have mechanical power and electricity all over the world; and a greater equalization of industrial productivity in all countries may tend to lessen war tensions. I believe that by a judicious combination of fossil fuels, atomic energy, and solar energy the whole world can have within this century all the mechanical power and material comforts that it wants. This development will not solve all the world's problems, because man does not live by kilowatts alone; but it will help.

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Sun, Sea, and Air[1]

By ROGER REVELLE

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THE GREAT SAGA of the Norse kings, the "Heimskringla," begins with the words "Earth's round face, whereon mankind dwells." The Vikings, like other primitive peoples, thought of Earth as their home and of themselves as its creatures. Today we know that Earth is the only planet of our solar system on which human life could have developed, for no other satellite of our sun has land masses surrounded by an ocean of liquid water or an atmosphere containing abundant free oxygen.

Our bodies are made up almost entirely of four elements drawn from sea water and air: hydrogen, carbon, oxygen, and nitrogen. The narrow temperature range in which we can survive is maintained by the great heat capacity of the sea and the atmosphere. The waste products that otherwise would suffocate us are continuously dispersed by the easy motions of the atmosphere. We can exist as land animals only because the sun's deadly ultraviolet and X-rays are fended off by the protective shield of the air, and because the great natural engine of the sea and the atmosphere pumps water continuously from the sea surface and pours it gently down upon the land.

Yet from our point of view, the earth is a careless mother. Large areas of her surface are too hot or too cold, too dry, or too wet to support any large number of human beings. Moreover, she is unreliable. Areas where there was once sufficient water for men to build civilizations are now so dry that only a few desperate nomads can live in them. Elsewhere, a mile-thick blanket of ice has crept down and obliterated once green farms and forests. Millions of our species suffer when a slight change in the running of the sea-atmosphere engine causes drought or flood. Sometimes the engine runs with unpleasant violence. Then thunderstorms and hurricanes, tornadoes, and typhoons bring destruction and death to many of us.

[1] Reprinted by permission from Oceanus, vol. 5, Nos. 3 and 4, summer and autumn 1957.

Because of our dependence on events taking place in the air, almost everyone is an amateur meteorologist. Wherever two or more people are gathered together the first topic of conversation is the weather, and this was probably just as true in the time of Hammurabi or Amenhotep as it is today. Professional weathermen are a new development, however, and it has only been within the last few decades that we have begun to gain an understanding of the great interrelated mechanisms of the air and the oceans.

THE SUN

We know that the sun pours a flood of particles and visible and invisible light into the top of our atmosphere. The amount of visible light appears to be nearly constant, but the intensity of ultraviolet and X-rays and the number of particles vary by at least a hundredfold. The particles are chiefly electrons and protons. The average number of hydrogen nuclei entering our atmosphere is surprisingly large, perhaps a billion per square centimeter per second. During the geological lifetime of the earth, if all this hydrogen were combined with oxygen as water, it would correspond to a layer over the ocean about 20 meters thick. The energy carried to the earth by these particles from the sun during periods of sunspot activity may be as much as one-tenth of the total energy of sunlight.

In addition to particles of ordinary hydrogen, there is new evidence that most of the tritium or radioactive hydrogen on earth also comes from the sun. It was formerly thought that all the tritium was produced by cosmic rays bombarding nitrogen and oxygen molecules in the upper air, but recent calculations indicate that the amount present is nearly ten times too large to be produced in this way.

The marked variations in ultraviolet radiation and in the number of particles coming from the sun cause large variations in the temperature and in the electrical and magnetic behavior of the upper atmosphere, because there is such a small amount of air at these high levels. Neither the majority of particles nor the ultraviolet rays penetrate very deeply, however, and it is not clear whether the variations in the amounts coming from the sun have appreciable effects near the earth's surface. Visible light is the dominant form of solar energy entering the lower atmosphere. Part of this light is reflected back to space, chiefly from the surface of clouds, snow, and ice. Most of it is absorbed in the atmosphere and the sea, from which it is ultimately re-radiated as infrared radiation.

In this respect, the atmosphere behaves much like the glass in a greenhouse. It easily transmits visible light but is rather opaque to the infrared or heat radiation coming from the ground and the sea surface. Just as in a greenhouse, the air temperature must be considerably warmer than it would be in the absence of materials

that absorb infrared, in order to allow a balance between incoming and outgoing radiation. In the greenhouse the absorbing material is the glass roof. The corresponding materials in the atmosphere are three substances present in quite minor amounts: water vapor, carbon dioxide, and ozone.

The temperatures in the upper air do not vary markedly with latitude and consequently the amount of back radiation is roughly the same all over the globe. But the amount of incoming sunlight is greater in the Tropics than in high latitudes. As a consequence, air and water warmed in the Tropics must move toward the Poles. Part of the energy received from the sun is thus used to carry the excess heat absorbed in low latitudes to high latitudes where it can be re-radiated. The amount of heat transported across the parallels of 30° is 10 to 20 percent of the total incoming radiation, but the mechanical work involved is less than 1 percent.

HEAT ENGINES

The situation can be thought of as if the sea and the atmosphere were interlinked heat engines of very low efficiency. These engines do mechanical work against friction by carrying the working fluids, sea water and air, from the "firebox" of the Tropics to the radiation-cooled "condenser" of the polar regions. The circulation of the working fluids is manifest in the winds of the air and the currents of the sea. In the atmosphere, it takes place through the coupling of rotary current patterns of all possible shapes and sizes. These include the trade-wind cells of oceanwide dimensions, the large-scale high- and low-pressure areas of midlatitudes, the wavelike jet stream, hurricanes, tornadoes, tiny whirls and vortices. In the sea, major units of the circulation include the Gulf Stream and the Kuroshio, the fast-moving equatorial currents and the sluggish currents of the abyssal depths. These circulation patterns are partly unstable, and show themselves to those of us who live in midlatitudes as the radical changes in weather with which we are all familiar. In low latitudes over the ocean the instability produces the terrifying hurricanes of the western Pacific and of our own east coast.

The behavior of the interlinked heat engines of the sea and the atmosphere is profoundly influenced by four facts: First is their peculiar shape; they are essentially two thin sheets wrapped around a sphere. Second, the sphere is rotating; the lower layers of air are dragged along by the rotation, and the movements of both the sea and the air are largely determined by the forces generated by the rotation (at a height above our heads of several hundred miles there is a transition to a zone where the sparse atoms of gas no longer move around the earth's axis). Third, the ocean is not a continuous

sheet like the atmosphere, but is broken up by the relatively dry areas we call continents. Fourth, like an invisible pousse-café, the atmosphere is stratified in thin layers that do not mix readily with each other, and each of these layers has to a considerable extent a separate behavior of its own. The same is true of the ocean but with the marked difference that while the temperatures of the different layers of the atmosphere are alternatively lower and higher as we go upward, the temperature of the ocean decreases continuously nearly to the freezing point at great depths. It increases slightly near the bottom because of the heat coming from the interior of the earth.

The energy needed to drive the sea-air circulation is only a small portion of the incoming solar radiation, but it is still enormous on a human scale. The winds of the earth have a total kinetic energy estimated to equal 7 million atomic bombs, or more electric power than all the powerplants in the United States could produce in a hundred years. This energy must be replenished every 9 to 12 days because of the loss by friction between the winds and the earth's surface.

Although there is a general agreement about the foregoing generalizations, our mental model of the sea-atmosphere system is so inadequate in many essentials that meteorologists are unable to predict anything very useful for more than a few days in advance about the circulation of the atmosphere.

CLIMATIC CHANGES

Even more fundamentally, we do not know the factors that determine the average conditions. Consequently, we are quite unable to forecast changes in climate. Yet we know that such changes have occurred in the relatively recent past. Only about 10,000 years ago the earth emerged from a dark age of snow and ice; less than 5,000 years ago, Greenland offered a fair and pleasant habitation for human beings. Within the last 50 years, the climate over eastern North America and northern Europe has again become slightly warmer and the Arctic wastes are perhaps again becoming accessible to human beings, while elsewhere prolonged droughts are destroying the work and hopes of decades. For the farmer, the strategist, and the statesman, an accurate forecast of climatic change over the next 50 years would be of immeasurable value. But such a forecast is completely beyond our present ability. Ability to forecast depends on understanding, and this comes in two interrelated ways: by constructing small models in our heads of the two great earth fluids, and by testing and refining these models through observations. This second method is one of the major objectives of the International Geophysical Year. In particular, we are concerned with measurements in areas that have

never been adequately explored and of phenomena that have never been adequately studied.

To increase our understanding of climatic change we can ask first, what changes have occurred in the past and how did they happen? Second, because a change in climate is essentially a change of average air temperature, we need to examine the ways in which the heat content of the air can vary. The heat content must be that required to give a balance between incoming and outgoing radiation; hence it can vary if there is a change in the amount of incoming radiation from the sun, in the proportion of sunlight reflected versus that absorbed, or in the amount of the infrared back radiation absorbed by carbon dioxide, water vapor, and ozone. A 1-percent change in the intensity of the incoming sunlight or in the amount of sunlight reflected back to space would give about a 1° centigrade change in the average air temperature.

The total solar radiation seems to be remarkably constant. The most recent continuous observations are those made at the Lowell Observatory since 1953. During this period of sunspot minimum no solar variations in the blue region of the spectrum greater than 0.3 percent have occurred. Ionospheric observations show, however, that ultraviolet components of the solar radiation are larger during periods of sunspot maxima, and the visual spectrum observations must therefore be continued throughout at least one sunspot cycle before we can say definitely that solar radiation is virtually constant over decades.

In contrast to the apparent constancy of the incoming radiation, the reflectivity of the earth would appear to be easily changeable. Clouds, snow, and ice reflect most of the sunlight that falls on them, whereas the ocean surface, vegetation, and bare ground are highly absorbing for visible light. At present about 50 percent of the earth's surface is normally covered with clouds, while large areas are capped with snow and ice, particularly during winter. An average of 35 percent of the incoming sunlight is reflected back to space without being absorbed. The average air temperature would decrease by 1° centigrade if the reflection increased to 36 percent through increased cloudiness or a spreading of the snow- and ice-covered areas.

Dust in the upper air also scatters and reflects sunlight before it can reach the ground and ocean surfaces. After the explosion of the volcano Krakatoa in 1883, the incoming radiation from the sun and sky decreased by 5 to 10 percent for three years. Changes in the water vapor, ozone, or carbon dioxide content of the air alter the amount and character of the infrared absorption. Calculations indicate that a 25-percent change in the carbon dioxide content of the air would change the average air temperature by 1° centigrade.

The factors affecting the average air temperature are interrelated; there are in fact what electronic engineers call "feedback" relationships among them. These feedback linkages are both positive and negative. For example, an increase of air temperature from whatever cause would result in a melting of part of the snow and ice cover of the earth and a corresponding reduction in the reflection. Consequently, the amount of absorbed radiation would increase and the temperature would rise still further. This is a positive feedback. Similarly, an increase of average air temperature would increase the evaporation from the oceans; hence the water-vapor content of the air and absorption of infrared radiation. The temperature would not increase without limit, however, because an increase in evaporation must eventually result in an increase of cloudiness as the water vapor condenses; hence an increase in the proportion of reflected sunlight. This is a negative feedback. Such complex feedback linkages tend to hunt or oscillate, with time constants determined by the speed of the different processes involved.

Thus far we have been discussing comparatively small changes in average air temperature over the earth. Such changes may be of great significance—it is generally estimated by meteorologists that a 4-degree drop in average air temperature would be sufficient to bring on a new ice age. But with present meteorological observing facilities they would be almost impossible to measure. What is observed are local changes of much greater magnitude. These must be brought about chiefly by variations in atmospheric and perhaps oceanic circulation, specifically in the locations of north-south transport of heat and matter.

For example, the January mean temperature at Spitsbergen increased by 24 degrees from 1913 to 1937, whereas during almost the same period there was a 3 to 5 degree drop in January mean temperature in the Great Basin of the western United States.

Because of the complex relationship between the amounts of insolation and infrared absorption on the one hand and the circulation patterns of north-south transport on the other, it is by no means certain whether an increase of insolation or absorption would bring on a colder or a warmer climate.

PAST CHANGES

The circulation patterns are profoundly affected by the distribution of continents and oceans, and therefore it is of great importance to make comparative studies of past climatic changes in the Northern and Southern Hemispheres, because of their markedly different patterns of sea and land. Since changes in the intensity of the north-south circulation should have different effects in high and low latitudes,

it is also necessary to attempt to determine the nature of simultaneous climatic changes in different latitude zones.

The great ice caps of Antarctica and Greenland and the mountain glaciers throughout the world are remarkable indicators of climatic change. During periods of warming or reduced precipitation the glaciers retreat; when the atmosphere is cooled or snowfall increases, they thicken and rapidly advance. Moreover, the layers of ice laid down in successive years constitute an unrivaled record of events on earth during past millennia.

Many aspects of glaciers will be studied during the IGY. Among the most significant from the standpoint of the heat and water budget of the earth will be the thickness of the ice. This will be measured by the seismic techniques used in prospecting for oil. Bore holes and cores will also be taken to study the frozen record of the past.

Ice caps now cover about 3 percent of the earth's surface. A melting of 2 feet per year over these surfaces seems quite possible from present data. This would result in a rise of sea level of about an inch per year or roughly 10 feet in 100 years. Even such a rise as this would bring serious consequences to many thickly populated coastal areas.

The sediments of the deep sea floor, like the ice caps, contain a detailed climatic record extending back over many thousands of years. For example, variations in the numbers of limy shells of the tiny animals called Foraminifera reflect variations in the oceanic circulation near the surface. The ratios of oxygen isotopes in these shells tell us something about past ocean temperatures. At least part of the present temperature differences we can measure between different layers in deep sea sediments may be the result not of heat flow from the earth's interior but of warmer temperature of the deep ocean waters a few hundreds or thousands of years ago. Studies of these sediments and their significance for climatic change will be an important part of the series of oceanographic expeditions to be conducted during the International Geophysical Year.

The meteorologist and the oceanographer can seldom use that peerless tool of the laboratory scientist—controlled experiment. As substitutes for experiment they must attempt to make comparative investigations of the behavior of the earth fluids under different conditions. For this reason a major part of the IGY meterological program will be focused on comparisons between the Southern and the Northern Hemispheres.

Because the earth is closer to the sun in January than in July, the Southern Hemisphere receives about 6 percent more radiation in summer than does the Northern. The geometry of the two hemispheres is also quite different. In the north, the Polar Sea with its thin, cracked skin of ice is surrounded by continents; in the south a

continent nearly twice the size of the United States, having an ice-covered surface 2 miles above sea level, lies at the Pole and is surrounded by the great southern ocean. This high central plateau, sheathed in darkness for 6 months each year, is a focal point for inward-circling storms and outward surges of cold air. The weather conditions in the Antarctic are nearly incredible; for example, wind velocities at Adelie Land have averaged 110 miles per hour for a day, more than 60 miles per hour for a month, and about 40 miles per hour for an entire year. The American IGY party now maintaining a vigil at the South Pole has already recorded temperatures below −100° F. with 15- to 20-knot winds.

As is well known, the testing of large atomic weapons produces considerable amounts of radioactive substances, some of which decay rather slowly. A large part of the radioactive material produced by atomic weapons tests is injected into upper strata of the air and can be used by meteorologists as a tracer of atmospheric movements, for example, to determine the rate at which the air at different levels is carried from the Northern to the Southern Hemisphere and vice versa, and the rate of mixing between the upper and the lower atmosphere. An important IGY objective will be worldwide measurements of these artificially radioactive substances.

GAINS AND LOSSES

A slight excess or deficit in the input of solar energy over the output of infrared radiation from the earth may cause large changes in weather and, if long continued, in climate. At present we are unable to determine whether such differences between income and outgo exist.

Here the earth satellite program shows great promise; one of the first satellites will carry relatively simple equipment for measuring the difference between the amounts of incoming and outgoing radiation at all points over its path. Later satellite experiments will include actual mapping of the earth's cloud and snow cover, allowing accurate and continuous measurements of the amount of sunlight reflected from the earth, a quantity that can at present only be rather crudely estimated.

A change in average air temperature represents, of course, a gain or loss of heat from the air, but it need not represent a gain or loss from the ocean-atmosphere-glacier system of the earth. On the other hand, an excess of heat could be stored for long periods on the earth without much change in the temperature of the lower air. There are two great mechanisms for this one: one is the melting of ice caps, the other is the heating of the deep waters of the ocean. The latter has by far the larger capacity. The energy required to melt all the ice in Antarctica is equivalent to about 2½ years' supply from the sun at the present rate of 175,000 calories per square centimeter each year. This

same amount of energy would raise the average temperature of the ocean by only a little more than 1° C. (On the other hand, the melting of ice caps would be somewhat more obvious to everyone, since it would result in a rise of sea level by at least 200 feet, and the consequent destruction of most of the world's largest cities!)

Because of the great heat capacity of the ocean, many meteorologists and oceanographers now believe that climatic changes lasting over decades or centuries may be intimately related to changes in the circulation of the deep sea. Effective techniques for studying this circulation have become available only in the last few years, and it is little understood. We know that cold water sinks to great depths from the surface in high latitudes, moves slowly toward the Equator and perhaps across it, and returns by an unknown path to the starting point. The time required for the round trip is not known; it may be measured in decades or millennia. Nor do we know whether the circulation is steady or intermittent like the flushing of water in a bowl.

One of the major enterprises of the International Geophysical Year will be a series of great oceanographic expeditions, conducted by 70 ships belonging to many countries. Their principal objective will be to obtain a comprehensive picture of the temperature and other properties of the deep sea waters, and to make direct and indirect measurements of their motions.

THE EARTH AND MAN

President Eisenhower has said that water is rapidly becoming our most critical natural resource. During the last few years, serious attempts have been made to develop inexpensive machines for converting sea water into fresh water. The fact is, of course, that nature herself operates a most effective distillation system. Nearly one-third of all the energy of sunlight falling on the sea surface is utilized in converting sea water to fresh water by evaporation. The immense quantity of solar power used in this way is several thousand times all the power produced by our industrial society from hydroelectric power and the burning of coal, oil, and natural gas.

The total quantity of water evaporated, if all of it fell on the surface of the land and was uniformly distributed, would result in an average rainfall of over 100 inches a year. Evidently the trouble with the natural distillation process is not the quantity of fresh water produced, but rather that nature's pipelines are badly placed. Too much water moves to some areas and not enough to others; moreover, the valve system seems to be capriciously managed. Sometimes the discharge is too great, bringing floods, while at other lines there is only a trickle and droughts occur.

Can anything be done about this faulty distribution system?

The quantity of solar energy used in driving the engine of the sea and the atmosphere is so great compared to any of the energy sources under man's control that it would seem impossible for us to affect weather or climate materially by any human action. Yet, a close look shows there may be some things we could do. Many of the processes in the atmosphere are metastable: a slight action may initiate a very large-scale process. We might learn how to regulate climate if we could find the right lever to pull.

One may predict that with the coming of greater understanding, promising methods for control of weather and climate will be found. The average reflectivity of the ground surface over the large areas might be reduced, for example, by rapid melting of the snow cover, thus increasing the percentage of sunlight absorbed. On the other hand, it might be possible to shut off some of the sun's radiation before it reaches the earth's surface, for example, by injecting a small amount of absorbing or reflecting substances into the upper atmosphere.

GREAT EXPERIMENT

During our lifetime we may be witnessing an example of one way in which human actions can affect weather and climate. Since the beginning of the industrial revolution, an amount of carbon dioxide equal to about 12 percent of the total already present in the atmosphere has been produced by the burning of coal, oil, and natural gas. The ability of the ocean to absorb carbon dioxide is very great and probably most of the amount added to the atmosphere during the last century has gone into the sea. During the next hundred years, however, the increasing use of fossil fuels in our worldwide industrial civilization should result in the production of about 1,700 billion tons of carbon dioxide—70 percent of the amount now in the atmosphere. Because of the rapid increase in the production rate, the fraction of the added carbon dioxide absorbed by the ocean will be lessened and an increase of perhaps 20 percent in atmospheric carbon dioxide can be expected. The effect of such an increase is not easy to predict, but there is some theoretical reason to believe that it could result in a warming of the lower atmosphere by several degrees. Thus, by consuming within a few generations the fossil fuels laid down in sedimentary rocks over many hundreds of millions of years, we are conducting, more or less in spite of ourselves, a great geophysical experiment. It is of vital importance to keep accurate records of this experiment in order to increase our understanding of the mechanisms controlling climate. With this in mind, careful measurements will be made during the IGY of the carbon dioxide content of the atmosphere, and studies will be initiated to refine our estimates of the absorption of carbon dioxide in the sea.

Rocketry[1]

By Donald Cox
and
Michael Stoiko

[With 1 plate]

INTRODUCTION[2]

Advances in the social and physical sciences, as in other fields, are usually brought about by a slow process of evolution—by the cumulative effects of innumerable small contributions. The history of modern technology, particularly rocketry, has been the story of such a process. Recently, however, four historic events have occurred which, considered in themselves, are milestones in the history of modern technological development. But when these seemingly independent occurrences are considered together—related to rocketry—they have a phenomenal catalytic effect on this normally slow process.

The first such event occurred on the evening of September 8, 1944, the date the first German vengeance weapon, the V–2, fell on London. The second event, which startled the world on the morning of August 6, 1945, was the nuclear destruction of Hiroshima. The third event occurred just before noon on January 19, 1946. It was the first successful radar contact with the moon. The fourth and most spectacular recent event occurred on October 4, 1957. The "beep . . . beep . . . beeps" had announced to the world that man had established his first artificial earth satellite.

These achievements some day will be recorded as the "four scientific wonders of the age," responsible for changing the course of human evolution. Together, they symbolize the accelerating force which is rapidly making the story of modern rocketry synonymous with the conquest of outer space. The outgrowth of these four symbols provides the foundations for this world force . . . space-power.

[1] Excerpts from the Preface and from Chapter 2 of Spacepower, and Chapter 3, "Rocketry Today," from the same book, by Donald Cox and Michael Stoiko, are reprinted by permission of the publisher, The John C. Winston Co.

Editor's Note: Since the publication of this book, some of the missiles mentioned in this survey have been dropped and many new missiles and facilities have appeared in the arsenals of the various nations.

[2] Excerpts from Preface to Spacepower.

In order fully to grasp and understand the tremendous impact that spacepower will have on all of us, we must look to astronautics, one of the most important sciences of this new era. Our definition of astronautics would encompass "The science of man's movements and/or his instruments in the universe." As such, astronautics covers many subdivisions, including anthropology, astronomy, astrophysics, space law, space medicine, space sociology, and space flight. It is this last area, "space flight," that is the most dramatic when considered in relation to the men, money, and material costs involved. Here is the vortex around which the other subdivisions revolve and obtain sustenance.

ROCKETRY YESTERDAY[2]

The underlying developments which led to the present state-of-the-art in rocketry are the results of a combined effort of many nations and peoples. Three main periods can be distinguished in the development process: the first period extends from antiquity to A.D. 1242 and Roger Bacon's introduction of "De Mirabili Potestate Artis et Naturae" (On the Marvelous Powers of Art and Nature); the second period covers Sir Isaac Newton's Laws of Motion through the time of Sir William Congreve's rockets (1670 to 1826); and the third period includes the publication of Goddard's "A Method of Reaching Extreme Altitudes" through to the present (1919–58).

In the first period, man learned how to make gunpowder and how to use the propulsive characteristics of this rapidly burning compound. In the second period, we saw not only the beginnings of science in rocketry, but we also witnessed the large-scale development and utilization of war rockets. In the third period, with the impetus of the Second World War, we saw the rocket develop from its previously limited role of an artillery rocket to that of a multipurpose weapon and research tool.

In these three periods, many famous names in history and science appear: in the first, Hero of Alexandria and Roger Bacon; in the second, Sir Isaac Newton and Sir William Congreve; and in the third appear such contributors as Konstantin E. Ziolkovsky and Nikolai A. Rynin of Russia; Hermann Oberth, Max Valier, Eugen Sänger, Wernher von Braun of Germany; Robert Esnault-Pelterie of France; and Dr. Robert H. Goddard of the United States.

In the early part of the twentieth century modern rocket research began with the work of Dr. Goddard, who, backed by a small grant from the Smithsonian Institution, directed a group in research and development of military rockets during World War I. The group

[2] Excerpts from Chapter 2 of Spacepower.

was successful, and a demonstration was held at the Aberdeen Proving Grounds on November 6 and 7, 1918. The reports from these demonstrations were so encouraging that the Government authorized limited rocket research between World War I and World War II.

It was not generally known, however, in or out of the United States, until 1919, that Dr. Goddard was engaged in rocket research and development. At that time, Goddard delivered his now famous monograph to the Smithsonian Institution entitled "A Method of Reaching Extreme Altitudes." In the second part of this paper, in addition to the report of his experimental work, Dr. Goddard showed that a rocket with a gross weight of 22,000 pounds would be capable of escaping from the earth and delivering a payload of magnesium powder to the moon. He estimated that in impacting on the moon a flash could be created which would be visible on the earth. It is interesting to note that the Vanguard launching vehicle weighs 22,000 pounds and, secondly, that many people today are proposing that we send nuclear or other type warheads to the moon to create an explosion which would be visible on earth.

By 1926 Dr. Goddard's research activities included almost every aspect of rocket design and culminated in a feasibility demonstration of the world's first liquid-propellant rockets. Although the demonstration was successful, his accomplishments were ahead of their time and not immediately recognized.

Dr. Goddard continued his research first in New England and then later in the deserts of New Mexico. Many experimental rocket-stabilization flights were conducted in New Mexico. On December 30, 1930, an 11-foot rocket reached a height of 2,000 feet and a velocity of 500 miles per hour. Another flight, on March 28, 1935, achieved a height of 4,800 feet and a velocity of 550 miles per hour. Subsequent rocket firings achieved altitudes of 7,500 feet and speeds of 700 miles per hour.

Some of Dr. Goddard's contributions to rocketry, of which there were many, were as follows:

1. Mathematical analysis of multistage rockets.
2. Feasibility of liquid propellants.
3. Centrifugal propellant pump.
4. The use of jet vane fins in the rocket exhaust.
5. Invention of the first practical gyroscope.

Goddard is truly the father of modern rocketry. In 1922, Hermann Oberth wrote to Goddard, requesting a copy of "A Method of Reaching Extreme Altitudes." The following year, Oberth published his classic book on space travel, "Die Rakete zu den Planetenräumen" (The Rocket to the Interplanetary Spaces). This book, written by a mathematician, discussen in great detail the theoretical requirements for

contiguous and interplanetary space travel. The book brought adverse comments from the uninformed and praise from the disciples. Subsequent publication supporting Oberth's thesis was Dr. Walter Hohmann's book, "Die Erreichbarkeit der Himmelskörper" (The Attainability of the Celestial Bodies). This book was a highly theoretical treatment of minimum energy departure trajectories from the earth and return to the earth from the other planets. This was followed by Max Valier's "Der Vorstoss in den Weltraum" (A Dash into Space). These classics were the forerunners of the many publications which followed on the feasibility of space flight.

In 1929 Hermann Oberth published his most important work, "Die Wege zur Raumschiffahrt" (The Roads to Space Travel). In this book Oberth presented a most complete analysis of contiguous and interplanetary space flight. He discussed in great detail the problems associated with the design of manned space vehicles and flights in these zones. He also covered the possibility of artificial satellites.

As a direct result of Oberth's publications, the German Society for Space Travel (Verein für Raumschiffahrt) was formed.

The German Rocket Society for the advancement of space travel was organized in 1929. After going through a period of natural growth, i.e., developing a unity of purpose and procuring test facilities, the group was successful in developing a number of liquid rockets. In 1933 the military, after witnessing a formal rocket demonstration by the society, commissioned one of the society members, Wernher von Braun, then aged 24, to develop an experimental military rocket.

In 12 short years (1933–45), the German military rocket research program had gone through an amazing period of development. Rocket research had progressed from the A–1 in 1933, weighing 330 pounds, which was never fired, to the famous A–4, commonly known as the V–2, weighing 24,000 pounds. Approximately 1,120 V–2's were fired on England, with 1,050 actually falling on London, and 2,500 were fired against other targets in Europe. To make the total complete, it should be mentioned that probably another thousand V–2's were fired for training purposes, and still hundreds more were brought to the United States for research.

Advanced thinking and planning had also gone into the A–10, a two-stage missile which would extend the range of the A–4 across the Atlantic.

To carry out this accelerated military rocket program, the Peenemünde Research Institute had been established in 1937 on the Baltic seacoast by the German Army. These facilities, which have long since become as famous as the rocket produced there, were very short lived. In the early months of 1945, the Peenemünde facilities were captured by Russian armies.

ROCKETRY TODAY[4]

The present state of science and of technological knowledge permits the building of machines that can rise beyond the limits of the atmosphere of the earth.

After further development these machines will be capable of attaining such velocities that they—left undisturbed in the void of ether space—will not fall back to earth; furthermore, they will even be able to leave the zone of terrestrial attraction.

—*Hermann Oberth.*
Die Rakete zu den Planetenräumen—1923
(The Rocket to the Interplanetary Spaces).

Shortly before the capture of Peenemünde, in the final phases of World War II, the United States, its Allies, and Russia realized that the Germans were way ahead of every nation in guided-missile development and application. Accordingly, they organized teams of technical experts, both civilian and military, to search the German research centers and factories for information pertaining to rocket development. When the European war ended, these technical teams proceeded to fulfill their assigned tasks. As a direct result of this action, literally tons of captured documents and all types of rocket hardware were confiscated by the participating nations.

One very important part of this program was the search for experienced rocket people. Of the thousands of technical personnel who worked at Peenemünde and other rocket-producing facilities, it was reported that the Soviet central agency, whose sole function was to recruit German rocket specialists after World War II, rounded up a total of 5,000 scientists, engineers, and technicians from the Peenemünde project. The United States took under its wings a few big names but let the bulk of the Peenemünde colony slip through its fingers to Russia. In this manner, Russia acquired almost all of Hitler's best rocket brains, and within an incredibly short period had them working around the clock 7 days a week on their rocket developments.

Thus, it was not until the capture of Peenemünde and the roundup of its scientists, documents, and missiles that a guided-missile program was initiated by some of the major nations of the world. Since then, however, the status of worldwide guided-missile programs indicates that Argentina, the British Commonwealth, Italy, Japan, France, Holland, Russia, Switzerland, Sweden, and the United States are actively engaged in a missile technological race on a scale that has seen no precedent or parallel in the course of human history. This missile race is centered around four basic military categories (see pl. 1) which include: (1) air-to-air (AAM); (2) air-to-surface

[4] Chapter 3 of Spacepower.

(ASM); (3) surface-to-air (SAM); and (4) surface-to-surface (SSM) missiles.

Let us examine in detail "rocketry today" and the results of this 12-year missile armament marathon.

ARGENTINA

Argentina is the only known country in South America that has entered the missile field. Its entry was with the AF3, a surface-to-surface missile developed for use against tanks, trucks, and small ships.

BRITISH COMMONWEALTH

The British Commonwealth's contributions to rocketry have been the subject of many highly controversial debates in the last few years. The authors believe that the most accurate account of the British achievements was recently expressed by Mr. Leonard Bertin, science correspondent for The London Daily Telegram and Morning Post, who, after touring major missile facilities in the British Isles and visiting the long-range missile test site in Woomera, Australia, stated: "With the limited resources it has available, England's missile development program is actually achieving a great deal."

The first concrete evidence supporting Mr. Bertin's opinion is the recent missiles data and photographic releases by the Ministry of Supply. This, coupled with announcement by The Society of British Aircraft Constructors (SBAC) that 400 British companies are actively engaged in missile and development work, substantiates that the British Commonwealth is advancing steadily in missile development. In addition, at the Royal Aircraft Establishment, scientists are actively working on new concepts related to basic missile research. The Farnborough facility is known to have a well-equipped laboratory, including the TRIDAC guided-missile simulator, and the Hawker Siddeley Co. has established one of the newer missile-research facilities near Coventry.

Supporting these research and development centers are several test facilities. The Ministry of Supply has added a 200,000-pound propulsion test complex (facility) to supplement the many currently in existence at this center. Also scheduled for completion in 1958 is the Ministry of Defense's large new missile firing range at South Uist off the west coast of Scotland. To date, however, the only operating range in England is the 250-acre Aberporth facility on the Welsh coast. It is estimated that about 1,000 large test missiles are launched at this facility yearly in addition to the many hundreds of smaller vehicles such as target drones. Jodrell Bank, the world's largest radio telescope, is situated in England and plays a vital role in tracking missiles and satellites.

The best-known Anglo-Australian rocket test facility is the Woomera Range in Australia, the site at which the majority of Britain's missiles have been tested. The Woomera test site consists of a corridor that cuts across 1,200 desolate miles of Australia, extending northwest to the shores of the Indian Ocean. This test range can easily be increased to 2,700 miles by extending it to Christmas Island in the Indian Ocean.

Today, as during World War II, the major concern of the British is defense, and missiles have been chosen as the best means, as borne out by Defense Minister Duncan Sandys' announcement in April 1957 that the English Electric P–1 is the last manned fighter; that Avro Vulcan B2 and the Handley Page Victor B2 are the last of the manned bombers; that all interception of enemy craft in defense of England will eventually be made by a single operational air-to-air missile, the Firestreak; that pending operational use of an intercontinental ballistic missile (ICBM), the range of the V-bombers would be increased by the use of an air-to-surface missile; and that because of the destructive capabilities of nuclear weapons, target defense will eventually be restricted to ICBM retaliation bases eliminating old-time emphasis on populated area protection.

In support of this concept, England has developed or is in various stages of developing missiles in the basic four categories: air-to-air, air-to-surface, surface-to-air, and the ever-important, long-range, surface-to-surface missile.

In the air-to-air category, three missiles are of importance—the Fireflash, Firestreak, and the Red Dean. The performance of the Fireflash, the first operational missile in this category, grew out of World War II requirements of the Royal Air Force. The Fireflash is currently in use on the Supermarine Swift MK7, the Hawker Hunter, and the Avon Sabre fighters. The vehicle configuration is characteristic of many British vehicles in that it has wrap-around, solid-propellant boost motors.

It is significant to note that the wrap-around booster technique seems to be unique with the British. Normally, missile boosters are attached in tandem; i.e., the missile is placed on top of the booster. This arrangement leads to a long, slim vehicle configuration. In the wrap-around configuration, the booster, usually in three or four pairs, is placed in parallel around the outside of the main rocket. This arrangement in turn leads to a short stubby rocket. In either case the boosters drop away after firing. It would be most difficult at this time to state that one technique is actually better than the other.

The second vehicle in this category, the Firestreak, is approximately 7 feet in length and somewhat larger than the Fireflash. It is propelled by a solid-propellant motor. Its range is 8 miles, and

guidance is infrared, i.e., heat seeking. This missile is scheduled for use on the English Electric P-1 and the Gloster Javelin fighters. The Royal Navy will also use it with its DH Sea Vixens aircraft. The Red Dean, the third in the series, was being developed by Vickers-Armstrongs when it was rumored to have been canceled.

In the air-to-surface category only one missile is reported to be under development. The missile is expected to be comparable in size to the U.S. Air Force's Rascal, and its application is reported to be with the RAF's Vulcan and Victor bombers.

In the surface-to-air category there are three missiles, the Bloodhound, Thunderbird, and the Sea Slug. All are reported now in production. The Bloodhound is expected to be Britain's first operational missile in this category. The second most publicized missile in this family is the Thunderbird. Performance of this vehicle is said to be on the same order as the U.S. Nike Hercules. The Royal Navy's entry in this family is the Sea Slug, designed especially for naval defense. The missile configuration includes the wrap-around, solid-propellant boosters as well as a solid-propellant sustainer motor. It has medium-range interception capability and can reach any aircraft flight altitude necessary for interception.

The surface-to-surface family boasts of only one vehicle, a 2,000-mile intermediate-range ballistic missile (IRBM). This vehicle has no known name at present. De Havilland in conjunction with Rolls Royce has prime responsibility for developing this missile for the RAF. The ICBM which was being developed by Vickers-Armstrongs was canceled for undisclosed reasons.

Among British Commonwealth missiles, Canada has made one attempt to develop an air-to-air missile, the Velvet Glove, but a change in government policy called for canceling it. Australia's contributions to date are the Jindivik subsonic bomber and the huge Woomera rocket test range.

It is apparent that the British have accomplished and are achieving a great deal in all phases of missile technology. In terms of trained manpower, research, and test facilities, the British Empire's potential is excellent—a potential which should someday render her one of the top three leaders in this field.

ITALY

Italy, one of the pioneers in jet propulsion, has been interested in rocketry since the end of World War II. This interest has been displayed by individuals, government, and industry. However, lack of funds and government direction has delayed positive action. In spite of these handicaps, however, Italy has developed several military rockets, two of which are the Airone and the Robotti. The

Airone is a solid-propellant, surface-to-surface missile approximately 6 feet long and 3 inches in diameter. Range is reported to be over 6 miles. The Robotti is a surface-to-air missile propelled by a liquid rocket engine using nitric acid and aniline. It is the opinion of many rocket experts that Italy has excellent research potential and will within the next few years become a leader in the missile production field.

JAPAN

Japan, one of the more recent entries in the missile field, is described as one of the most enthusiastic. This country's missile activities include military rocketry, research rocketry, and space-flight studies.

The military rockets include the MM–1 and the TMA–O–AC. The MM–1 is an air-to-air guided missile, and the TMA–O–AC is identified simply as a military rocket.

Japan's research rocket program is the result of a decision of the National Science Council of Japan to participate in the 1957–58 International Geophysical Year (IGY). As part of this program, a decision was made to use sounding rockets to supplement balloon observations. To develop these rockets in time for the IGY, a 4-year missile development program was initiated. This program called for a series of five rockets—the Pencil, Baby, Kappa, Sigma, and Omega—which would progressively lead to a very high (150-mile) IGY sounding rocket. Japan announced in October 1957 that one of her rockets had gained a 75-mile altitude.

FRANCE

In Europe, France has been one of the leaders in the missile field since the end of World War II and has established an impressive record with her relatively limited resources. Her missile developments have been geared to the type of war she feels she is most apt to fight. In line with this philosophy, antiaircraft and wire-guided antitank missile research has been emphasized.

Some of the better known antiaircraft missiles are the Navy's Maruca and Masalca, and the Army's Sud–Est (SE) series and LRBA–DEFA's ramp-launched PARCA.

In the antitank category, the SS10 and the SS11 programs are outstanding. The first program, the SS10, includes the SFECMAS–5200 and DEFA's Entac missiles. These two missiles are almost identical in range and velocity. Both are wire controlled and can be launched against tanks either from the surface or from the air. The second program, the SS11, includes the SFECMAS–5210 missile, which is said to be a longer range version of the SFECMAS–5200.

Four other surface-to-surface missiles of importance include: (1) Zborowski's BTZ–411.01 bazooka-type, two-stage, solid-propellant

missile; (2) the infantryman's Lutin, a radio-guided, rocket-boosted ramjet; (3) the Ogre I, photo-reconnaissance, liquid-propellant-boosted ramjet; and (4) the SE–4200, which is ramp launched by two solid boosters and ramjet sustained. The missile is currently in production.

There are five missiles in the air-to-air category: the M04, M20, M051, M510, and M511. Of these five, the M04 is probably the best known. The M04 can be used in either air-to-air or surface-to-air applications. It is approximately 15 feet long, 16 inches in diameter, and weighs over 1,000 pounds. This missile utilizes a liquid-propellant rocket engine, delivering 2,750 pounds of thrust for 14 seconds, and it can fly over 1,000 miles per hour, carrying approximately 245 pounds payload. The M04 was first successfully tested in 1952.

The M20 and M051 are Matra production missiles carried by the Mystere A and B fighters. The M20 uses a liquid-propellant engine, and the M051 utilizes a solid-propellant motor.

The last two missiles in this category are the M510 and M511. They are comparable in length to the Matra M051. Although the performance of these missiles is classified, it has been reported that the M511 is scheduled for use with the Trident rocket-powered airplane.

French air-to-surface missiles are the least developed and consist of only three missiles, the BB10, SNCASE 1522, and an ASM, which is said to be similar to the U.S. Air Force's Rascal.

French missile designers' independent look at their missile requirements has resulted in some truly remarkable advances in the state of the art. Their wire-guided antitank missiles and their antiaircraft missiles are tops in their fields. The French method of guiding antitank missiles by wire (similar to a kite) has been adopted by the United States. Also, the adaptation of ramjets in small missiles by the French has been revolutionary. France is rated as a third-ranking military power in rocket development.

HOLLAND

A smaller nation contributing to rocketry today is Holland. Utilizing a French SFECMAS SS10 pulsejet motor, which develops 190 pounds thrust, the Aviolanda Co. developed a pilotless target aircraft. The plane is boost-launched by rockets, has a conventional aircraft configuration, and is radio controlled.

SOVIET UNION

The Soviet Union, one of the two giants in the guided-missile field today, achieved its missile mastery within a record-breaking period from an incredibly primitive start. It is fairly obvious from present results that the Russians, after taking over Peenemünde

and enlisting the aid of many of its former specialists, made exceptionally good use of both.

Although many, if not most, of her current missiles reflect the design and thinking of the German influence, Russia today is completely on her own. The transition from almost complete dependence on German know-how to complete independence took place essentially within three 5-year periods.

The first period, from 1945 to 1950, was one in which the Russian missile industry depended a hundred percent on the experience of the German rocket specialists in all branches. This was the Russian learning period. It is reported that from the beginning the Russians followed a policy of picking clean the Nazi rocket scientists' brains. Soviet scientists and engineers observed every move the Germans made and quizzed them endlessly on the Peenemünde experiments and general German rocket theory.

In the second period, from 1950–55, Russian specialists began to phase out their German counterparts. And finally, in the third period, i.e., since 1955, the Russian missile industry has been entirely on its own and is making tremendous headway.

Today, the Russian arsenal not only includes special application missiles, such as their satellite-launching and high-altitude research vehicles, but also has missiles in all four major military categories: air-to-air, air-to-surface, surface-to-air, and surface-to-surface. The last category, surface-to-surface, includes the particularly important submarine underwater-launched missile.

In the air-to-air category the Russians basically have two missiles, the 3.2-inch rocket and M–100 series. The 3.2-inch rocket is the standard missile in this category. It is said that the 3.2 is a carryover from the German World War II R4M, which was a spin-stabilized, short-range, solid-propellant missile.

The M–100 and M–100A are higher performing rockets from the same family. The M–100A is approximately 8 feet long and 10 inches in diameter, and weighs between 100 and 200 pounds. It is a production missile propelled by a solid-propellant motor with a range of about 5 miles.

There are reported to be four missiles in the air-to-surface group: the RS82, RS132, RS–URS–132, and the Comet III. The first three of this grouping are unguided solid-propellant missiles, and the Comet III, which is radar guided, has a range of approximately 100 miles.

The surface-to-air category lists three missiles: the M–1, T–7, and the T–8. The first vehicle, the M–1, is 14.7 feet long, 22 inches in diameter, and has a takeoff gross weight of 3,300 pounds. It is solid-boost launched, sustained by a hydrogen peroxide and hydrazine

liquid-propellant engine, and has a maximum operational ceiling of about 50,000 feet. The performance of this missile is somewhat comparable to the U.S. Army's Nike. Although the M–1 is now obsolete, it initially was pressed into service several years ago as a defense against the U.S. Air Force's B–29 and B–36 bombers.

The second missile in this category, the T–7, is a more efficiently performing missile based on the German World War II Wasserfall. The T–7 is 25 feet long and 25 inches in diameter. It weighs 3 to 4 tons and has a maximum altitude of 75,000 feet. Like the M–1, it is boost-launched and sustained by a liquid-propellant engine. The missile was designed to defend Russian targets against potential attacks from B–47 and B–52 bombers. United States authorities have confirmed that these missiles are currently in production and are located at missile sites around most major target areas.

The last vehicle in the surface-to-air group is the T–8, which is employed as a barrage flak weapon against low-altitude targets.

In the surface-to-surface type can be found the heart of the Russian military and scientific missile strength. As such, this list includes the medium-range ballistic missiles, intermediate-range missiles, intercontinental ballistic missiles, as well as the satellite-launching and lunar vehicles. Each of the missiles in this family is of extreme importance, and therefore will be discussed in some detail in the order mentioned above.

There are three missiles in the medium-range, surface-to-surface category. These missiles are the T–1 (M–101), the S8, and the T–7A. The T–1 is said to be an improved version of the German V–2. It is estimated to be 50 feet long, 5.5 feet in diameter, and powered by a liquid oxygen and kerosene rocket engine. The engine thrust is rated at 77,000 pounds, and the range is given as 400 miles. The S8 is said to be another modification of the German V–2, and is somewhat similar to the T–1. This vehicle is specifically designed to be launched from underground tubes. The last missile of the medium-range, surface-to-surface type is the T–7A. This vehicle is 25 feet long, has a diameter of 2.5 feet, and a takeoff gross weight of 8,800 pounds. It is reported that the vehicle is currently in production and is operational.

The Russians have four missiles in their arsenal in the intermediate range, surface-to-surface classification. Two of these, the T–2 (M–103) and T–4 (M–102), belong to the Army, and Comets I and II are Soviet Navy missiles.

The Army's T–2 is an improved version of the German two-stage A–4/A–9, which was initially designed by the Germans to bomb New York during World War II. The T–2 is approximately 125 feet in length, 15 feet in diameter, and has a range of 1,800 miles.

The first-stage propulsion system is a liquid-propellant rocket engine utilizing liquid oxygen and kerosene as propellants. The engine thrust is rated at approximately 254,000 pounds. It should be noted that the second stage of the T–2 is basically the T–1 (engine thrust 77,000 pounds).

The second of the Army's intermediate-range vehicles is the T–4. The T–4 is still another version of the German V–2, differing only by the addition of wings. This vehicle is a production item and is commonly known as the winged T–1. It has the same engine as the T–1 and a reported maximum range of 1,000 miles. This missile is also recognized as a test bed for the T–4A, hypersonic glide bomber.

In order to evaluate fully and accurately the Russian missile capability, the Soviet naval missile arsenal must be taken into consideration. It is most generally known that the Soviet Navy is well equipped for missile warfare. Its submarine fleet is said to number between 400 to 800 operational vessels with an additional 100 under construction. In addition to the vast submarine fleet, the Soviet Navy is being equipped with several types of missile ships; for example, antiaircraft and short- and medium-range missile attack ships. United States Naval Intelligence has admitted that the Soviet Navy is second only to the United States Fleet in numbers and is growing very fast.

Probably one of the most potentially dangerous weapons systems that the Russians can deploy against the United States and the Free World is their growing submarine fleet, coupled with their underwater-launched ballistic missiles. Of the several techniques available for launching missiles underwater, in all probability a modified version of the deadly German V–2 submersible ballistic missile launcher would be used. In the older German plan, three V–2 missiles in their containers could be towed horizontally and underwater by one submarine at approximately 15 miles per hour from German seaports to any coastline, depending only on the cruise capacity of the submarine. Once on location, and to ready the missile for launching, the ballast end of the container was to be flooded, forcing the container into the vertical position. When in the upright position, a built-in gyroscope system would hold the container in the desired launch position by counteracting any yaw or roll movements. The missile container was to be outfitted with a control station and propellant tankage in addition to the necessary servicing equipment. The weight of the container and missile was about 70 tons, of which the missile and propellants represented about 35 tons. After the necessary prelaunch servicing, the missile was to be remotely fired from the mother submarine.

When the Russians took Peenemünde, they acquired this fantastic weapons system which was then ready for production!

It is no secret that the Russian Navy is today capable of towing huge ballistic rockets in their submersible containers to any coastline that it desires. With only part of its fleet of 800 submarines assigned to such a mission, it could position offshore in close proximity to any target within the United States. Furthermore, a mission of this type does not require ICBM's nor necessarily IRBM's. Most target areas could probably be reached with the Soviet Navy's Comet I and Comet II missiles reputed to have a range of 100 and 700 miles, respectively.

Dr. Walter Dornberger, former Peenemünde commandant, has said be believes the Russian "emphasis on underwater vessels indicates a plan to use submarines offensively, in American waters, quite possibly as tow vessels for missile launchers."

Completing the military arsenal are Russia's ICBM and antipodal bomber programs. The Russian ICBM designated as the T–3 (M–104) is reported to be a two-stage vehicle approximately 100 to 160 feet in length, and 100 to 150 tons in weight. The first stage is said to be powered by two T–2 motors (254,000 pounds of thrust each), and the second stage by a single T–1 motor (77,000 pounds of thrust). The hypersonic antipodal (skip-glide) bomber has been reported in a number of journals as weighing 100 tons, with the boost stage engines delivering between 800,000 and 1,000,000 pounds thrust and having an attack capability at approximately 10,000 miles per hour.

The last family of vehicles in the surface-to-surface category and certainly one of the most interesting is the scientific research vehicle. Two vehicles of particular current interest are the satellite-launching vehicle and the lunar vehicle.

Since the Russians launched their first earth satellite, they have not as yet officially released information regarding the satellite-launching vehicle. This silence on the part of the Russian scientists and engineers has resulted in many irresponsible press releases from responsible quarters in the United States regarding the Soviet capability. However, cooler heads have prevailed, and, today, there seems to be a consensus regarding this vehicle's configuration as well as the over-all Russian missile capability.

It is most generally agreed that the Russian satellite-launching vehicle is basically a modification of the T–3 intercontinental ballistic missile, and that it was assembled adapting existing hardware such as the T–1 and Wasserfall engines. The vehicle is described as being approximately 100 feet long, 7 to 8 feet in diameter, and having a takeoff gross weight of 150,000 pounds. It is a three-stage vehicle using the same propellants in all stages, namely, liquid oxygen and kerosene. The first-stage propulsion system is the 254,000-pound-thrust T–2 engine; the second stage is the T–1, 77,000-pound-thrust

engine; and the third stage is said to be a 20,000-pound-thrust improved Wasserfall engine.

SWITZERLAND

Another nation which has been actively engaged in missile production is Switzerland. The Orelikon Co. has developed missiles in all but one of the four major military categories.

The surface-to-air (antiaircraft) development of the "Series 50" missiles started shortly after World War II. They weigh about 550 pounds each and have a range and ceiling of 12 miles. The more recent "Series 54" has a takeoff gross weight of 772 pounds. It is powered by a nitric acid-hydrocarbon fuel, liquid rocket engine delivering about 2,200 pounds thrust. The range and ceiling are 15.5 miles and 9.3 miles respectively. The "Series 56" and "Series 57" are the latest versions under development.

In the air-to-surface category, Orelikon has produced two outstanding FF, FF (forward-firing, folding-fin) missiles. These two missiles have been developed expressly for the British Gloster Meteor and Venom aircraft. The Cobra, another Orelikon missile, is a surface-to-surface, wire-controlled, solid-propellant, antitank missile. The weight of the Cobra is reported to be one-tenth the weight of the U.S. Army's Dart.

The most significant aspect of the Orelikon Co.'s operation is its policy of selling missiles to any foreign power throughout the world.

SWEDEN

Sweden, another small nation engaged in missile activities, has one of the better rounded programs. In addition to her missile activity, she is actively engaged in research on high-energy fuels, ramjet propulsion, and advanced rocket designs. Specifically, Sweden's missile program has one missile in three of the four basic military categories. These include the Jaktrobot, an air-to-air, in development; the Sjorobot, a surface-to-surface naval missile soon to become operational; and the Luftforsvarsrobot, a surface-to-air missile in development for her Air Force since 1955. This missile is said to be capable of interception at very high altitudes and at extreme ranges (120 to 150 miles).

UNITED STATES

The United States missile program after World War II was one which emphasized the "broad look" into the state-of-the-art and not quantity production of systems with questionable tactical value, whereas the Soviets adopted postwar crash programs which utilized German rocketry knowledge both for immediate production and as a point of departure for building systems that could span continents.

It was intended that the policy of the United States should eventu-

ally result in the development and production of a select few missiles which would be the best available in their respective categories. It was also intended that this period, like the Russian 5-year "brain picking" period, should fill many of the basic research and engineering gaps as well as build up a cadre of missile specialists throughout the supporting industries.

This concept, coupled with the pressures of an uncertain international picture, was indirectly responsible for fostering the much-discussed parallel programing of the missile efforts which is still in existence today (Jupiter-Thor). Although the international pressures during the immediate postwar period were not as acute (because of the then nuclear superiority in the United States) as they are today, they were, nevertheless, present.

These pressures even in the postwar period did not permit a normal, step-by-step engineering approach. Instead they dictated the simultaneous support of several approaches to the same problem in the hope that one would pay off. It was recognized that each branch of the military service had special tactical obligations possibly requiring missiles in the same category, and, furthermore, that these requirements would naturally lead to competition and probably duplication in some areas. Moreover, as the state-of-the-art developed, a more critical evaluation of these projects was possible. These evaluations resulted in canceling less promising projects (Navaho) and placing greater emphasis on the more promising ones (Atlas and Titan).

As to the soundness of this philosophy, there is agreement among those close to the facts that this concept has permitted the investigation of a greater number of approaches to a particular missile problem; that this policy has also resulted in producing in a shorter period of time greater quantities of technical information, which was readily exchanged between projects, allowing one group to profit from the experience of the other; and that in the final analysis it has developed the potential for producing far better weapons systems in the future.

Perhaps the most significant event after World War II which gave the greatest impetus to American rocketry was the shipment of stocks of unused German V–2's for upper-air research and operational training purposes. The highlight of this program came in 1946 when a two-stage vehicle consisting of a WAC Corporal atop a V–2 reached a record altitude of 244 miles and a speed of 5,000 miles per hour.

To supplement the depleted V–2 stockpiles in the latter part of 1940, limited funds were appropriated for building bigger and better research rockets. The Aerobee and the Martin Viking were developed at this time. Viking 11 still holds the world's altitude record for a single-stage rocket (158.4 miles).

With the advent of war in Korea, missile development programs were given new impetus. This acceleration was reflected in the missile budget. In the fiscal year 1951 the missile budget was $21 million; in 1952, it was increased to $169 million; and in 1953, it reached $800 million. The one-billion mark was surpassed in 1954; and, in late 1957, it went over the two-billion-dollars-a-year level and is still increasing.

Thus, within the last 10 years, the United States missile industry has grown from the precarious incubator stage to a healthy three-billion-dollars-a-year business and is still expanding in all directions.

There are today in the United States approximately 1,000 industries engaged in development, research, or production of rockets and missiles. To some, rocketry represents 100 percent of their business; furthermore, these industries employ about 50,000 engineers and technical specialists, as well as an estimated 100,000 other employees on the nontechnical level. The three branches of the Armed Forces have also committed a significant percentage of their manpower (in addition to their utilization of more than half of the nation's civilian scientific manpower) to implement their respective missile defense responsibilities.

Since the early V–2 experiments, the Nation has developed and produced successful missiles in all four major military categories. The giants in the surface-to-surface category are nearing an advanced stage of development, and by the end of 1958 the United States should have successfully launched several artificial earth satellites.

Without question, rocketry in the United States today is in a crucial transitional period where momentary daily developments can alter significantly the scientific, political, and military status of the Nation. To appreciate its current missile position, let us examine in greater detail some of the most important missiles in the basic tactical and strategic categories, considering first the air-to-air family.

There are, as this is written, four major missiles in the air-to-air category: the Mighty Mouse, Falcon, Sparrow I, and the Sidewinder. Of these four, the Mighty Mouse is the oldest and best known. It has been the most reliable and for years the most utilized of its category. The Mighty Mouse is 48 inches long, 2.75 inches in diameter, and is propelled by a solid rocket motor. The projectile is equipped with a homing head and a proximity fuze. The power of the Air Force's Mighty Mouse is equivalent to a 70-mm. cannon shell which probably is sufficient to bring down the largest aircraft.

One of the newer guided types of Air Force air-to-air missiles is the Falcon. The Falcon is slightly less than 78 inches in length and has a span of 20 inches. It is powered by a solid-propellant motor with 6,000-pounds thrust, has a range of about 5 miles, and a top

velocity better than 1,200 miles per hour. The missile is radar guided, and its kill rate is high. This missile has the lethal power to stop any aircraft.

Two of the newer missiles in this category are the Navy's Sparrow I and the Sidewinder. The Sparrow, now operational in the fleet, is powered by a solid motor and is radar guided. The accuracy of this missile has been demonstrated against other aircraft and missiles. There are currently two other versions of the Sparrow, the Sparrow II and the Sparrow III. It has been reported that the Sparrow II will replace the Canadian Velvet Glove.

The Sidewinder is another naval air operational missile. It is 9 feet long and 4½ inches in diameter. The powerplant is a solid-propellant motor. Guidance is infrared homing. The range is approximately 5 miles and currently the kill rate is said to be 7 out of 10. It is reported that the Navy intends to replace the Sparrow I with the Sidewinder.

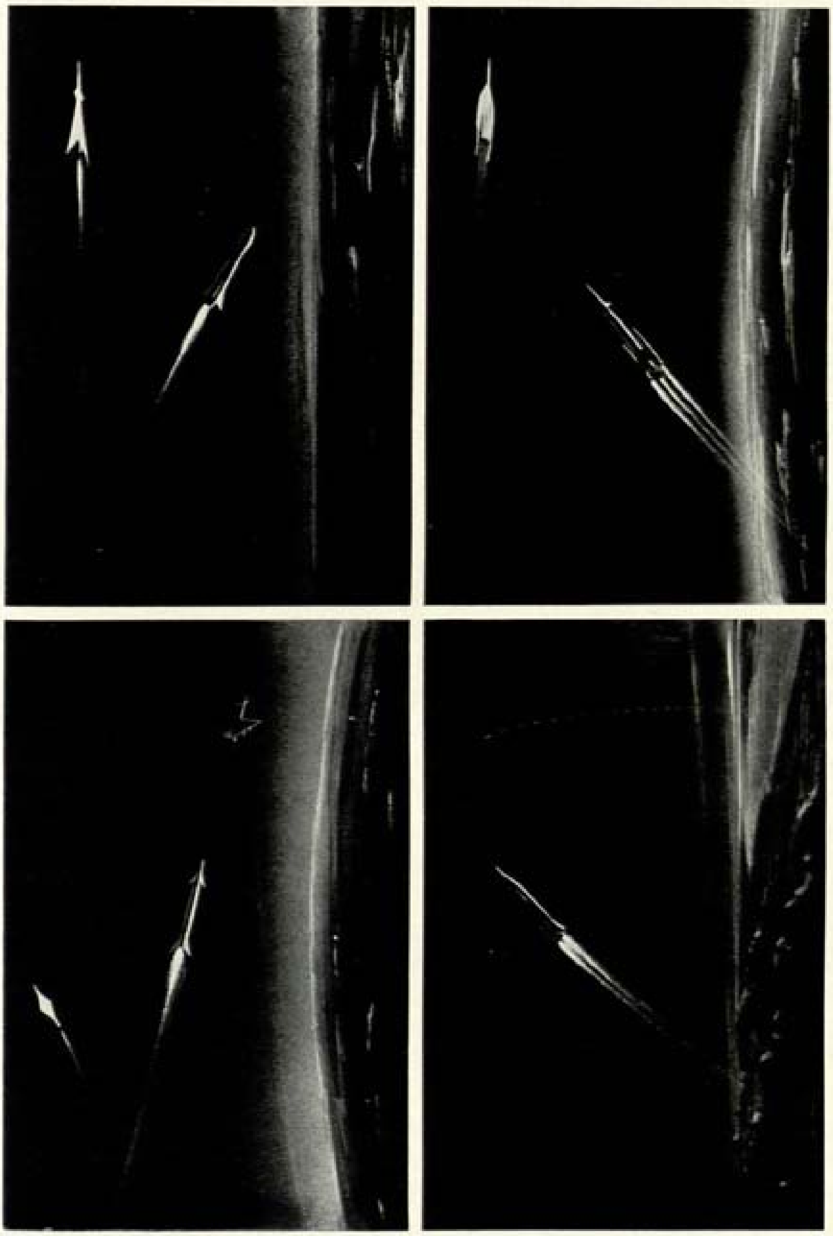
There are three other missiles in this category that should be mentioned. The first is the Ding-Dong, a liquid-propelled missile capable of carrying atomic warheads. Little is known of this missile, but it is said to be in the advanced stages of development. The second is the Diamondback. The performance of this missile is not known. Finally, the third is the Navy's Zuni. The Zuni is an air-to-air or an air-to-ground missile. It can be used in conjunction with high-performance fighters and attack-type aircraft. It can be used against other aircraft as well as against such ground targets as tanks, gun implacements, etc.

In the air-to-surface category the Navy seems to be particularly active, especially in antisubmarine applications. In the past decade the Navy has had more than six missiles in this family, although it is not known whether any are currently operational. The Tiny Tim is the best known of this category. Since the Tiny Tim, there have been the Petrel, Dove, Goose, and Duck.

More recently, the Navy has been evaluating the Bullpup, also an air-to-ground missile. It is expected that this missile will soon join the fleet. The missile is approximately 11 feet long and a foot in diameter. It is powered by a solid-propellant motor. The Bulldog, a larger improved version of the Bullpup, is also a solid-propellant missile in this class.

Finally, one of the newer Navy air-to-surface missiles is the Corvus, designed for use on carrier-based aircraft. Its current status is unknown; however, it is known that the missile's aerodynamic characteristics have been evaluated through wind-tunnel tests.

As far as the Air Force is concerned, they have only one missile in the air-to-surface class, the Rascal. The Rascal is approximately 35



Upper: Left, AAM, air-to-air; *right*, ASM, air-to-surface. *Lower: Left*, SSM, surface-to-surface; *right*, SAM, surface-to-air.

feet long and 4½ feet in diameter. It is powered by three 6,000-pound-thrust engines, has a speed of approximately 1,000 miles per hour and a range of 100 miles. There is no additional information available on its current status.

There are currently six missiles in the antiaircraft category. They are as follows: the Nike Ajax, the Nike Hercules, the Hawk, the Terrier, the Tartar, and the Talos. The primary function of the ground-to-air missile is the protection of major cities, vital industries, and ships at sea from every type of enemy aircraft carrying modern warheads or guided missiles. In addition, this weapons system must be capable of stopping multiple threats from several directions and altitudes simultaneously and at safe distances consistent with the types of warheads employed.

The best known of our antiaircraft missiles are the Nike Ajax and the Nike Hercules.

The Nike Ajax is approximately 20 feet long and a foot in diameter; speed is 1,500 miles per hour, range 10 to 30 miles, and ceiling about 50,000 feet. The vehicle is solid rocket boost launched and has a liquid rocket sustainer. The Nike Ajax is now in service, being mass produced and delivered to antiaircraft batteries in and around major cities and vital industrial areas throughout the United States. Each Nike battery consists of 12 missile launchers, manned and operated by approximately 100 officers and enlisted men. Although the Nike is designed to intercept moving and evasive targets and has an exceptional kill potential, it has been the subject of controversy. It has been argued that the missile does not offer sufficient down-range protection against high-flying modern aircraft carrying nuclear or H-bomb warheads.

The second of the Nike series, the Nike Hercules, has been developed as a replacement for the Ajax and has been called the "double" Ajax. The Hercules is 27 feet long and 2 feet in diameter. The vehicle is solid-boost launched and solid rocket motor sustained; the speed is 2,000 to 2,300 miles per hour, and range is reported as three times the range of the Ajax, or about 70 miles. The missile is described as being far more maneuverable and deadly than the Ajax because of its atomic warhead. The Hercules is currently in the final stages of development and initial stages of production. Replacement of the Ajax by the Hercules should begin in the spring of 1958.

The Army's Hawk was designed to supplement the Nike, i.e., fill the gap between zero altitude and minimum Nike altitude capability. The Hawk is 16 feet 4 inches long, and 14 inches in diameter. It is propelled by a solid rocket motor. The speed has been described as being highly supersonic with a range of 50 miles. The missile is in the final stages of development, and, when it is made available, it

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most likely will first see service in the New York City and the Washington-Baltimore areas.

The Terrier, a Navy missile, is in operational use on the cruisers U.S.S. *Boston*, U.S.S. *Canberra*, and the destroyer U.S.S. *Gyatt*. The missile is 27 feet long and a foot in diameter; speed is 1,500 miles per hour, range about 20 miles, and ceiling 60,000 feet. The missile is boost launched and sustained by a solid rocket motor. By 1961, Terrier I is expected to be operational on approximately 22 capital ships. Terrier II, currently under development, is reported to be twice the size of the Terrier I.

The Tartar, another Navy missile from this category, is a substantially more efficient single-stage vehicle that is expected to replace Terrier I by 1961. The missile, currently in the early production phases, will be used as secondary batteries on large ships or destroyers, and on other small vessels.

At the present time the arsenal of short-range, surface-to-surface tactical missiles consists of four members: Honest John, Little John, Dart, and LaCrosse. The function of these short-range, surface-to-surface missiles is twofold. First, it must provide the infantryman with an effective weapons system for defending himself against all immediate fixed and mobile units; and, second, it must have the capability of reaching behind the immediate contact area to destroy selected targets.

Probably the best known of this family is the Honest John. The Honest John is 27 feet long and 2.5 feet in diameter. The range of this weapon has been quoted as 20 to 30 miles. The vehicle is powered by a solid rocket motor and is an unguided, free-flight artillery rocket capable of delivering nuclear warheads. It is currently assigned to the Army's new pentomic divisions. The first tactical unit armed with this rocket was the 101st Airborne Division.

The Little John is, as the name implies, a smaller solid rocket motor missile with a shorter range. It was designed to supplement the Honest John and provide all-weather artillery support.

The Dart is one of the newest missiles that has been developed. It is 5 feet long, 8 inches in diameter, and has a 3-foot wing span. Speed is over 600 miles per hour. The range is unknown, although in one public demonstration the missile hit the target at a range of 2,100 yards. The Dart is powered by a single-stage smokeless solid rocket motor and is wire guided. Since its range exceeds that of any known tank armament, it can be fired safely from a fixed or mobile position. The missile is in production but is not yet operational.

The LaCrosse is a solid rocket motor propelled, all-weather, ground-support missile developed for the Army and the Marine Corps. It is 20 feet long, 20.5 inches in diameter, and has a range of 15 to 20 miles. The missile is truck mounted and extremely mobile. It is currently in production.

With these four new missiles—Honest John, Little John, Dart, and LaCrosse—supplementing weapons in this category that have been battle proved in the last two wars, the American infantryman is assured of the close support required.

In the medium-range, surface-to-surface category (enemy ground targets up to 500 miles), there are the Corporal (the most popularly known of this group), the Sergeant, and the Jupiter A (Redstone) missiles.

The Corporal is approximately 45 feet long and 2.5 feet in diameter. It weighs about 5 tons fully fueled, and the range is about 150 miles. This vehicle is one of the Nation's first guided missiles. It is radio guided, flies a ballistic trajectory after cutoff, and can carry an atomic warhead. The missile is currently in large-scale production and in full use by the Armed Forces.

The Sergeant missile, an outgrowth of the Hermes RVA–10, is a late addition to the Army's tactical missile family. It is more than 22 feet long and 3 feet in diameter. With a launch weight of 25,000 to 35,000 pounds including the payload, the range of this missile is estimated at 50 to 70 miles. Thrust is estimated at 50,000 to 75,000 pounds. The propulsion system is said to be one of the largest solid-propellant motors in development. When this vehicle becomes operational, it may replace the Corporal.

The last vehicle in this series is the Jupiter A, more commonly known as Redstone. It is 69 feet long and 6 feet in diameter. The range of the vehicle is given as 200 to 250 miles. The Jupiter A resembles the V–2 in many respects and is described as the test bed for the Jupiter C, in addition to its tactical function. The vehicle is powered by a 75,000-pound-thrust, liquid-propellant engine. This particular powerplant, although not as efficient as the more modern engines, is nevertheless one of the more reliable. It is expected that the Jupiter A will become operational shortly. When it does, the utilization of this weapon will extend the Army's striking capability well beyond the Army group zone of action.

As of January 1, 1958, the United States had under development five long-range ballistic missiles. Basically they are of two types: the shorter-range 1,500-mile intermediate-range ballistic missile (IRBM); and the extreme-range 500- to 5,500-mile intercontinental ballistic missile (ICBM). Of the five missiles under development, three are in the shorter intermediate range, and the other two are in the intercontinental range.

In the IRBM class, the Thor is being developed by the Air Force, the Jupiter by the Army, and the Polaris by the Navy.

The Thor, officially designated as the WS–315, is a single-stage missile powered by a liquid rocket engine of 135,000-pounds thrust. It is claimed that the development of the Thor will serve as a component

test bed for the Atlas and Titan ICBM's. The Thor is currently undergoing development testing. The first three firings of this missile ended in failures; however, the ultimate success of this weapon is not questioned. When it is released for operational use, the Strategic Air Command will be responsible for its tactical deployment.

The Jupiter, like the Thor, is a single-stage, intermediate-range ballistic missile. The similarities do not end here. Both vehicles use the same engine, and it has been reported that they may also adapt the same airframes. This vehicle is estimated to be 50 to 60 feet in length and 8 feet in diameter. The Jupiter IRBM, like the Thor, has known test failures. The first two failures of the Jupiter test vehicle were attributed to sloshing fuel. The third test vehicle was a success and flew its prescribed range of 1,500 miles. The Navy had initially sponsored the development of the Jupiter with the Army, but, because of special shipboard problems, the Polaris was substituted for the Jupiter by the Navy.

The Polaris is a two-stage, fleet ballistic missile vehicle capable of being launched from surface ships or from underwater by special submarines. The propulsion system is a solid rocket motor, said to be the largest built to date. The motor is housed within a vehicle approximately 40 to 50 feet long and 100 inches in diameter. Range is given as 800 to 1,500 miles, and the warhead is said to be nuclear.

It is the opinion of the authors that the sublaunch IRBM will achieve a role of greater strategic significance in the very near future. Furthermore, it is believed that the use of the solid-propellant motor for this application will come of age and be accepted by all services. (It is interesting to note that there is no evidence to date that the Soviets have developed a large solid motor for extreme-range missiles.)

The United States Air Force has the prime responsibility for developing the ICBM. There are two missiles that are currently under development in this category—the Atlas and the Titan.

The Atlas is approximately 100 feet in length and 12 feet in diameter. The vehicle is boosted by two 135,000-pound-thrust, liquid-propellant engines and sustained by a single 100,000-pound-thrust, liquid-propellant engine. The Atlas is known as a "stage-and-a-half missile," i.e., "parallel staged," somewhat similar to the British wrap-around technique. At launch all three engines are utilized. The vehicle takeoff gross weight is over 200,000 pounds. Its maximum range is 5,500 miles, apogee (maximum altitude) about 800 miles, and reentry velocity approximately 15,000 miles per hour. The expected accuracy is 20 miles, using celestial guidance. The current status or operational date of the missile is not known, but it is expected to be some time after 1960. The first two firings of this vehicle in June and September 1957 ended in misfire. The cause has

been traced to failure in the propellant feed system. Finally, on December 17, 1957, the third Atlas test vehicle was successfully launched and guided several hundred miles downrange to a prescribed target area.

The Titan, currently a backup to the Atlas project, is a more sophisticated approach to the ICBM design. The Titan is a two-stage "tandem" vehicle with an estimated length of over 100 feet and diameter of 10 feet. The vehicle weighs more than 200,000 pounds at takeoff. The propulsion system is believed to have 300,000 pounds of thrust in the first stage and 60,000 pounds of thrust in the second. The missile is currently in the development phase—and Air Force officials have said that they are pleased with the progress.

The missile arsenal would be incomplete without mention of the surface-to-surface, air-breathing, pilotless aircraft missiles.

Currently, there are four surface-to-surface pilotless aircraft. There are the Navy's Triton and Regulus II and the Air Force's Snark and Matador. The propulsion for these vehicles is either turbojet or ramjet, and the ranges vary from the Matador's medium range of 600 miles to the Triton and Regulus with a range from 1,000 to 1,500 miles. The Snark can claim a range of over 5,000 miles. All vehicles are capable of carrying nuclear warheads. The prime difference between these vehicles is that the Navy vehicles are launched from submarines whereas the Air Force vehicles are launched conventionally.

The antiaircraft, air-breathing missiles are the well-known Navy Talos and the Air Force Bomarc. As is characteristic with all air-breathing engines, there are operational limits in both speed and altitude.

The Air Force's Bomarc, because of its long-range capabilities, is known as an "area" antiaircraft defense missile, as opposed to the Army's Nike "point defense" missile. The Bomarc is almost 47 feet long and 3 feet in diameter. Speeds and altitudes have not been officially released; however, some of the earlier test vehicles achieved velocities of over 1,500 miles and altitudes of over 60,000 feet. The range is given as 200 to 300 miles. The vehicle is boosted by a liquid rocket and sustained by two ramjet engines. The range of the missile is greater than the other missiles of this category. On May 16, 1957, the Bomarc was awarded an initial production contract. It is expected that as soon as the Bomarc becomes available in quantity, it will be operated by the Air Defense Command in the more strategic areas.

We have summarized the state of missile development today among nations. It must be noted that we have only touched on the highlights

and that most nations have missiles other than those mentioned, either developed or being developed, including rocket-powered aircraft.

CRITERIA TO GAGE A NATION'S MISSILE POTENTIAL

A look at the missile arsenal in any nation is only one factor in the evaluation of its missile potential. In addition to missile hardware, a comprehensive evaluation should include the following equally pertinent factors:

1. A nation's potential in the missile field should be measured by the current caliber of its leaders and numbers of scientists, engineers, and trained technicians, as well as by the capability of its educational institutions to train and maintain the balance of technical and nontechnical personnel required for the future.

2. A nation's potential in the missile field should also be measured by its natural resources, by the numbers of its supporting industries, and by the quality of its basic research and test facilities.

3. And furthermore, a nation's potential in the missile field should be measured by the availability of operational missiles in any one of the four basic military categories which fulfill that nation's specific strategic requirements.

EIGHT AXIOMS ON MISSILERY

In addition to the above criteria for gaging a nation's missile potential, we offer the following eight axioms on missilery as a means for a realistic assessment of rocketry today:

1. The statement "behind in the missile race" without qualifications is meaningless.

2. If leads in certain missile categories do exist, it is primarily because of a concentrated effort in that area.

3. Rocketry is a matter of emphasis—not just on funding but also on direction.

4. The know-how of building missiles and rockets is not one nation's secret, nor is this know-how limited to a select few organizations or scientists. The physics of rocketry is well understood by many both here and abroad.

5. At present it appears that no nation has made a major missile technological breakthrough. This is especially true from an aerodynamic and propulsion viewpoint.

6. The probability of a successful missile launching applies "equally" to all nations.

7. The citizens of the United States and the leaders they have elected over at least the last 15 years are responsible for the Nation's current position in rocketry.

8. An informed people will insure that American democracy will courageously and successfully meet the challenge of the coming Space Age.

Fresh Water for Arid Lands[1]

By David S. Jenkins
Director, Office of Saline Water
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[With 5 plates]

From a status of barely casual interest, the increasing demand for fresh water and the associated search for supplementary sources have almost overnight come to preoccupy public interest and technical thinking everywhere. Population growth, coupled with a startling increase in unit water consumption, has imposed severe demands on water resources [1] [2], to the extent that even the most amply provided parts of the world have begun to feel alarm. Figure 1 shows the rise in water use in the United States since 1900. Elsewhere similar increases have occurred. There are indeed grounds for alarm, in view of our investment in water-resource projects and our dependence on them. For many years a considerable part of our construction expenditures has been devoted to building the project works, and simultaneously questions of ownership and control of fresh-water sources have given rise to regional and international contentions. Even in many nonarid lands, our natural water supplies draw nearer to exhaustion and we look hopefully toward the possibilities of going to the oceans and to the brackish waters [2] about us for new supplies of fresh water.

But in the arid regions, water is as gold. Men have long dreamed of finding living space for additional people in the great areas of desert and semiarid land in which the world abounds. But so long as water cannot be obtained except at remote locations and in small we shall be able to bring fresh water to them at low cost, they promise quantities, the lands outside of these oases must remain barren. When to become the productive base for a new growth of human activities.

The purpose of this symposium is to appraise this problem and to pool our knowledge of its difficulties and prospects. The following general sketch of saline water conversion and its application to the needs of arid lands is necessarily based on the work with which I am

[1] General paper on saline water conversion, for the UNESCO Symposium on Salinity Problems in Arid Lands, Tehran, Iran, Oct. 11–18, 1958, and published by permission of UNESCO.

[2] Numbers in brackets indicate references at end of text.

most familiar. That is the work carried on during the past 5 years by the United States of America, and that initiated by the Organization for European Economic Cooperation. From this work we know that low-cost sea-water conversion is not yet here, but we also believe that in time it will be at hand. Our hope for the future is that today's community of interest and strength of cooperation will continue, showing the way to final solution of the problem.

Before entering upon specific discussion of the arid-lands problem, I wish to review the course of the research work into saline-water conversion that is being conducted under the Office of Saline Water of the United States Department of the Interior [3], and elsewhere, and mention some processes that have been studied.

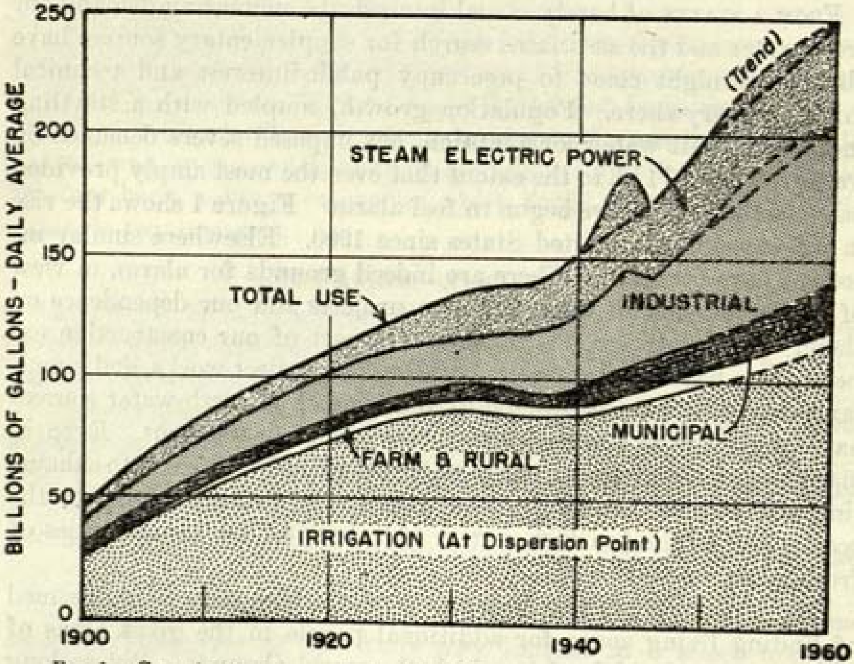


Fig. 1.—Growth of water use in the United States, since 1900. (After Picton.)

For many years scientists and technicians had been at work investigating the possibilities of more efficient saline-water conversion than could be accomplished by the time-honored distillation process. Noteworthy stimulus was given to such efforts by the United States Government in 1952, when it established in the Department of the Interior a program to encourage private scientific interest and activity in desalting, together with a limited fund to support conversion research and development work by its citizens. Three years later this authority was enlarged, and provision was added for devoting part of the fund to the support of process research in other nations.

The act [4] proved to be a powerful scientific and technical stimulus. One of its effects was to reinforce technical activity abroad as

well as at home, bringing about a valuable international exchange of information on saline-water conversion. The strength of this mutual interest became apparent in the Washington Symposium [5] on the subject held in November 1957, and is evidenced again by the present gathering.

The Washington Symposium confirmed that although we may improve present distillation processes, much exploratory research is needed to develop wholly new approaches to desalting. It is my firm conviction that nature has locked away from us temporarily one of her most fascinating secrets. From principles of physical chemistry and thermodynamics we know that theoretically we should be able to get fresh water from the ocean for an over-all cost of about 10 cents a thousand gallons with reasonable allowances for inefficiencies. Already science has succeeded in reducing the cost to about 10 times that amount, with considerable promise of further reduction to about 5 times or 50 cents. This will make it possible to supply water for a number of special new uses, particularly in areas of low-cost labor and materials. But to unlock this secret of nature so as to serve general irrigation uses will take a scientific development comparable to that which uncovered nuclear fission and fusion. Its accomplishment may well rival nuclear energy in its effect upon the world economy.

How best can we solve this problem? Not knowing which approach may turn out ultimately to be the best, we must pursue all possible and logical leads. Many new approaches should be investigated, and effort should be devoted to such fundamental studies as the mechanisms by which salt-water phreatophytes select nitrate and phosphate ions but reject sodium and chloride, as well as to the functions of the kidneys in maintaining salt balance in the human, animal, or fish systems. Fortunately, some research is being directed to approaches of this type.

In order to separate water from a salt-water solution, we must expend energy [6]. The minimum theoretical thermodynamic energy needed to separate water molecules from salt ions can be calculated from the experiment shown in figure 2. At the same temperature and pressure, more water molecules will change into the vapor phase from the fresh water (left) than from the salt water (center). By compressing the vapor above the salt water to the same pressure as that above the fresh water, it can be made to condense to fresh water (right). The energy required is just equal to the energy that binds the water molecules to salt ions. For sea water this minimum requirement is 2.8 kilowatt-hours per 1,000 U.S. gallons. Inventors' claims involving energy requirements less than this minimum are bound to be false.

The actual energy needed to evaporate fresh water from salt water is necessarily much greater than this theoretical requirement, which assumes a barely perceptible rate of separation and complete efficiency in conversion of energy. Murphy [7] has estimated that this minimum energy requirement for a practical process may be about four times the theoretical, or about 12 kilowatt-hours per thousand gallons. Simple distillation, for example, requires 1,000 times as much energy, but already distillation systems of today require energy expenditures of only about 200 kilowatt-hours per thousand gallons.

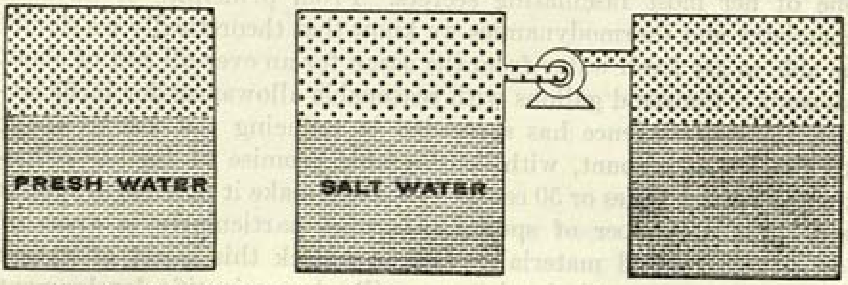


FIG. 2.—Theoretical energy needed to separate water molecules from salt ions.

Distillation, known and practiced for long ages, remains to date the most advanced (and almost the only) method of applying this energy to the work of salt-water separation. While simple in basic principle, it is complex and costly in application, and involves the use of large and expensive equipment. To discover other methods, the Office of Saline Water upon its establishment undertook an extensive survey [8] of scientific and technical knowledge. Included were various physical, chemical, and electrical actions, as well as several modifications of the conventional distillation process designed to increase the productivity and reduce the size and cost of the necessary equipment.

Some 30 potential conversion processes and pertinent phenomena were originally listed from this survey, but they were soon narrowed down to 16, which in turn were ultimately reduced to 5 groups of processes, namely: (1) thermal and mechanical distillation; (2) solar distillation; (3) membrane processes; (4) freezing; and (5) others, the latter including such processes and phenomena as ion exchange, solvent extraction, and biological action.

To date these studies [9], as well as parallel researches abroad, have shown that several processes other than distillation are technically feasible on a laboratory scale; only one has reached actual commercial use, however. This is the recently developed process of electrodialysis, in which the ions composing the salt are forced out of the saline water through pairs of positive and negative ion-selective membranes by the force of an electric current. One other process—

separation of water from salt by freezing—is approaching the point of commercial possibility, but it still requires much further development. And, as part of the distillation group, small low-temperature stills using the heat of the sun have been extensively developed experimentally on a small-scale basis in the United States and elsewhere, particularly in several Mediterranean countries and Australia.

THERMAL AND MECHANICAL DISTILLATION

Improvement of conventional distillation processes, both to reduce their high investment cost by increasing the rate of heat transfer and to reduce the energy cost by diminishing the heat losses, engaged extensive study from the first. The earliest projects of the Office of Saline Water included studies of very large vapor-compression systems [10] and the possibility of reducing their costs, as well as large-scale multiple-effect evaporation systems separately and in combination with power-generation cycles.

Although there are several different types of distillation equipments and cycles [11], all are presently subject to the same general limitations—scale deposition and corrosion. Scale-forming constituents, principally calcium carbonate, calcium sulphate, and magnesium hydroxide, are precipitated out of solution as evaporator temperatures rise above 160° F. The scale fouls heat transfer surfaces and impedes fluid circulation. In addition, brines become more corrosive, necessitating use of expensive alloy as temperatures approach or exceed the normal boiling point of water, 212° F.

Therefore, a series of research and development studies has been in progress in the fields of heat transfer, scale prevention, and less expensive corrosion-resistant materials of construction. Some of these studies are sponsored by the Office of Saline Water and other Government agencies, while others are carried out by independent manufacturers in the United States and elsewhere and by agencies of other governments, such as the British Admiralty. In most instances, each of the principal investigations, which are described below, are directed toward a particular evaporator type. However, much of the knowledge and techniques gained from one series of experiments, where successful, will be adaptable to the general distillation field.

Formation of scale deposits in the equipment is a serious problem in practically all distillation processes, and under certain conditions in electrodialysis. A fundamental investigation of the basic factors affecting scale deposition is being conducted at the University of Michigan.

An attractive distillation process using long-tube vertical evaporators of the kind employed in the salt industry has been proposed by W. L. Badger of Ann Arbor, Mich. [12]. In this cycle sea water

is passed through a series of evaporators under reduced pressure and temperature, utilizing either heat applied directly from a steam generator or that recovered from the exhaust of a steam turbine in connection with electric power generators [13]. (Fig. 3.) The efficiency and economy of the process require completely scale-free operation which we believe can be achieved through pH control and/or internal sludge-stabilization techniques. In addition, Badger proposed the use of low-cost (ferrous) metals throughout the plant. In order to bring these theories into practice, a pilot plant has been erected at a seashore location in North Carolina for testing scale prevention, metals corrosion, heat transfer rates, and other variables for the long-tube vertical-evaporator distillation process (pl. 1, fig. 1). Badger estimates the total cost of water from a large plant at about 40 cents per thousand gallons.

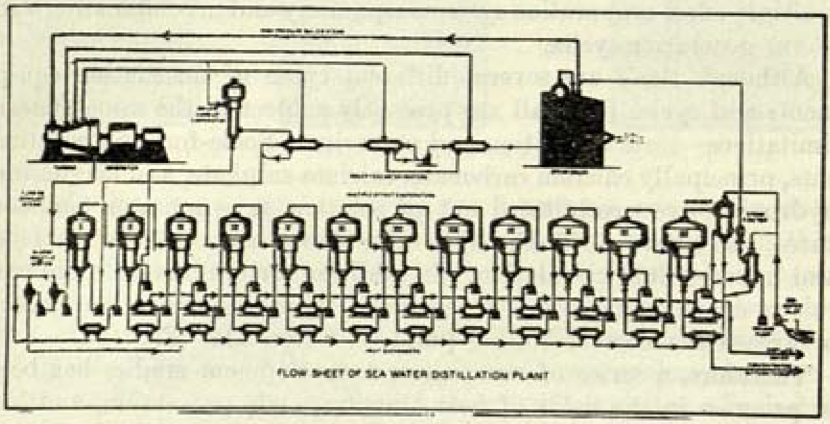


FIG. 3.—Flow sheet of multistage, long-tube vertical distillation plant. (Layout is after cycle of W. L. Badger.)

Improved evaporators in which greatly increased rates of heat transfer are achieved give promise of reducing capital as well as operating costs. In one such development [14], the heat transfer coefficient is increased to 2,000–3,500 B.t.u. per hour per square foot per °F., as compared to 500 or less in conventional equipment. In this process, invented by Dr. Kenneth C. D. Hickman of Rochester, N.Y., the heat-transfer area is in the shape of conical surfaces and is rotated, thereby causing the feed water to spread over the surface in thin films, under centrifugal force. Several experimental models have been built, from household sizes (300 g.p.d.) to much larger plants (25,000 g.p.d.) (pl. 1, fig. 1), and are being tested on brackish water as well as sea water.

Another heat-transfer system is under development by Drs. B. F. Dodge and A. M. Eshaya of Yale University, New Haven, Conn. Tests were run on laboratory equipment at the University [16] which demonstrated that heat transfer coefficients of 2,000 B.t.u. per hour per

square foot per °F. could be maintained in a system utilizing forced circulation and drop-wise condensation in vapor-compression distillation processes. Similar and complementary research was conducted by the British Admiralty [17] under the program of the Organization for European Economic Cooperation (OEEC.) Several private organizations in the United States and Europe are experimenting with drop-wise promoters for various types of heat exchanger surfaces.

The flash type of distillation process is now receiving increasing commercial application. In this process, warm salt water enters an evaporation chamber in which the pressure has been reduced below the boiling point of the salt water, thereby inducing a portion of liquid to vaporize (flash) into steam. As with most of the present types of commercial evaporation equipments, the flash units have been primarily developed for marine use. However, Westinghouse Corp. of Pittsburgh, Pa., completed one of the largest distillation plants in the world at Kuwait (pl. 1, fig. 2), making use of the multistage flash process. That installation consists of four 4-stage flash evaporators with a total capacity of 2½ m.g.p.d. Other companies are also offering multistage flash evaporators, and other land installations are presently being considered for this type of equipment. The Office of Saline Water is developing improved multistage flash distillers for potential combinations with nuclear-process [18] steam reactors, as this type of evaporator will make use of very large amounts of steam in civilian-type applications.

There are also locations where waste heat is currently available or where ocean temperature differences are sufficient to induce flash evaporation [19]. Therefore, low-temperature flash evaporation was recently studied by Griscom-Russell Co. [20] for Massillon, Ohio, for the Office of Saline Water, as adapted to a single-stage flash evaporator using the energy of a stream of warm waste water from a power station of an industrial plant, or from natural sources. Estimates showed that, given a temperature difference of 30° F. between the warm and the cold water, plants of 100,000 and 10,000,000 gallons output capacity would produce fresh water from sea water at over-all costs of $1.28 and $0.71 per 1,000 gallons respectively, using the Office of Saline Water standardized cost estimating procedure [21] as modified for this process.

SOLAR DISTILLATION

Distillation by means of solar heat has the advantage of eliminating the cost of the fuel energy otherwise required. However, the diffuse nature of solar energy makes necessary the use of large areas for collection. The major problem in solar distillation is reduction of

equipment costs. Research on solar stills having that and increasing efficiencies as objectives has been carried out by the Office of Saline Water [22, 23]. Both glass and plastic membranes have found application as transparent covers for solar stills, and equipment costs are being reduced.

A number of typical American still designs, some intended for research use only, are shown in plate 2 and plate 3, figure 1. They include stills of suspended-envelope type, canopy type, and flat tilted type. Their output was found to be, rather uniformly, about 1 pound of fresh water per square foot per average day of sunshine in a moderately warm climate.

Small solar stills have had extensive practical development in Algeria and Morocco [24] and Australia [25]. Manufacture of stills with effective surface of 10 to 12 square feet is reported for one maker in Algeria, while another has developed a much larger still, to be made up of jointed units 10 by 40 feet each.

A design for a deep-basin still with an area of 5,000 square feet, to be built directly on the ground, was prepared in 1957 by George O. G. Löf of Denver, Colo. (pl. 3, fig. 2).

The Office of Saline Water has initiated a comprehensive development program on solar stills through contract with Battelle Memorial Institute of Columbus, Ohio. Prototypes of various existing and improved designs are being installed for further development at a central seashore test station near Port Orange, Fla. The first small pilot plant of the Löf deep-basin still is now being constructed there. The next two prototypes to be built will be of plastic films in place of the glass. The new plastic has been developed by the Du Pont Co. of Wilmington, Del. One will be based on the design shown in plate 2, figure 2, using an air-supported transparent cover, and will also have an area of about 2,500 square feet. Low-cost preformed concrete bases under development are expected to reduce costs further and greatly simplify field construction. The second Du Pont type of about 500 square feet was originally designed to utilize a wire support for the plastics cover (pl. 4, fig. 1). However, within the last few weeks Du Pont has prepared a folded or pleated film which promises to remove the need for the wire support and further reduce costs. Others to be installed and tested at the Port Orange research center are the suspended envelope developed by Bjorksten Laboratories of Madison, Wis., and the tilted stills developed by Maria Telkes of New York University, both under the direction of the Office of Saline Water.

A need exists for two major types of solar-distillation equipment: small stills, some of which may be portable; and large-capacity stills. The small stills should have production capacities that range from

about 20 gallons to several hundred gallons per day of fresh water. The large stills would cover many acres. They would be most useful where other conversion methods are more costly or impracticable and where solar intensities are high and land costs low. Both types have attractive possibilities for areas where the stills can be constructed with local materials and labor. Much developmental work is necessary to reduce the unit cost on a per-square-foot basis.

It is anticipated that the solar distillation center in Florida will result in engineering designs and specifications for practical small units and will point the way for future solar distillation plants of much larger capacity.

MEMBRANE PROCESSES

Desalinization processes utilizing membranes have been developed during the past few years to the point where several are known to be technically feasible and one appears to be economically feasible for the treatment of brackish waters under certain conditions [26].

Specifically, the membrane processes showing promise for the purification of brackish waters consist of (1) electrodialysis where an electromotive force is applied to a cell consisting of ion-selective membranes; (2) "osmionic" where the concentration gradient between the solutions supplies the potential to drive ions through ion-selective membranes; and (3) reverse osmosis where sufficient pressure is applied to the solution to force water through an ion-restraining membrane into the fresh-water side. The practicality of using biological membranes through the use of algae is now being investigated by the Office of Saline Water [27].

One of the limiting factors in the use of these processes has been the membranes themselves. Consequently, during the past few years considerable research has been conducted by organizations in several countries aimed at improving the characteristics of those membranes. As a result, greatly improved ion-selective membranes have been developed. Such membranes are now available commercially at a cost per unit area of approximately one-fifth of what it was formerly.

If the cost of membranes and equipment can be further reduced, some authorities believe that the use of ion-selective membranes for the demineralization of sea water might become economically feasible.

Electrodialysis.—An electrodialysis cell consists of alternate cation and anion permeable membranes (pl. 4, fig. 2). Upon the application of an electromotive force the positive ions, such as sodium, pass through the cation permeable membranes, whereas the negative ions, such as chloride, move in the opposite direction and pass through the anion permeable membranes. Thus, the water passing between alternate membrane pairs is depleted of salt, while that passing through the intervening pairs is enriched.

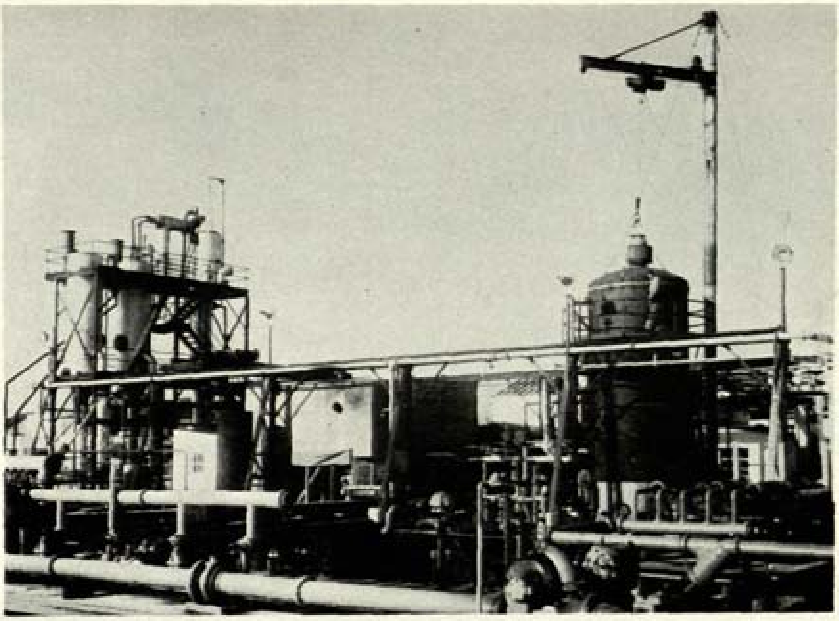
Electrodialysis as a conversion process has developed rapidly from a laboratory phase to commercial operating units in about 6 years. Developments have been carried out in the Netherlands [28], Great Britain [29], South Africa [30], and the United States [31], and more recently in Japan, Soviet Russia [32], and Israel.

One of the most advanced processes is that of Ionics, Inc., of Cambridge, Mass., developed partly through the Office of Saline Water. That process utilizes strong membranes having considerable durability, and a long tortuous flow path. Following laboratory tests that had highly favorable results, the process was incorporated in pilot tests [33]. The equipment, which was mounted in a trailer truck (pl. 4, fig. 2), was operated for some months on two naturally occurring saline waters in Arizona and South Dakota having salinities of 4,000 p.p.m. and 2,000 p.p.m. respectively. Operating difficulties such as fouling by scale were corrected by acid feed, and the process was in each location successfully carried to a residual 350 p.p.m. concentration. High cost of equipment and membranes at present quoted prices accounts for about 80 percent of the cost of the water. With future increased production, these costs should be reduced.

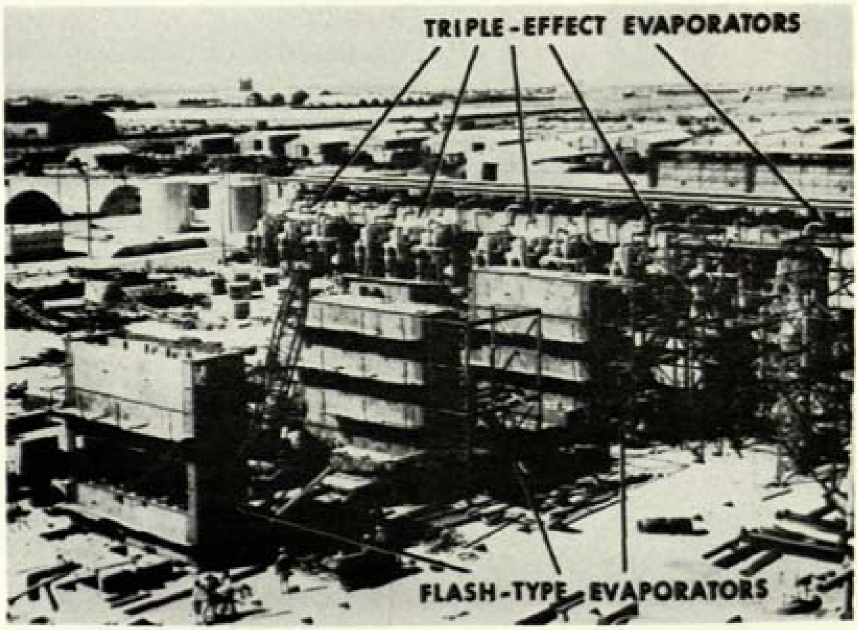
More than 20 Ionics., Inc., production plants are in use having capacities ranging from 500 gallons per day upward, with the largest plant of 86,400 gallons per day in the Middle East at Bahrein. The other well-advanced process is that of the Netherlands, TNO, also used in modified form in South Africa, in which thinner, less durable, but less expensive membranes are used in a continuous sheet-flow process. The one South African plant is reported to have a capacity of 2,400,000 imperial gallons per day.

The Office of Saline Water is conducting membrane evaluation and improved cell development at the laboratories of the Bureau of Reclamation in Denver, Colo. Membranes being tested are from American as well as other manufacturers. The electrodialysis units are from Ionics, Inc., and the Netherlands, TNO. The Texas Electric Service Co. of Fort Worth is developing improvements in the Ionics process.

Osmionic.—The second membrane process mentioned is known as osmionic, a term which was coined because of the osmotic and ionic forces involved in the process [34]. This is one of the new processes developed under the Saline Water Conversion Program of the United States and is somewhat similar to electrodialysis, except that it requires no outside electrical current and no electrodes. The driving force is obtained from the difference in concentration between a brine and the water to be demineralized. The power supply therefore might be obtained from salt deposits, brine wells, or by ponding saline water and allowing the sun to concentrate the water.

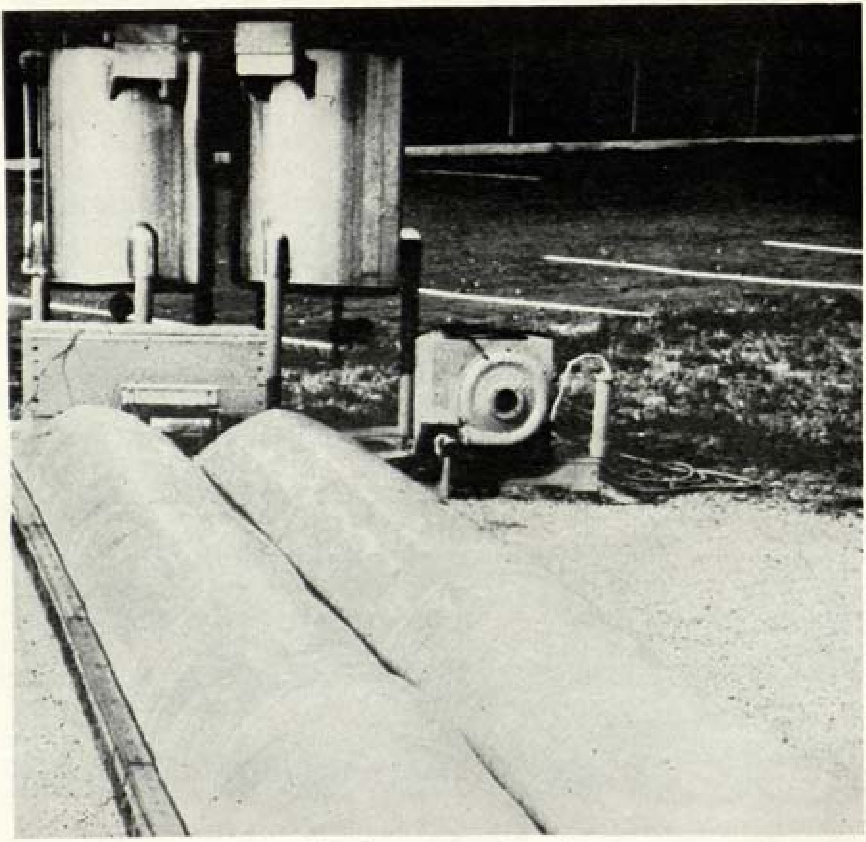


1. Pilot plants of W. L. Badger and Hickman distillation processes at Wrightsville Beach, N.C.

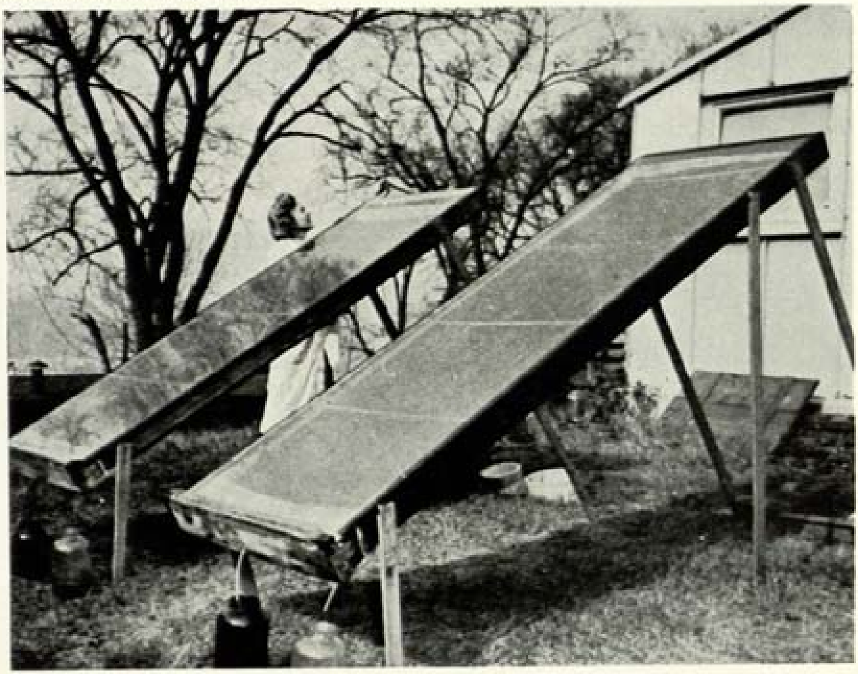


2. Sea-water evaporators at Kuwait on the Persian Gulf. Westinghouse Electric Corp. flash evaporators.

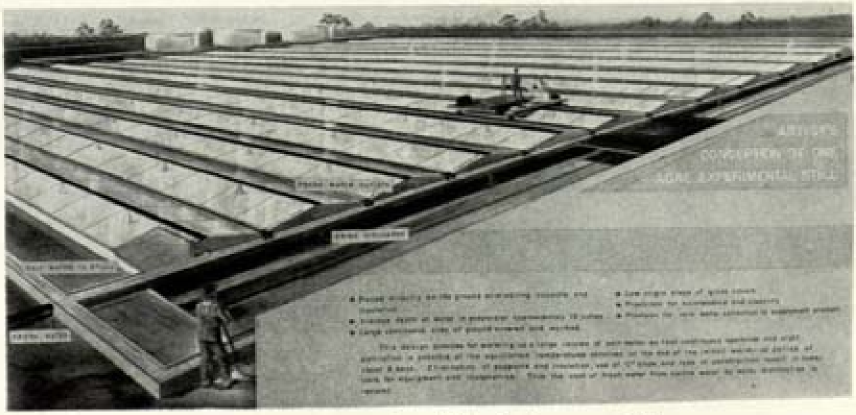
1. Bjorksten suspended envelope solar still.



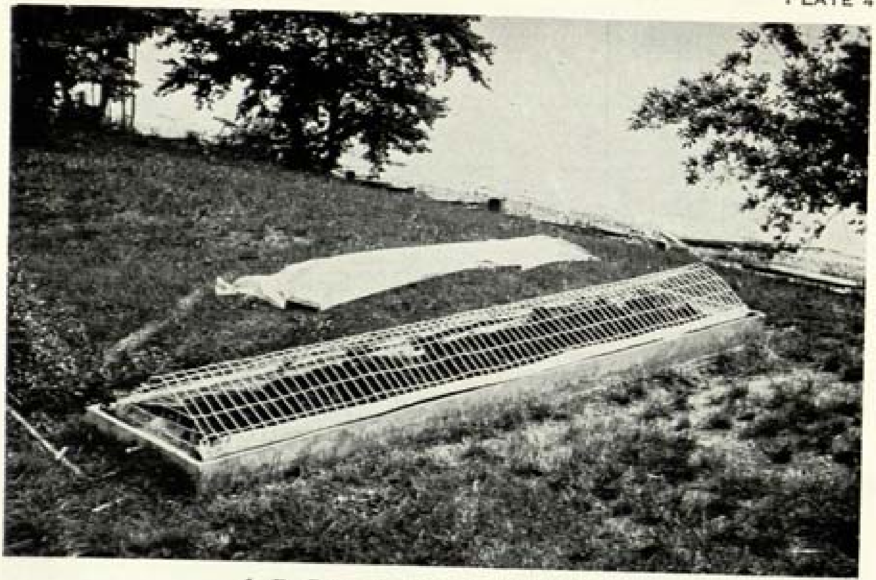
2. Du Pont canopy solar still.



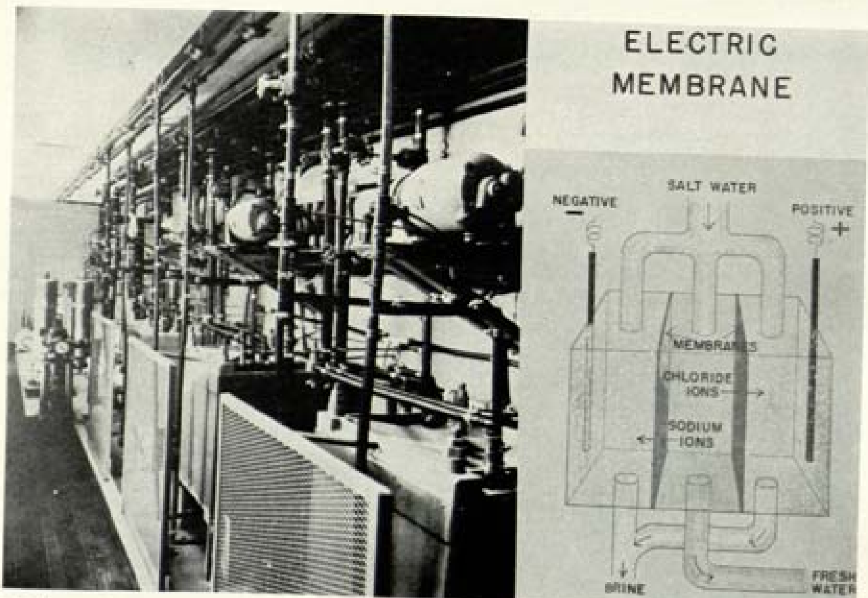
1. Telkes's flat tilted solar still.



2. Löf deep basin solar still (artist's conception).



1. Du Pont plastic wire supported still.



2. Electrodialysis experimental field test unit showing interior of trailer unit on left and diagram of process on right.

Areas that might benefit from salt-water conversion in the State of California.

In the simplest form of the apparatus, two cation and two anion selective membranes form a 3-compartment cell (fig. 4). Each chamber initially contains feed water, and the assembly or unit cell is immersed in brine. The passage of ions from brine to the less concentrated water in the outer chambers through the appropriate membranes is necessarily electrostatically coupled with the simultaneous transfer of ions from the center to the outer chambers.

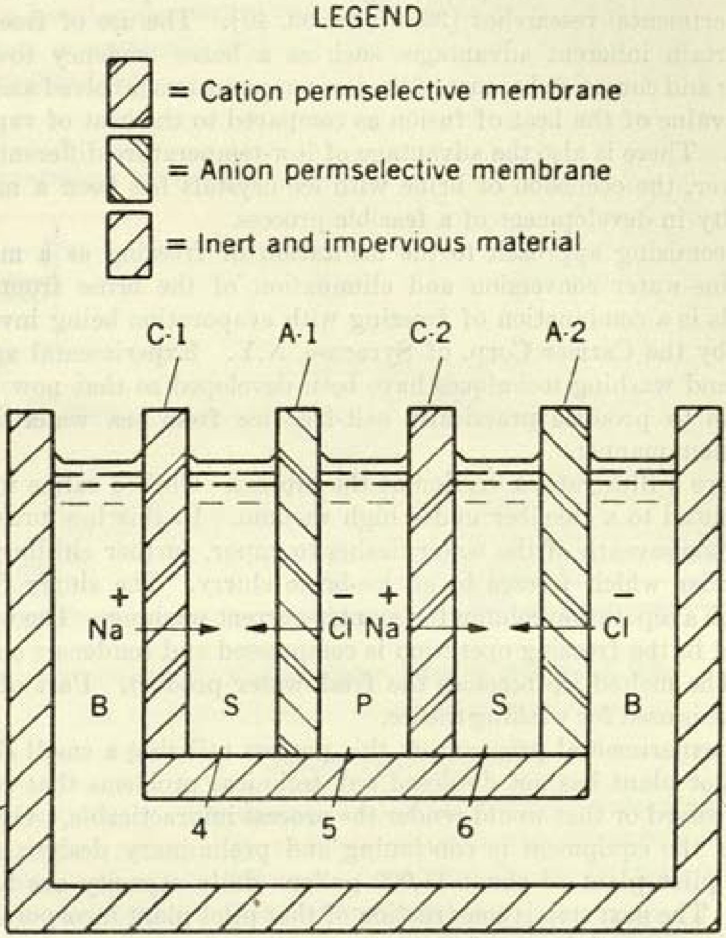


FIG. 4.—Schematic cross section of osmionic unit cell.

Reverse osmosis.—Osmosis involves the passage of water through a membrane from a dilute solution to a more concentrated one [35]. If enough pressure is applied to the more concentrated solution (more than 350 p.s.i. for sea water) then the osmotic flow can be reversed and pure water will be forced through the membrane. Results of research sponsored by the Office of Saline Water have demonstrated

that around 97 percent of the salts of sea water can be removed in one pass through a membrane, such as cellulose acetate, but at slow rate. Investigation aimed at increasing the durability and flow rate of membranes is continuing.

FREEZING

Salt-water separation by freezing has been the subject of a number of experimental researches [36, 37, 38, 39, 40]. The use of freezing has certain inherent advantages such as a lesser tendency toward scaling and corrosion because of the low temperatures involved and the lower value of the heat of fusion as compared to the heat of vaporization. There is also the advantage of low-temperature differentials. However, the occlusion of brine with ice crystals has been a major difficulty in development of a feasible process.

A promising approach to the utilization of freezing as a means of saline-water conversion and elimination of the brine from the crystals is a combination of freezing with evaporation being investigated by the Carrier Corp. of Syracuse, N.Y. Experimental apparatus and washing techniques have been developed so that now it is possible to produce practically salt-free ice from sea water in a continuous manner.

Figure 5 illustrates a version of the process. Chilled saline water is admitted to a chamber under high vacuum. In this low pressure about one-seventh of the water flashes to vapor, further chilling the remainder which freezes to an ice-brine slurry. The slurry flows through a separation column for counter-current washing. The vapor formed in the freezing operation is compressed and condenses on the ice. The melted ice becomes the fresh-water product. Part of the product is used for washing the ice.

The experimental program on this process utilizing a small shop-size pilot plant has not disclosed any technical problems that could not be solved or that would render the process impracticable. Operation of the equipment is continuing and preliminary designs of a larger pilot plant of about 15,000 gallons daily capacity are being made. The next step is construction of that pilot plant incorporating all components of the complete process.

In another approach to the use of freezing for demineralizing saline water, an immiscible refrigerant such as isobutane is vaporized in direct contact with the saline solution. The development of this principle is under way at Cornell University [41], Ithaca, N.Y. Because most equipment necessary for this process could be of comparatively simple design, it may be particularly adaptable to large-scale installations.

Some rather basic research has been conducted in an attempt to adapt the zone refining technique to convert saline water. A frozen

zone is passed along a column of salt water to concentrate the salt impurities at one end. This has been done and fresh water actually obtained but rates of production are very low; it remains to be determined if there is a basis for a practical method.

Research and development on demineralization by freezing appear worthy of great emphasis. Its inherent advantages indicate that a freezing process when completely developed should be able to compete economically with the most promising developments in the distillation field.

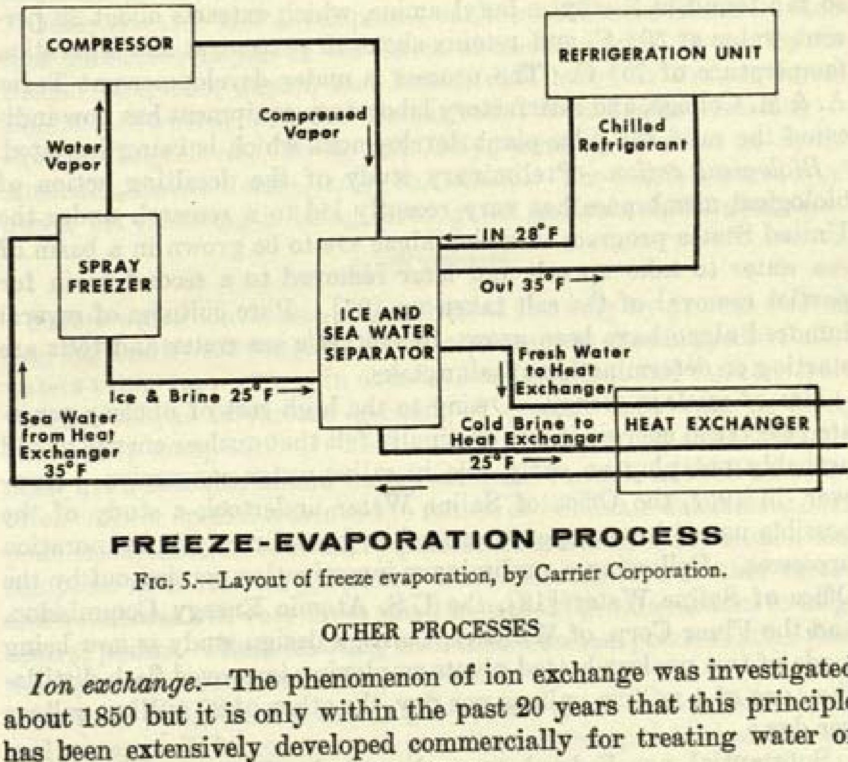


FIG. 5.—Layout of freeze evaporation, by Carrier Corporation.

OTHER PROCESSES

Ion exchange.—The phenomenon of ion exchange was investigated about 1850 but it is only within the past 20 years that this principle has been extensively developed commercially for treating water of low salinity and for removal of hardness.

Salt ions can be removed from saline water by passing the water through a mixed bed of ion-exchange material. That material soon becomes saturated and must be regenerated by use of relatively expensive acids and bases.

To overcome this excessive cost, a process suggested by Gilliland [42] is being developed at the University of California [43], at Berkeley, which employes ammonium bicarbonate as a regenerant. When saline water is passed through such a bed, it is demineralized and the effluent consists of water containing only ammonium bicarbonate. Heating the solution removes the chemical as carbon dioxide

and ammonia gases which are collected and used again to regenerate the exchange resins in the bed. Thus, the costly chemicals used for regeneration are replaced by heat. Solar heat may be applicable.

More information, such as the type of construction materials required, durability or life of the exchange resins, etc., is essential before precise cost estimates can be made.

Solvent extraction.—The extraction of water from saline solutions by an organic solvent, to be recovered later from the extracted mixture of water and solvent by temperature change, has been found sufficiently promising for further research. One of the best solvents [44] so far found is N-ethyl-n-butyl amine, which extracts about 30 percent water at 30° C. and retains about 13 percent at the separation temperature of 75° C. The process is under development at Texas A. & M. College, and satisfactory laboratory equipment has now indicated the need for pilot-plant development which is being initiated.

Biological action.—Preliminary study of the desalting action of biological membranes has very recently led to a research under the United States program in which algae are to be grown in a basin of sea water to take up salt and later removed to a second basin for partial removal of the salt taken up [27]. Pure cultures of several hundred algae have been grown in synthetic sea water and tests are starting on determination of salt uptake.

Use of nuclear energy.—Owing to the high cost of nuclear generated electrical energy, it was originally felt that nuclear energy would probably not play an early role in saline-water conversion. However, in 1957, the Office of Saline Water undertook a study of the possible use of low-temperature nuclear heat directly in evaporation processes. Following a preliminary investigation carried out by the Office of Saline Water [18], the U.S. Atomic Energy Commission, and the Fluor Corp. of Whittier, Calif., a design study is now being made of two nuclear-heated plants employing improved flash distillation, one of 1 million gallons per day, the other of 20 million gallons per day.

Substantial non-Federal research and development in desalting has been conducted in the United States by private industrial organizations. That work consists mainly of practical improvements in multiple-effect, flash, and vapor-compression distillation, and development of electrodialysis. The University of California [43] has carried out a research and development program in several fields including distillation, solar distillation, ion exchange, osmosis, and several exploratory researches.

Saline-water conversion research and development outside the United States in general parallels and supplements that in America. In 1952 the OEEC organized Working Party No. 8 to serve as an

ad hoc committee to plan and initiate a program of international cooperative research in saline-water conversion. Working Party No. 8 completed its work in 1956, having attained its objectives of establishing research and development activities in four fields: the United Kingdom conducted research in scale prevention and other methods of improving distillation equipment; Algeria and Morocco are developing ion exchange and solar distillation; and the Netherlands developed an electrodialysis process. The Department of the Interior cooperated with the working party and assisted in the researches by exchanging technical information and by consultation.

Other research and development outside the United States includes that on electrodialysis in the Union of South Africa, Soviet Russia, United Kingdom, Japan, and Israel; distillation in France, Israel, England, Sweden, and the Netherlands West Indies; freezing in France, Yugoslavia, Israel, and Italy; solar distillation in Spain, Australia, Soviet Russia, Italy; and others. The possible use of wind power for desalting is being investigated in Spain and Pakistan.

COST TRENDS

Saline-water conversion is complicated not only by process difficulties, but also by the range of water requirements encountered. Saline waters often vary widely in chemical composition, and the converted water is subject to various demands of quality. Sea water is fairly uniform in composition, with about 35,000 p.p.m. of salts. On the other hand brackish inland waters are quite variable in total salts and often call for special treatment to reduce or eliminate deleterious compounds, objectionable for use by plants and animals, or for human consumption or industrial purposes. Hardness may be a further factor, and quantities will vary from small household demineralizers to large central plants. Thus, desalting is at times a custom process rather than merely routine salt-removal treatment.

In most instances the consumptive demand will be quite variable, and storage will be necessary to permit uniform operation of the conversion plant. Raw-water storage may at times be necessary to take up fluctuations in supply. Depending on source and use conditions, also, distribution from a central plant may be more efficient and economical than operation of several plants in the same general region. Lift and conveyance of desalted water from the seashore will constitute a major cost.

Such variations in the requirements as to practical application of saline-water conversion will obviously affect design and cost planning. Process costs alone are therefore likely to be an inadequate guide to the total cost of converted water. When supply to a population of some size is at issue, moreover, reliability of services becomes a vital require-

ment and likely to influence decisions on choice of process and planning of the conversion plant. In view of these and other considerations, the U.S. Congress recently authorized the construction of five demonstration plants, two of which shall have a capacity of at least 1 million gallons per day. The five plants, to be built at both seashore and interior sites, will provide invaluable information on the cost and value of large-scale saline-water conversion.

Compared to other developments such as atomic energy, the amount of research and practical development effort devoted to saline-water conversion has been very small indeed. Nevertheless, considerable commercial utilization has been made of the results, as shown on pages 92 and 104, Department of the Interior Report on Saline Water Conversion for 1957 [3].

In the matter of cost of conversion, detailed treatment is being given in the paper at this Symposium by Prof. Everett D. Howe of the University of California. In more brief consideration of costs here, we are reminded that early in the research program, it was found that few engineers or industrial firms used similar factors for computing costs. Some inventors and others omitted many of the factors when estimating costs.

As a practical matter, therefore, the Office of Saline Water concluded that a standard cost-estimating procedure should be developed and that has been done. Copies are available from the Office of Saline Water, Department of the Interior, Washington 25, D.C. The method is flexible enough to be used for any locality by adjustment of the cost factors.

The following table contains estimates of cost per 1,000 gallons by various saline-water conversion processes in the United States, without credits for sale of power or other byproducts.

TABLE 1.—*Cost estimates per 1,000 gallons*

	1952[1] existing installations		1957 designed or projected installations		1960-70 anticipated (if further research is successful)	
	Sea water 35,000 p.p.m.	Brackish 5,000 p.p.m.	35,000 p.p.m.	5,000 p.p.m.	35,000 p.p.m.	5,000 p.p.m.
					Less than—	Less than—
Distillation (including solar)	$2.00–$5.00	$2.00–$5.00	$1.00–$3.00	$1.00–$3.00	$0.50	$0.50
Membrane processes	(2)	(2)	6.00	.80	1.00	.25
Freezing	(2)	(2)	(2)	(2)	.50	.50
Others	(2)	(2)	(2)	(2)	.50	.25

[1] p.p.m.—parts per million.
[2] Not developed.

It will be seen that distillation costs show some reduction from those reported 6 years ago, and that further reductions are forecast for all processes, although their acceptability for large-scale irrigation of low-value crops in the United States is not yet predictable. The price laid on the water could probably be borne by only high-value crops under most favorable circumstances of season and market, and for small homestead uses for vegetables and livestock. As processes are developed, cost is reduced, and methods are adapted to specific local materials and labor, the uses of converted sea and brackish waters are expected to increase.

APPLICATIONS TO ARID LANDS

Our present interest being directed to the potential arid-land uses of saline-water conversion, the following discussion deals with this subject more specifically, with application to present conditions and probable growth. The special importance of the arid-land areas of the Middle East is readily seen in the light of their ancient history and their prominence throughout the ages, under conditions very different from those of today.

A primary uncertainty is presented by the wide variations in the price and cost levels in various parts of the world. Labor and material costs in different regions tend to differ in roughly the same ratio as the over-all price levels of the regions. Therefore, adjustments are necessary of costs and values, carried over into the applicable labor costs and other operating expense when translating costs as computed for United States conditions to those elsewhere, such as in the arid belt of the Middle East. Where local materials and labor can be used in a particular conversion process, cost of the product water for a conversion plant would be reduced. But likewise its monetary value there would be reduced as well. Water costs estimated for the future would then be lessened in the ratio of the probable future price levels of the two regions; such value adjustment might lessen anticipated conversion costs, possibly to the point of making some developments economically sound in the arid lands of the Middle East that would appear uneconomical in the United States of America. For example, it has been estimated that the 4-stage flash-distillation plant built at Kuwait by the Westinghouse Corp., designed to utilize waste gas at no cost, produces fresh water at about 75 cents a thousand gallons, but if fuel at United States prices were used in that plant, cost would exceed $2. In that case the plant would probably have been designed as a 9- or 10-stage plant so as to conserve fuel.

The general pattern of modern development of arid coastal lands in the Middle East rests in part on a basis of industrial demand—this term being taken to include shipping and other transportation and

communication requirements. Through the growth of industry and agriculture there arises a basic growth and a wider range of activities, thereby establishing a much broadened economy and culture. It is to the industrial and domestic water supply that converted saline water finds its first uses.

It is generally accepted that water is worth what it can produce. However, the benefits that water can produce cannot always be measured in terms of money. Although the crop or the manufactured product that water creates has a definite local monetary value, the indirect benefits in terms of improved living standards and a more abundant local and national economy, with resulting welfare and contentment of peoples themselves, comprise a wealth that can never be measured in dollars, rials, or rubles.

As far as is known, the use of desalted water for irrigation is practiced only to the extent of some subsistence and hydroponic farming. However, progress to date certainly justifies limited anticipation of some early agricultural uses without rigid equations of cash benefits to costs and some looking to the future when economic feasibility may be reached. For this purpose a preliminary study was made of irrigable areas in Texas and California [45] at various elevations and distances from the coast which need additional water and might be served directly or by exchange from converted sea water. This was done for California on a basin-by-basin basis as shown by plate 5. As one example, in basin No. 9 in California it was found that some 150,000 acre-feet of new converted sea water could be used on irrigable soils below 500 feet elevation, after first making full use of all available fresh-water supplies in the entire basin. In the lower Rio Grande Basin in Texas some 1,650,000 acre-feet could be used on the same basis.

Similar information on areas bordering the eastern Mediterranean which might be reached with converted sea water could be compiled. Available topographic data indicate that there are more than 20 million acres of land at elevations below 200 meters and within 100 miles of the seacoast in the eastern Mediterranean countries of Greece, Turkey, Syria, Lebanon, Israel, and Egypt. Additional extensive areas of arable land undoubtedly border sources of brackish waters. If use were made also of the valuable information on water deficiencies and surpluses of southeast Asia being prepared for this committee in the World Climatic Atlas by the Laboratory of Climatology of Centerton, N.J., together with available data on arable soils in the area, determination could be made of the location and extent of arable lands within these vast areas which could become productive with converted saline waters. It is urged that such studies be undertaken.

The foregoing has to do with irrigation only, but we should not be unmindful that more than three-fourths of the people in the world

live at elevations less than 1,500 feet above sea level. Thus, considerable ultimate municipal and industrial use of converted saline water in these areas seems assured.

Finally, a word as to the future. As I have pointed out, the need for substantially new discoveries of phenomena or processes for saline-water conversion is not always understood. It is believed possible that a considerable amount of further basic research to discover phenomena and processes not yet explored will prove justified. There are equal possibilities for much additional progress in the development and improvement of the specific processes discussed and partly explored to date in the quest for low-cost saline-water conversion. These possibilities as well as those of basic research should be greatly furthered by improved coordination of the efforts of the various countries concerned with a view to building on the foundation laid by the Washington Symposium and continued by this Symposium.

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The Abundance of the Chemical Elements[1]

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[With 4 plates]

Everybody knows that gold is a very rare element and iron is very abundant on the surface of the earth. Elements like magnesium, silicon, oxygen, or aluminum represent the major constituents of the earth's crust and its rocks, whereas others like gallium, platinum, thallium, and uranium are present only in rare minerals or in the form of minor impurities. Just how much more abundant one element is relative to another is a question dealt with in the field of geochemistry.

The first attempt to answer this question in a quantitative way was made by F. W. Clarke and H. S. Washington during the last decades of the 19th century. Numerous rock analyses were compared by these authors and an average figure for the occurrence of each element in terrestrial rocks was given. In 1889 Clarke said that he attempted to represent the relative abundances of the elements obtained in this way by a curve, taking their atomic weight for one set of ordinates. He had hoped that some sort of periodicity might become evident, but no such regularity appeared. During the following 50 years the work of geochemists led to an understanding of the distribution of the elements between various types of rocks, but it could not yet be explained why some elements were more abundant than others.

Another basic question that could not be answered at the time that Clarke and Washington began their studies was whether the earth was unique in its chemical composition compared to other heavenly bodies. Did other planets, the sun, and the stars have an entirely different composition or was the composition of the earth's crust representative in a general way of the material of which the universe is composed? Three lines of new scientific evidence enable us now to interpret geochemical data and answer all these questions in a satisfactory way.

[1] Reprinted by permission from Foote Prints, vol. 29, No. 2, 1957, published by Foote Mineral Company, Philadelphia, Pa.

These are: spectral analysis of the sun and stars, chemical analysis of meteorites, and the isotopic composition of the elements.

THE COMPOSITION OF THE SUN AND STARS

Spectral analysis of the light of stars and distant nebulae is undoubtedly the most direct way to determine the relative abundances of the elements in the universe as a whole. The intensity of the absorption lines, the so-called Frauenhofer lines, in the spectrum depends on the concentration of the atoms causing the absorption. In general it is not difficult to identify the element that causes an observed absorption line. In order to calculate the correlation of line intensity with atomic concentration, a number of physical properties of the absorbing atoms and the thermodynamic state of the absorbing stellar matter have to be known in detail.

Unfortunately, the experimental determinations of these properties are not yet complete and one has to rely in many cases on theoretical calculations which often give only crude approximations. Furthermore, various other quantities such as optical depth of the layer in which the absorption occurs, thermal velocity of the absorbing atoms, their macroscopic turbulent motion, and other characteristics have to be known before the exact functional dependence of line intensity and atomic concentration can be calculated.

The first abundance data based on special analyses were obtained by Miss Payn in 1925 and by Russel in 1929. Since then the work of these authors has been improved and extended by many investigators, and it was found that the chemical composition of the universe is indeed remarkably uniform, although the most recent investigations indicate definite systematic variations in the composition of stars, depending on their age and their position in the galaxies.

The most important result of the astronomical investigations is the discovery that hydrogen is by far the most abundant element in the universe. Next to hydrogen in abundance is helium. In the sun helium constitutes about one-fourth of the atoms. All the other elements make up only about 1 percent of the sun's total mass. The most prominent of these other elements are carbon, nitrogen, oxygen, and neon. Among the metals sodium, magnesium, aluminum, calcium, and iron are the most abundant ones.

COMPOSITION OF METEORITES

Another set of empirical abundance data can be derived from chemical analysis of meteorites. It is generally assumed that meteoritic matter has undergone less chemical fractionation than any terrestrial material found on the surface of the earth since the time it was formed from solar material. The main type of fractionation recognizable in meteorites is that of a separation of the elements into three chemical phases: a metal phase, a sulfide phase, and a silicate phase.

Iron meteorites consist of metal and small amounts of sulfide only. Other meteorites are composed entirely of silicate.

A large fraction of meteorites, primarily the so-called chondrites, contain all three phases in remarkably constant proportions. It is generally believed that the chondrites contain all the condensable, nonvolatile components of solar matter in approximately primeval proportion. In any case it seems unlikely that chemically similar elements were separated from each other when the meteorites formed from a gas cloud because of the incompleteness of the separation of the three main phases.

Harold C. Urey compared the mean densities of meteorites with those of the terrestrial planets and the moon and concluded that average chondrites and the moon probably contain the same ratio of metal to silicate, whereas the earth and the terrestrial planets contain relatively more metal. During the formation of the terrestrial planets a fraction of the silicate originally present escaped condensation. The much lower densities of the outer planets, Jupiter, Saturn, Uranus, Neptune, and Pluto, show that these planets have retained most of the volatile substances, a large part of the hydrogen and helium, the oxygen as water, nitrogen as ammonia, and carbon as methane.

Clearly, chemical analysis of meteorites cannot tell us anything about the solar abundances of the rare gases and of elements that form such highly volatile compounds. The concentration of many other elements in meteorites, however, shows a surprising agreement with the results of astronomical data. The relative amounts of elements such as sodium, aluminum, silicon, potassium, or calcium are found to be the same in the sun and in meteorites within the limits of errors of the analytical methods. Some values for heavier elements, for example strontium and barium, are also in perfect agreement.

True differences undoubtedly exist in the case of the lightest elements, particularly for lithium, beryllium, and boron. The concentrations of these elements on the surface of the sun are much smaller than those expected from the data on meteorites. The abundance of lithium relative to silicon on the sun is less than one-hundredth of that in meteorites. Beryllium and boron may be almost completely absent.

The deficiency of these elements on the sun is now understood as a consequence of thermonuclear reactions in the sun's interior. These reactions use up these elements as well as the heavy hydrogen isotope, deuterium. At the high temperatures of the sun's interior these elements react with protons and form either helium or heavier nuclear species. The nature of these reactions is now known in detail. It is also known that the isotopes of carbon and nitrogen participate

in nuclear reactions which lead to the transmutation of hydrogen into helium. The sun and the stars derive their energy from this transmutation.

THE ISOTOPIC COMPOSITION OF THE ELEMENTS

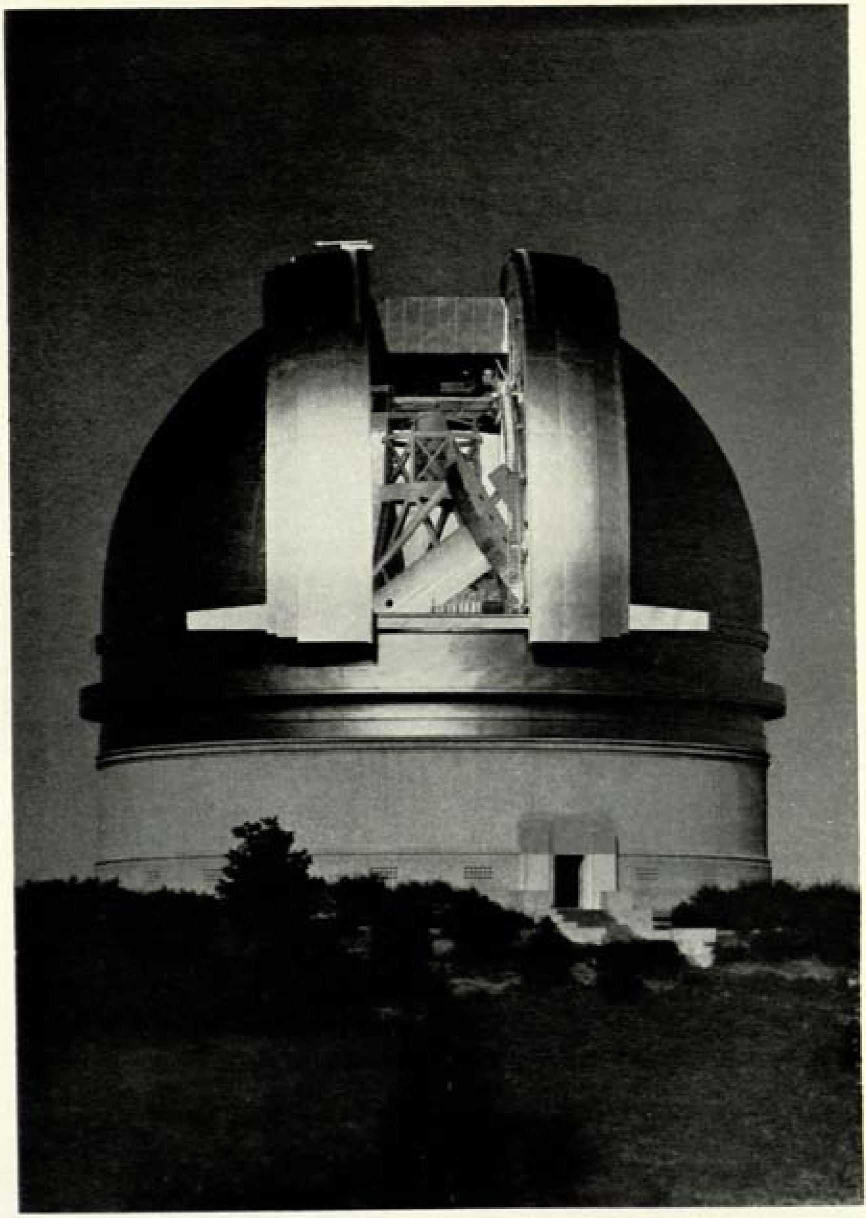
The nuclei of the atoms are composed of neutrons and protons. Nuclei containing the same number of protons are called isotopes; they belong to the same chemical element and in general cannot be separated from one another by natural chemical processes. Most elements are composed of more than one isotope. The isotopic composition of all the elements is known with great accuracy.

For most elements, this composition is absolutely constant. It is the same in all terrestrial material and in meteorites. Small variations have only been observed for light elements as a consequence of minute differences in the chemical properties due to the difference in mass. Variations also occur if one or more isotopes of an element are produced by radioactive decay as in the case of lead. Otherwise we have reason to assume that the isotopic composition of the elements is basically a universal quantity valid for our solar system and for many stars.

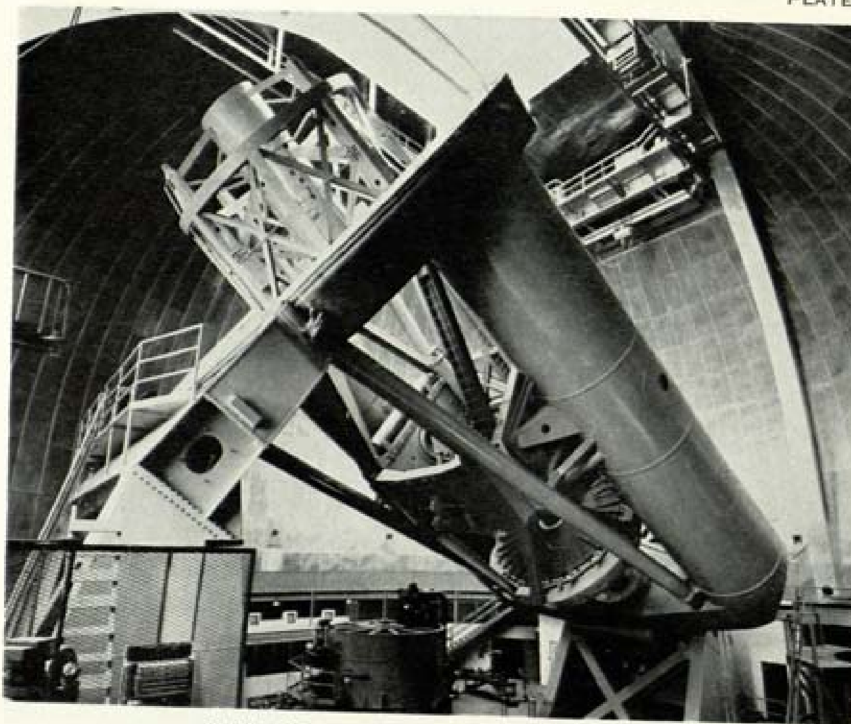
If one plots the logarithm of the percentage of each isotope in a given element against the mass number (the number of neutrons plus protons) of the isotope, very peculiar figures are obtained, as shown in figure 1, taking several elements as examples. It was impossible for a long time to interpret these figures and to explain them in a quantitative way. Many scientists have been fascinated by their mysterious appearance in the same way that men have been fascinated by the mysterious features of the constellations in the night sky for the past thousands of years.

Certain rules have been recognized governing the isotopic composition of the elements, as for example the rule of Harkins which states that isotopes with an odd mass number are on the average less abundant than their even-mass-numbered neighbors. Another remarkable observation can be expressed in the following way: the geometry of the figures obtained by plotting the logarithms of the isotope abundances of a given element against their mass number, as shown in figure 2, is similar for neighboring elements with even atomic number. The character of the figures changes in general only gradually with atomic number.

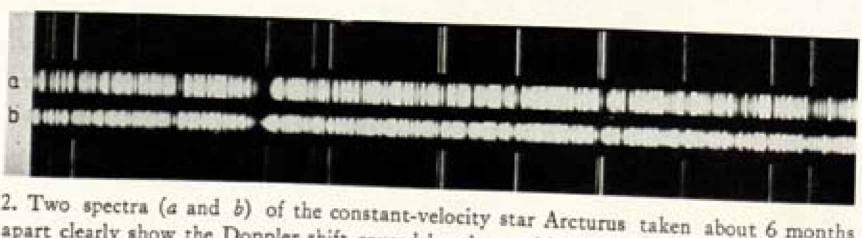
However, in regions where the nuclei contain certain numbers of neutrons, an abrupt change occurs. These numbers of neutrons, the so-called magic numbers, signify nuclear shell closures. The prominent magic numbers are: 8, 20, 28, 50, 82, and 126. The irregularities that occur beyond barium may be interpreted on this basis, since we are dealing with isotopes of a "magic number" of 82.



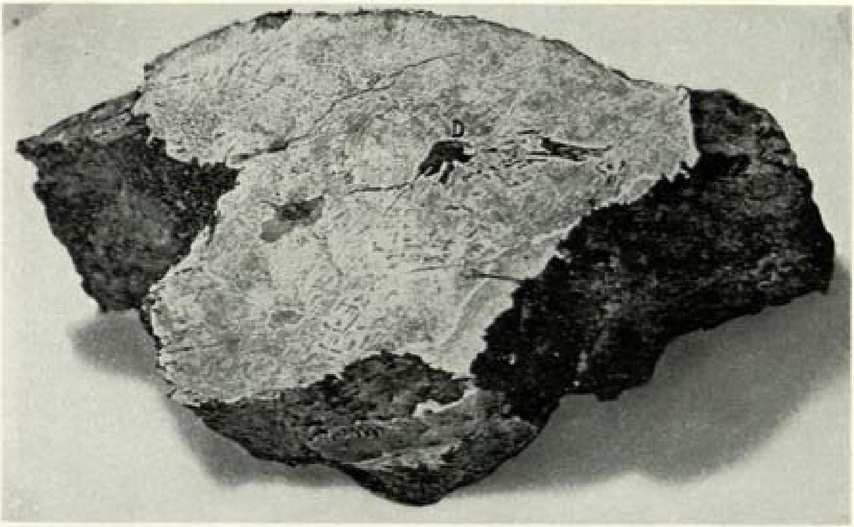
Moonlight view of the 200-inch Hale telescope dome at Palomar. Astronomic observation is an important source of data on cosmic abundances of the elements.



1. The 200-inch Hale telescope pointing north.



2. Two spectra (*a* and *b*) of the constant-velocity star Arcturus taken about 6 months apart clearly show the Doppler shift caused by the earth's orbital velocity of 50 km./sec.



1. Canon Diabolo meteorite, recovered in 1891 by A. E. Foote.

2. The Foote deposits at Kings Mountain, N.C., are rich in lithium and also contain substantial quantities of beryllium. In adjacent pegmatites, the heavier elements tin and columbium (niobium) also occur.

Large active solar prominence 140,000 miles high. The solar abundances of the elements, as determined by spectral analysis, are now known to be a function of the properties of the atomic nuclei. Hydrogen is the most abundant element, while helium constitutes about one-fourth of the atoms in the sun.

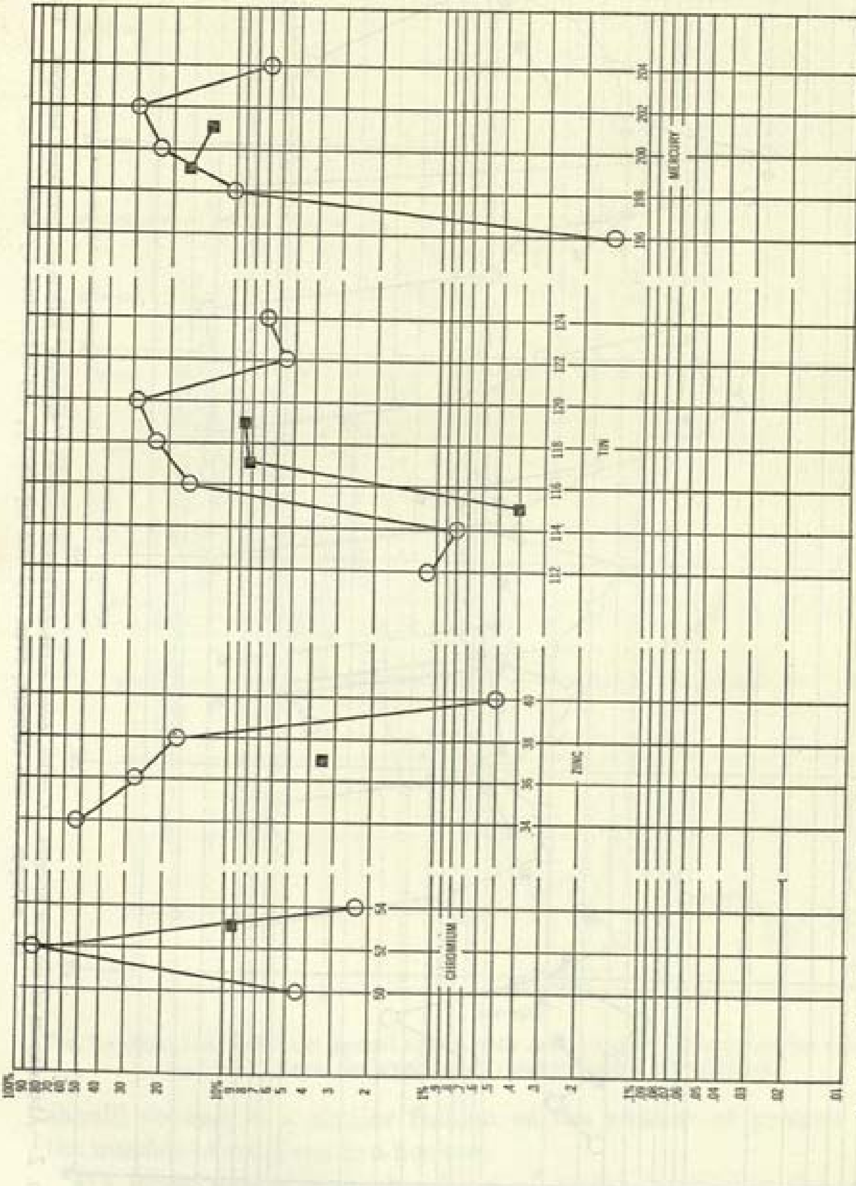


FIG. 1.—Graphic presentation of isotopic composition of some elements. Circles denote even-mass-numbered isotopes; squares, odd-mass-numbered isotopes.

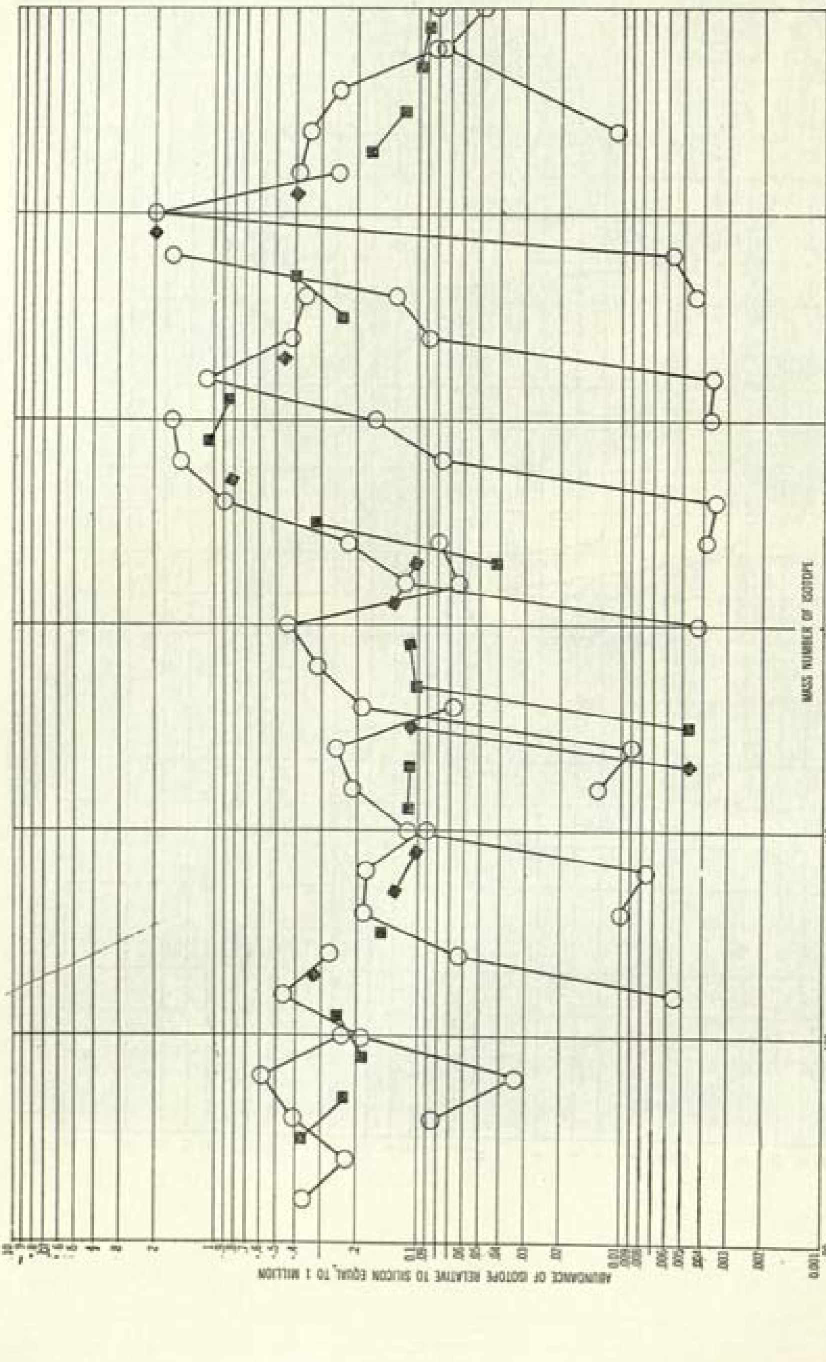


FIG. 2.—Abundances of nuclear species. Circles, even-mass-numbered isotopes. Squares, odd-mass-numbered isotopes. The points for isotopes of each element, even and odd separately, are connected by lines.

Furthermore, one can see that nuclear species containing just such a number of neutrons are in general exceptionally abundant (fig. 3).

These facts indicate that the abundance of nuclear species is determined by nuclear properties. The individual abundances of nuclear species should therefore form a coherent system of some kind; they

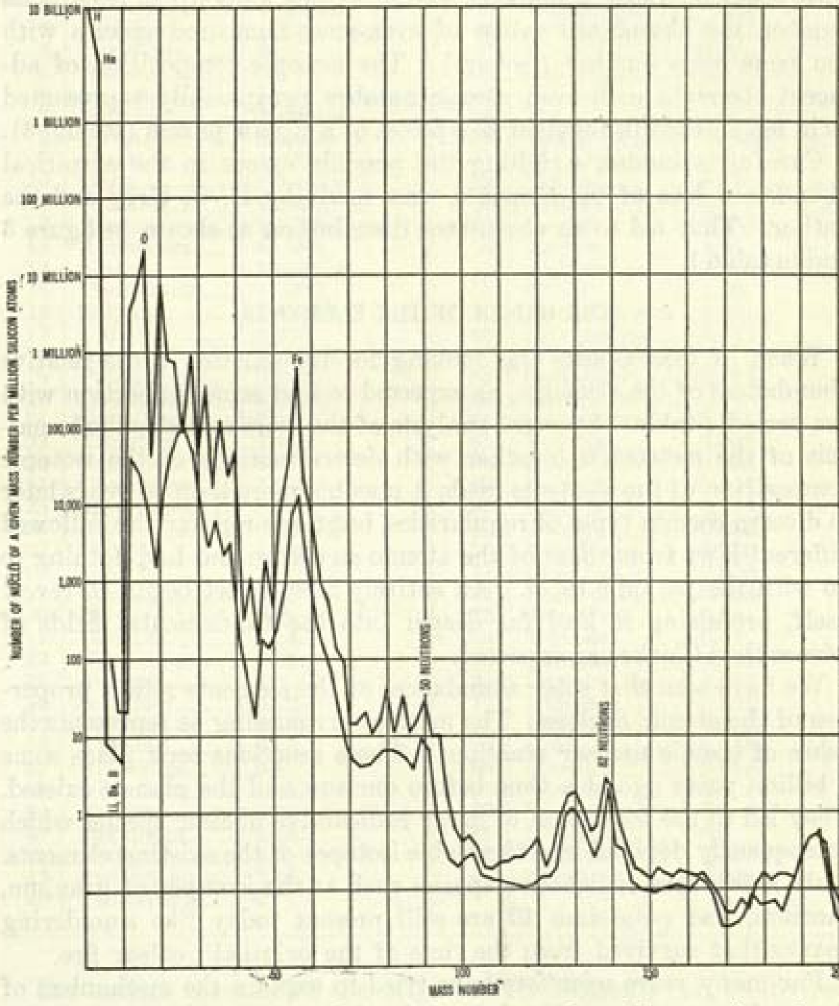


Fig. 3.—Abundance of nuclei plotted against their mass number. The upper line refers to nuclei with even, the lower line to those with odd, mass number.

should depend in a similar fashion on the number of protons and the number of neutrons in a nucleus.

We know the relative abundance of nuclei containing the same number of protons (isotopes) with great precision from mass-spectroscopic measurements, and can expect that all the abundances of the nuclear species should in some way be connected with these data. This indeed can be shown to be the case.

It is possible to modify within the limits of the error of the analytical data the values for the abundances of the elements in meteorites in such a way that the abundances of the individual nuclear species as a function of their mass number form regular smooth lines for the odd-mass-numbered isotopes. A similar smooth line is obtained with these modified abundance values, if one adds up at each mass number the abundance values of even-mass-numbered species with the same mass number (isobars). The isotopic composition of adjacent elements with even atomic number (graphically represented as in fig. 2) then fit together like pieces of a jigsaw puzzle (see fig. 3).

Careful estimates, weighing the possible errors in the empirical abundance data of the elements, were made by H. C. Urey and the author. They led to an abundance distribution as shown in figure 3 and in table 1.

THE ORIGIN OF THE ELEMENTS

When in 1889 Clarke was looking for regularities in the relative abundances of the elements, he expected to find some connection with the periodic table. Spectral analysis of the stars and chemical analysis of the meteorites together with determinations of the isotopic composition of the elements made it possible more than 40 years later to discern certain types of regularities, but these regularities followed different laws from those of the atomic structure and had nothing to do with the periodic table. An entirely new aspect began to reveal itself, promising to lead far deeper into the fundamental fields of science than Clarke had expected.

We have seen that solar abundances of the elements reflect properties of the atomic nucleus. The matter surrounding us represents the ashes of cosmic nuclear reactions. These reactions took place some 6 billion years ago at a time before our sun and the planets existed. They led to the formation of many radioactive nuclear species which subsequently decayed into the stable isotopes of the existing elements. Only a few rare radioactive species such as the isotopes of uranium, thorium, and potassium 40 are still present today like smoldering sparks that survived from the time of the original nuclear fire.

For many years scientists have tried to explain the mechanism of the nuclear reactions that led to the formation of nuclear species and their abundance distribution. Our detailed knowledge of nuclear abundances serves now as a firm basis for such considerations. Many theories have been advanced, none of which could account for all the empirical facts, even in a crude way. All the past theories had in common the assumption that the matter surrounding us was created by one and the same nuclear process. The existence of radioactive nuclei and their abundance lead to the conclusion that this process must have taken place some 5 to 7 billion years ago.

TABLE 1.—*Abundances of the elements in the primeval gas cloud from which the earth and the meteorites formed*

[The number of atoms of each element per million atoms of silicon is given in the table]

Atomic No.	Element	Atoms	Atomic No.	Element	Atoms
1	Hydrogen	30 billion.	44	Ruthenium	1.49.
2	Helium	4 billion.	45	Rhodium	0.214.
3	Lithium	100.	46	Palladium	0.675.
4	Beryllium	20.	47	Silver	0.26.
5	Boron	24.	48	Cadmium	0.89.
6	Carbon	10 million.	49	Indium	0.11.
7	Nitrogen	3 million.	50	Tin	1.33.
8	Oxygen	30 million.	51	Antimony	0.246.
9	Fluorine	1,600.	52	Tellurium	4.67.
10	Neon	8.6 million.	53	Iodine	0.80.
11	Sodium	43,800.	54	Xenon	4.0.
12	Magnesium	912,000.	55	Cesium	0.456.
13	Aluminum	94,800.	56	Barium	3.66.
14	Silicon	1 million.	57	Lanthanum	2.00.
15	Phosphorus	10,000.	58	Cerium	2.26.
16	Sulphur	375,000.	59	Praseodymium	0.40.
17	Chlorine	8,850.	60	Neodymium	1.44.
18	Argon	150,000.	61	Promethium	0.
19	Potassium	3,160.	62	Samarium	0.664.
20	Calcium	49,000.	63	Europium	0.19.
21	Scandium	28.	64	Gadolinium	0.684.
22	Titanium	2,440.	65	Terbium	0.096.
23	Vanadium	220.	66	Dysprosium	0.556.
24	Chromium	7,800.	67	Holmium	0.118.
25	Manganese	6,850.	68	Erbium	0.316.
26	Iron	600,000.	69	Thulium	0.032.
27	Cobalt	1,800.	70	Ytterbium	0.220.
28	Nickel	27,400.	71	Lutetium	0.050.
29	Copper	212.	72	Hafnium	0.438.
30	Zinc	486.	73	Tantalum	0.065.
31	Gallium	11.4.	74	Tungsten	0.49.
32	Germanium	50.5.	75	Rhenium	0.135.
33	Arsenic	4.	76	Osmium	1.00.
34	Selenium	67.6.	77	Iridium	0.821.
35	Bromine	13.4.	78	Platinum	1.625.
36	Krypton	51.3.	79	Gold	0.145.
37	Rubidium	6.5.	80	Mercury	0.017.
38	Strontium	18.9.	81	Thallium	0.1.
39	Yttrium	8.9.	82	Lead	0.5.
40	Zirconium	54.5.	83	Bismuth	0.1.
41	Niobium	1.0.	90	Thorium	0.02.
42	Molybdenum	2.42.	92	Uranium	0.006.
43	Technetium	0.			

The earlier theories of the origin of the elements can be divided into two groups: equilibrium theories and nonequilibrium theories. In the equilibrium theories it is assumed that the existing abundance distribution corresponds approximately to the equilibrium concentrations of the nuclear species at a certain temperature and pressure at which they were "frozen in." This assumption requires a correlation of abundances with the total binding energies of the nuclei. Such correlation seems indeed to exist, but only within certain relatively narrow ranges of mass numbers. The thermodynamic parameters,

however, cannot be adjusted in such a way that the over-all abundance distribution would correspond to that of a thermodynamic equilibrium. It was therefore assumed that equilibrium considerations cannot be regarded as a useful way of obtaining reasonable approximations.

In the nonequilibrium theories it is hopefully assumed that a relatively simple type of kinetic process has led to the empirical abundance distribution. Two such theories have been attracting wide interest: the neutron buildup theory, proposed in 1948 by George Gamow, and the polyneutron fission theory by Mayer and Teller. According to the neutron buildup theory the heavier nuclei were formed by the addition of neutrons to very light nuclei and by subsequent beta decay into stable nuclear species.

Many features, in particular the smoothness of the abundance lines (fig. 3) at higher mass numbers, show conclusively that such processes have indeed taken place. However, this theory cannot explain the abundance of the lighter elements, the excessive abundance of iron, and the existence of the light isotopes of many heavier elements. Similarly, the polyneutron fission theory predicts certain features in the abundance distribution but fails to approximate the over-all trend of the abundance data as a function of mass number. The theory leads to abundances of the heavy elements which are many thousand times too high.

These and many other attempts have finally convinced scientists that it is impossible to explain the abundances of the elements and their isotopes as a product of one particular type of nuclear reaction. A group of scientists at the California Institute of Technology has found a surprisingly simple way out of this dilemma by considering solar and planetary matter as a mixture of the product of different types of nuclear reactions, in particular such reactions as can plausibly be assumed to occur in the interior of stars.

Occasionally astronomers observe the sudden appearance of a bright new star, a so-called nova. The brightest of them, the supernovae, occur in our galaxies about once every 500 years. The supernovae, however, are bright enough to be observable in distant galaxies almost every year. The energy produced in a supernova outburst is equivalent to that of a hydrogen bomb of a size several times that of the sun. The debris of the stellar explosion is thrown out into space.

One interesting observation points to a true similarity between manmade hydrogen bombs and supernova explosions. The astronomer Baade observed that the light intensity of some supernovae decreases in a regular way within 56 days to just one-half of its value. The debris from explosions of hydrogen bombs was found to contain the heavy isotope californium 254. This isotope has a natural fission

half-life of just 56 days. The possibility has been widely discussed recently that the light emitted by the gas cloud resulting from the explosion of a supernova is essentially supplied by energy from the breakup of californium 254 nuclei.

If this hypothesis is true, then the occurrence of such a transuranium element as californium in supernovae proves that neutron buildup of heavy elements takes place during the explosion, necessarily leading to the formation of all nuclear species predicted by the neutron buildup theory.

There is a variety of other possibilities that can lead to the explosion of a star. Helium, continuously produced from hydrogen in most stars, can react at the high pressures of a stellar interior to form carbon 12, oxygen 16, and heavier elements. When the buildup of nuclei reaches iron, the star can become unstable and expel a large fraction of its mass into outer space. The debris of such stars will contain large amounts of iron. Other types of stellar explosions will result in the formation of the light elements preferentially. Certain types of stars have been observed to eject matter continuously. Various mechanisms of nuclear synthesis proposed in earlier theories may be realized in the interior of different types of stars. In this way it becomes understandable that these theories were capable of predicting the relative abundances of nucleids of a certain type and of a certain mass range, but always failed to account for all the empirical facts.

The question of whether one can accept the hypothesis that the elements have formed in stars depends largely on quantitative considerations of the absolute amounts that can be produced in such a way during a reasonable time interval, and the amount necessary to explain the observed composition of the stars of our galaxies. One can estimate that at present only about one-half of the mass of our galaxies is concentrated in stars. The other half is present in the form of interstellar gas and dust.

It can be assumed that about 7 billion years ago our galaxies had the form of a huge gas mass of pure hydrogen. Out of this gas mass, large hydrogen stars condensed. In their interior hydrogen was converted into helium and into heavier elements. The rate of such processes in large stars is greater than in small ones, so that the large stars become unstable relatively quickly. The matter they ejected contained heavier elements. New generations of stars accumulated continuously from interstellar matter. They contained increasing amounts of heavier elements. Our sun, the solar system, and the earth were formed about 4.5 billion years ago. New astronomical evidence indicates that stars younger than our sun contain a larger percentage of heavier elements.

To many scientists this picture seems now acceptable. Many details are still unknown or questionable and will have to be evaluated in close collaboration between astronomers, nuclear physicists, and geochemists. In this connection the abundances of the elements lithium, beryllium, and boron may become particularly interesting, because these elements can only form under very special conditions. They are easily destroyed at high stellar temperatures.

Our picture of the origin of the elements cannot be correlated in its present stage with the fundamental question whether the universe as a whole is eternal or has been created at a defined time. The present attempts by F. Hoyle and others to recognize nuclear genesis as part of a consistent cosmological model are not quite convincing. We can expect fascinating developments of our knowledge in these fields of science.

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Earthquakes and Related Sources of Evidence on the Earth's Internal Structure

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EARTHQUAKE ENERGY

When the subject of earthquakes is mentioned the nonseismologist commonly thinks of death and destruction: every year there are a number of earthquakes in various parts of the world which command newspaper headlines because of the great damage done. Perhaps the greatest recent earthquake is the one that occurred in Assam on August 15, 1950, causing utter devastation over some thousands of square miles, and felt over an area in excess of a million square miles.

During the past 200 years or so there has been a steady accumulation of systematic knowledge of earthquake occurrence and effects. For example, it is now well known that earthquakes originate largely in two main belts. Eighty percent of all earthquake energy comes from a belt that passes around the Pacific Ocean and affects countries with coastlines bordering on this ocean—for example, New Zealand, New Guinea, Japan, the Aleutian Islands, Alaska, California, Colombia, Ecuador, and Chile. A second belt passes through the Mediterranean region eastward across Asia, and joins the first belt in the East Indies. The energy released in the second belt amounts to 15 percent of the total, leaving only 5 percent for the whole of the rest of the world.

It is also known that 85 percent of the energy comes from centers or "foci" within 50 miles or less of the surface, the remaining 15 percent coming from foci down to a depth of 450 miles. During the present century, i.e., over the whole period of accurate recording of earthquakes, there has, in fact, been no earthquake with a focal depth exceeding 450 miles. Moreover, all but one of the earthquakes which originated near this extreme depth have been confined to the circum-pacific belt. The exceptional earthquake originated at a depth of nearly 400 miles below Spain in 1954.

The total number of earthquakes is very great. On an average there are 10 earthquakes each year which are regarded as national disasters. Another hundred, classed as destructive earthquakes, do considerable damage, while a thousand do at least some damage. Ten thousand others are strong enough to cause alarm, and a hundred thousand are felt by human beings every year. In addition to that, a great many more earthquakes are instrumentally detected.

The energy released in an extreme earthquake is more than one (American) billion times that in the smallest generally felt earthquake. In the extreme earthquake the energy is about the same as that in a major hurricane; but whereas the latter energy takes some hours or more to spend itself and covers a great area, the energy in an earthquake issues in the space of a few seconds at most from a confined region below the earth's surface whose linear dimensions do not ordinarily exceed a few miles. The energy in the extreme earthquake is nearly a hundred thousand times that in a normal atom bomb explosion, and perhaps ten to one hundred times that in a typical hydrogen bomb explosion.

Seismologists, who study earthquakes by physical means, have long realized that any real understanding of the forces that bring about earthquakes must be preceded by a thorough detailed study of the structure of the earth below the surface. And it happens that earthquakes themselves provide the principal means of unraveling this structure. The greater part of seismologists' efforts is, in fact, devoted to analyzing physical data on earthquakes with a view to charting out the earth's interior to the highest precision possible.

When an earthquake occurs, it sends waves down into the earth's interior, and the shapes and speeds of the waves are influenced by the nether regions they traverse. The waves, on emerging again at the surface, are recorded by seismographs in the thousand or so seismological observatories that are spread over the globe in nearly all countries. Every year there are many earthquakes large enough to send sizable waves right through the earth's interior, including the center. In deciphering the "seismograms," i.e., the records of the waves taken at the surface, the seismologist is in effect X-raying the earth, for seismic waves, mathematically speaking, are very similar to light waves.

The immediate cause of the larger earthquakes is known to be the release of elastic strain energy which has accumulated in sizable volumes of material in the earth below the surface, sometimes over a long period beforehand. There comes a stage when the material is strained to breaking point, and the place where fracture starts becomes the focus of an earthquake. The point of the earth's surface above the focus is called the epicenter; it is usually in the vicinity of the epicenter that the main damage is done. If the epicenter is

at sea, then, depending on the characteristics of the fracture at the focus, there may be formed great seismic sea waves, or tsunami, which can cause havoc along low-lying shores of adjacent U- and V-shaped bays. There is as yet no universally accepted explanation of the primary causes that give rise to this accumulation of strain energy in the earth's interior, although nearly all theories relate the development of strain to the earth's thermal history.

TYPES OF EARTHQUAKE WAVES

When a seismogram is scrutinized, it is found, on the first level of examination, to show the presence of three broad classes of seismic waves. The first identification of these waves was made by Oldham in England in 1897, nearly 70 years after the relevant mathematical wave theory had been formulated.

One of the three classes consists of waves that travel over the earth's surface and do not penetrate to great depths. On seismograms taken at considerable epicentral distances, these waves appear as the largest (except when the depth of focus is appreciable); this is because the surface waves, which spread out in only two dimensions, diminish more slowly with distance than the other waves which spread out through the three dimensions of the earth's interior. The surface waves are dispersed as they travel (the speed of any one group of surface waves depends on the wavelength) and the degree of dispersion for a given epicentral distance throws important light on the structure of the outermost 25 miles or so of the earth. The present article, however, will be mainly concerned with the other classes of waves, called bodily waves, for these are the ones which supply information on the earth's deeper interior.

The two classes of bodily seismic waves are called the primary or P waves, and the secondary or S waves, respectively. Both P and S waves travel faster than the surface waves, and they contribute to the earlier part of the record on the seismogram. The P waves are longitudinal like waves in sound, while the S waves cause the particles of the earth to move transversely to the direction of wave advance. For points not too close to the focus and epicenter, earthquake energy can for many purposes be regarded as traveling outward along seismic rays, analogous to rays of light. For most of their length both P and S rays are curved, with their concavity upward, although a limited number of surfaces of discontinuity inside the earth exist at which the rays are bent suddenly downward. Thus rays which start off downward at the focus, but not too steeply, emerge at relatively short distances from the epicenter, while the steeper rays emerge at greater distances, even as far away as the antipodal point, or anticenter.

The P waves travel through solid parts of the earth about 1½ times as fast as S waves. In fluid regions, the S waves are not transmitted. Thus the detection of S in addition to P waves in a part of the earth is positive evidence of solidity (in a sense to be defined a little later). Likewise, failure to detect S waves is negative evidence of fluidity. Near the outer surface of the earth, P waves travel at a speed of about 3 miles per second. The greatest speed, 8½ miles per second, is reached at a depth of 1,800 miles below the surface.

One of the great labors of seismologists over the first 40 years of this century was to evolve, by successive approximation from crude beginnings, seismic travel-time tables which give the travel times along seismic rays in terms of the angular distances subtended by the rays at the earth's center. The accuracy of the Jeffreys-Bullen tables, which are the ones used in compiling the International Seismological Summary, is of the order of 1 or 2 seconds in travel times of the order of 20 minutes, in the best instances. (Twenty minutes is the time taken for a seismic P pulse to go straight through the earth from one side to the other.)

REGIONS OF THE EARTH'S INTERIOR

From the travel-time tables, it is possible by a mathematical process to estimate the speeds of P and S waves at points throughout a large part of the earth's interior. In the case of P waves, the speeds are moderately well known throughout nearly the whole interior, while for S waves this knowledge is available down to a depth of 1,800 miles. On the basis of the calculations, it has become possible to divide the interior into a number of concentric regions. The boundaries between these regions are indicated by the levels at which the P and S velocities, or their gradients with respect to depth, change abruptly with increase of depth.

In continental regions, there is a fairly marked jump in the P and S velocities some 25 miles below the surface. The first evidence for this was obtained by the seismologist Mohorovičić in investigating local features of a Balkan earthquake in 1909, though he thought the change occurred rather deeper than 25 miles. Later work by others showed the change of property to be worldwide, and the boundary where the change occurs has come to be called the Mohorovičić discontinuity. In oceanic regions, work to date indicates that the depth of the discontinuity is of the order of only 5 miles below the ocean floor. The region which lies above the discontinuity is sometimes called the earth's crust, though it is well to realize that the term has only a conventional meaning nowadays. For more than a thousand miles below the crust, the earth is solid, with increasing rigidity. Above the crust, the velocities of the P and S waves vary rather erratically and can vary in the horizontal as well as the ver-

tical direction. In contrast, the velocities below the crust depend very largely on the depth alone, and the variation with depth is much more steady.

An early triumph in seismology was the revelation that the earth has a large core sharply separated from the part outside, called the mantle. The existence of a central core had been suspected for the last century, but was not established until Oldham supplied the necessary evidence from seismology in 1906. In 1913, Gutenberg (then in Göttingen, now of California) made a famous calculation which gave the depth of the core boundary as 1,800 miles, a figure that Jeffreys with the use of statistical theory showed in 1939 to be accurate within 3 miles or so.

The discovery of the existence of the central core came about this way. Consider P waves issuing from a large hypothetical earthquake with focus at the South Pole. Then it transpires that the waves would be strongly recorded at all stations in the Southern Hemisphere, and, as well, in the Northern Hemisphere as far north as latitude 15°, i.e., up to the latitude of Guatemala. But between the latitudes of Guatemala (15° N.) and Winnipeg (52° N.), there would be a "shadow zone" in which the regular P waves would be much less prominent. Then at the latitude of Winnipeg, the P waves would come in strongly again and be well recorded from there to the North Pole. The whole of the United States would thus be inside the shadow zone for the particular earthquake. Similar shadow zones occur with all earthquakes large enough to be recorded on the opposite side of the earth, the location of the shadow zone depending, of course, on the location of the focus.

On examination it was seen that the only possible explanation of the shadow is the presence of a central core. The regular P rays which emerge at epicentral distances up to 105° lie entirely in the mantle. Rays which emerge at 105° just graze the boundary of the core. Slightly steeper P rays strike the boundary at an angle and the shadow is produced through these rays being bent or "refracted" sharply downward at the boundary, with the result that they do not emerge at the surface until at distances beyond 142°. The phenomenon is similar to the refraction of light rays at the boundary which separates a water surface from the air and which causes a straight stick partly immersed in the water to be apparently bent at the surface.

No S waves have ever been detected in the earth's central core. This is part of the evidence that shows the central core, for most of its volume, to be in a fluid or molten state. The complete evidence for this conclusion includes measurements of tidal deformation of the solid earth, and astronomical observations that enable movements of the earth's poles to be determined. These measurements, together

with seismic data on the earth's mantle, make it possible, by a difficult mathematical calculation, to set limits on the extent to which the earth's central core can deviate from the fluid state. Recent important calculations of the Japanese Takeuchi and the Russian Molodenski indicate that the outer part (at least) of the central core is very close to the fluid state.

On the other hand, both S and P waves are detected throughout the whole of the mantle. This shows that, apart from the oceans and isolated pockets of molten material near volcanoes, the earth is essentially solid down to a depth of 1,800 miles.

It is well at this point that some indication should be given of the terms "solid" and "fluid." The elastic properties of an ordinary material in a laboratory are specified by the values of two coefficients which together describe how the material will be deformed under any given applied stress. The two coefficients are commonly taken as the "incompressibility," which specifies the resistance of the material to change of density under pressure, and the "rigidity," which specifies the resistance to distortion of shape. For ordinary materials, values of the coefficients are determined by fairly direct laboratory measurements. For materials of the earth's deep interior the values are inferred from observations of seismic waves themselves; seismology shows that, in spite of the great pressures that occur, the stress-strain relations for materials deep down in the earth have, to good approximation, the same mathematical form as for materials at ordinary pressures.

Materials, both at the earth's surface and in the deep interior, are called solid when the coefficients which represent the incompressibility and rigidity are both appreciable, and fluid when the rigidity is very small compared with the incompressibility.

The seismic data show that the rigidity and the incompressibility both increase steadily with depth throughout the mantle. Inside the core, the rigidity falls to a small fraction of the mantle value while the incompressibility maintains a high value.

It needs to be remarked that the discrimination here made between solid and fluid relates only to the behavior under stresses of short duration such as those involved in the transmission of seismic waves, i.e., stresses that have periods of the order of a few seconds or so. A material that is solid in the sense here defined might nevertheless be subject to internal convection currents taking place over long periods of time. Whether such convection currents or other long-sustained forms of flow do take place in the earth's mantle is a matter of current controversy which the data of seismology cannot at present resolve.

So far, we have seen that seismic data enable us to make a broad division of the earth into a solid mantle, including crust and subcrust, and a central core which is largely fluid or molten.

The behavior of P and S waves in the mantle reveals further that there is some measure of inhomogeneity in the mantle below the crust. In the outermost 700 miles of the subcrust the velocity gradients are too great to be compatible with a uniform chemical and physical state. The precise location of these changes is complicated by the fact that the steep velocity gradients cause the travel-time curves to bend back on themselves, and this makes for difficulty in identifying the corresponding pulses on seismograms. The evidence shows that these changes of property may set in at a level as high as a hundred miles below the surface, and that they are complete at a depth of 700 miles or less. The changes may be due to variation in chemical composition or to a physical change of state brought about by the considerable pressure.

From a depth of 700 miles to within 100 miles or so of the core, the P and S velocity gradients are very steady, and it is likely that the chemical composition is nearly uniform in this part of the earth. In the lowest 100 miles of the mantle the velocity gradients fall to nearly zero and suggest some departure from uniformity.

Prior to 1936, the central core was thought to consist of nearly homogeneous molten iron and nickel. Then in 1936, a Danish seismologist, Miss I. Lehmann, looked more closely at records of two New Zealand earthquakes in the "shadow zone." It was already known that the shadow zone is not a complete shadow—that there are relatively small observations of P waves in the zone. Before 1936, these observations had been attributed to various diffraction effects—to deviations from the ray theory in waves refracted by the core boundary. Similar diffraction effects are well known in the transmission of light. Miss Lehmann proposed, as an alternative explanation, that some of the waves observed in the shadow zone are really associated with rays that have passed into an *inner* core, inside the central core, the P velocity in the inner core being great enough to bend sharply upward certain of the rays which penetrate into it.

Gutenberg and Richter showed that the travel-time data available by 1938 fitted Miss Lehmann's hypothesis, and in 1939 the existence of the inner core came to be well established when Jeffreys showed that the competing hypothesis of diffraction could not explain the size of some of the observed waves in the shadow zone. Small though the waves were, some of them were too large to be accounted for by diffraction. Recently, Burke-Gaffney and I have been able, from a study of several hydrogen-bomb explosions of 1954, to show the separate existence both of Miss Lehmann's waves, and of diffracted waves, on the same seismograms; this adds a further link to the chain of evidence for the existence of the central core.

Thus the earth is further divided into what, for want of a better name, is called the outer core extending between depths of 1,800 and

nearly 3,200 miles, and the inner core occupying the remaining 800 miles to the earth's center. As will be shown later it is probable that the inner core is solid. In between these two parts of the central core there may exist a transition region about 100 miles thick. Jeffreys has found evidence of such a region, though not all seismologists as yet support the finding. It is difficult at the present stage to draw sharp conclusions on this part of the earth, and more evidence is desirable.

The following table summarizes in broad terms the division of the earth into regions according to the evidence from seismology.

TABLE 1.—*Division of the earth into regions according to the evidence from seismology*

Region	Range of depth	Description
A	0–10 miles (oceanic) 0–25 miles (continental)	The earth's ocean and "outer layers." Very variable in composition.
B, C	25–700 miles	The upper mantle, in which there is some variation of composition not yet precisely located.
D′ D″	700–1,700 miles 1,700–1,800 miles	The lower mantle; D′ appears to be nearly uniform in composition; in D″ there is probably some accumulation of somewhat denser material.
E	1,800–3,100 miles	The outer core. Fluid, and probably uniform in composition.
F	3,100–3,200 miles	Somewhat uncertain transition region between outer and inner core.
G	3,200–3,960 miles	The inner core, probably solid.

DENSITY, PRESSURE, GRAVITY, AND ELASTICITY IN THE EARTH'S DEEP INTERIOR

To a good approximation, the velocities of seismic waves at any point inside the earth depend on just three properties, namely the incompressibility k, the rigidity μ, and the density ρ. The previous section shows that values of the P and S velocities are known down to the base of the layer E. (Inside E, the S velocity is taken to be zero because of the evidence for fluidity.) This knowledge supplies two equations connecting the three items k, μ, and ρ. If only a third independent source of information were available, it would be a matter of simple algebra to calculate the values of all three of k, μ, and ρ down to a depth of more than 3,000 miles, and so obtain good knowledge of the variation of density and elasticity in the earth.

In practice, no such third source of information is directly available, and the problem has to be attacked indirectly. Use is made first of the fact that in parts of the earth where the composition is uniform,

the density changes due to increasing pressure are related to the incompressibility, so that seismic data can be further brought to bear to determine density gradients in these parts of the earth. Second, restrictions on the possible density variations are provided from knowledge of the mass and moment of inertia of the earth. (The moment of inertia, which contains information on the degree of central condensation of matter in the earth, is found from the dynamics of the earth-moon system in conjunction with measurements of the shape of the earth.) Third, by matching P and S velocities in the outer part of the earth against the results of laboratory experiments on rocks, an estimate can be made of the density just below the crust.

Calculations that I carried out some years ago on these lines gave density values ranging from 3.3 gm/cm^3 just below the crust to about 5½ gm/cm^3 at the bottom of the mantle. The value jumps suddenly to 9½ gm/cm^3 at the top of the outer core, and is between 11 and 12 gm/cm^3 at the bottom of the outer core. At the earth's center, the density probably lies between 14½ and 18 gm/cm^3. The uncertainty on the central value cannot be resolved until more is known about the character of the transition region F.

This work also enabled a number of other properties of the deep interior to be deduced. Atmospheric pressure at sea level is referred to as 1 atmosphere (15 pounds weight per square inch). In a steam locomotive the pressure may be about 30 atmospheres. At the bottom of the Pacific Ocean, the pressure can reach 800 atmospheres. In special high-pressure laboratories, values between 100,000 and 300,000 atmospheres have been reached. Inside the earth, however, the pressures become still greater. At the bottom of the mantle, the immense value of 1⅓ million atmospheres is reached, while at the earth's center the figure lies between 3½ and 4 million atmospheres.

Another section of the results relates to the acceleration g due to gravity in the earth. It is remarkable that, down to a depth of 1,500 miles, g keeps within 2 percent of its surface value of 32 ft./sec^2. The maximum value, 34 ft./sec^2, is reached at the bottom of the mantle. Inside the core the value of g steadily diminishes, becoming zero at the center.

The calculations showed further that the rigidity steadily increases with depth throughout the entire mantle until at the bottom the value is about four times that for steel at atmospheric pressure. The value then drops suddenly across the core boundary, and remains close to zero throughout the outer core, in keeping with the evidence that the outer core is fluid or molten.

But perhaps the most important fruits in this series of calculations were the results for the incompressibility k. Whereas the outer core boundary is characterized by sudden large changes in the values of

the density and rigidity, the figures for k showed a change of only 5 percent, a change which, moreover, is inside the margin of uncertainty on which the calculations rest. Further, the gradient of k with respect to pressure was not detectably different on the two sides of the boundary.

This led me to suggest that, for the materials of the earth's deep interior, k changes fairly smoothly with the increasing pressure everywhere between a depth of 700 miles and the earth's center, a suggestion that has since received support from theoretical work on the variation of k with pressure beyond 10 million atmospheres.

This hypothesis of the smooth variation of k in the earth's central core led me further to the inference that the inner core is solid in the sense earlier defined, this being the natural interpretation of the jump in the P velocity which Miss Lehmann found between the outer and inner core. The seismic wave velocity equations show that either k or the rigidity μ must jump to account for the jump in the P velocity, and the available evidence all points to the conclusion that the jump is in μ. The jump is from zero rigidity in the outer core to a rigidity in the inner core two to four times that of steel.

It would be desirable to have the solidity of the inner core tested by direct detection of S waves in the inner core. The difficulty here is to excite S waves in the inner core from waves incident through the outer core from above; the latter waves, because of the fluidity of the outer core, must necessarily be P waves. A calculation that I have made on the expected amplitudes of S waves in the inner core shows that they are at best on the border of observability with present seismic resolving power, even with the mightiest earthquakes. The problem is illustrated by the fact that when atom bombs have been exploded underwater, and thus in a fluid region analogous to the earth's molten outer core, detectable S waves are only rarely excited in the mantle below the ocean even when P waves are quite well observed.

These various details show that, while much remains to be done, seismology has already given a good insight into the principal mechanical properties of the earth's interior.

THE EARTH'S COMPOSITION

In now venturing a few remarks on the earth's composition, I need to say that this subject is much more conjectural than the subject of the earth's mechanical properties. The numerical results that emerge from seismology lead, however, to a few interesting suggestions on composition, even though much uncertainty remains.

Ideas on the composition of the mantle come from matching numerical values of the density, the incompressibility, and their gradients with respect to pressure, against results derived in high-

pressure experiments on rocks made by Adams, Williamson, Bridgman, Birch, and others. This work indicates that the outer mantle probably consists of ultrabasic rock, an olivine composition being commonly assumed; other possibilities that have been considered are that the rocks are eclogite or peridotite. Birch has suggested that the lower mantle may consist of phases including silica, magnesia, and iron oxide. It is possible that an appreciable quantity of free iron also occurs in the mantle. It is not yet certain whether the changes in the outer mantle are essentially progressive composition changes or are due to change of crystal type or other physical transformation. There is as yet no widely accepted explanation of the character of the changes inside the lowest 100 miles of the mantle.

The question of the composition of the central core has lately become interesting. Until a few years ago, it was widely accepted that the whole core consists predominantly of iron and nickel. This conclusion was based on observations of meteorite composition, and on the known relatively high density in the core.

Then in 1941 two European geophysicists put forward the radically different theory that the core consists of compressed hydrogen. Overwhelming arguments against this theory were quickly stated, but the theory led to an important calculation in 1946 which showed that, at 700,000 atmospheres (a pressure reached inside the earth's lower mantle), the density of hydrogen would suddenly jump from about 0.4 to 0.8 gm/cm^3. This led to the idea, first advanced by W. H. Ramsey of Great Britain, that perhaps at the huge pressure of 1⅓ million atmospheres reached at the outer core boundary, the material there existing might suddenly jump in density from 5½ to 9½ gm/cm^3 as a direct consequence of the high pressure and not as a change of composition from rock to iron. Such modification of the rock (or other material) of the lower mantle would incidentally have all the physical properties of a metal and be electrically conducting. Thus theories which attribute the earth's magnetism to currents in the outer core would not be affected.

An interesting point is that, on the new theory, the density in the earth's interior would be largely determined by pressure alone, which would not be the case if the mantle and core were of distinct chemical composition. Hence, knowing the pressure-density relation for the earth, it becomes possible on the new theory, given the mass of a planet of identical composition, to compute its diameter. Starting from the known masses of Venus and Mars, calculations made in this way give in fact fair agreement with the observed diameters of the two planets, and also with the observed ellipticity of figure of Mars. In contrast, Jeffreys has shown that Venus, the Earth, and Mars must have considerably different over-all compositions if the earth's mantle and core are chemically distinct. Hence the Ramsey theory is closely

linked with the question of a common composition of the three planets. The planet Mercury in its present state has too high a mean density to fit this common composition, but there is a possibility that the present Mercury through its proximity to the sun and consequent temperature may be appreciably denser than the primitive Mercury.

The question of the composition of the outer core continues to be controversial, and as yet it has not been possible to devise a crucial experimental or theoretical test to discriminate between the old and the new theories.

Although the regions E and F of the earth may not be composed predominantly of iron and nickel, several arguments all show that these two metals must predominate in the inner core. The course of the P velocity variations further suggests that there is some progressive change of composition inside the inner core, perhaps due to the presence of some additional denser materials.

EARTHQUAKES AND NUCLEAR EXPLOSIONS

Atom and hydrogen bombs resemble earthquakes in that they can send seismic waves down into the earth's interior. Although, as pointed out earlier in this article, the available energy in them is less than that in the waves produced by large natural earthquakes, there is a great compensating advantage to seismic research in that the source and location of artificial explosions can be known in advance.

In spite of the knowledge so far gained from natural earthquakes, we are much troubled in our inferences from this data because of our initial total ignorance of conditions at the source. On the other hand, a nuclear explosion can in effect be regarded as a "controlled earthquake" in which the time and place of origin can be precisely known, so that there is the possibility of inferring the internal structure of the earth much more accurately. For this reason, seismologists have been greatly interested in the possibility of using nuclear explosions to help them in their studies. Chemical explosions have already been employed with much success in unraveling the structure of the earth's crust. But larger sources are needed to send waves deep into the interior.

The very first atom bomb, exploded in New Mexico in 1945, was seismically recorded. A noteworthy feature of that explosion is that, whereas the origin time recorded at the source was uncertain by 15 seconds, the origin time is known to within 2 seconds from seismic records.

There was no mistake at the source in recording the Bikini underwater explosion of July 1946. The origin time of that explosion was officially released to two decimal places of a second! The resulting seismic waves were recorded at eight observatories in the United States at epicentral distances as great as 5,000 miles. Even though so

few observatories recorded the waves, the results are seismically valuable, and have supplied important corrections to the travel-time tables.

From 1947 until 1957 there was no general release of source data on nuclear explosions in any country, although in some cases individual seismologists have been given access to data. For example, Dr. B. Gutenberg and Dr. D. S. Carder have been able to make important inferences from records of a number of explosions carried out by the United States. In Australia, a group of seismologists was given advance knowledge, and subsequently the relevant source data, on four nuclear tests carried out in central Australia. This information has been invaluable in leading to our first reliable knowledge of the broad structure down to a depth of 30 miles or so in a part of Australia.

The United States hydrogen-bomb explosions of 1954 have proved to be of great interest, and have been the subject of special studies by T. N. Burke-Gaffney, Director of the Riverview Observatory (Sydney), and myself.

About the middle of March 1954 news that a hydrogen bomb had been exploded was made public. Following this, information from Japanese fishermen indicated that the explosion had taken place near Bikini Atoll slightly before dawn on March 1, local time. This news made it feasible for a search to be made on a sufficiently limited stretch of the Riverview seismograms, and it transpired that there was indeed an isolated sharp movement near the expected time. The routine summary of seismic wave onsets recorded at Brisbane, 600 miles from Sydney, also reported a sharp movement in agreement with the Riverview reading.

This was enough to warrant an inspection of overseas seismological bulletins as they came in. It soon became evident that seismic waves from four of the 1954 hydrogen-bomb explosions had been distinctly recorded in at least 12 countries. Strangely enough, several of the observatories concerned had not realized that certain of their routine readings related to these explosions.

When all the data were put together, we diagnosed what we felt to be the pattern of the explosions, and made estimates of the origin times. A recent release by the United States Atomic Energy Commission shows that our estimates were correct within 0.0, 0.1, 0.4, and 0.7 second, respectively. The results have proved to have been of importance to geophysics in shedding further light on the earth's inner core, and have supplied additional useful corrections to the travel-time tables.

Further work on hydrogen-bomb explosions has been carried out by Gutenberg, Carder, Burke-Gaffney, and Rothé.

Last September there was an interesting development following my presidential address to the International Association of Seismology and the Physics of the Earth's Interior on the subject of "Seismology

in Our Atomic Age." Three days later a cable from Dr. W. F. Libby of the United States Atomic Energy Commission gave advance source details of an underground explosion that was carried out in Nevada on September 19. This advance news greatly excited the seismologists gathered at Toronto who made hurried endeavors to have the seismic waves from the explosion as well recorded as possible.

Actually, the waves that went into the ground from the explosion turned out to be relatively small, and, generally speaking, were recorded only in Western United States at distances up to about 700 miles. There were, however, recordings by special field instruments which had been set up for the purpose in Mexico at a distance of 1,400 miles, and by a very sensitive seismograph in Alaska, 2,300 miles away. Doubt remains as to whether the more distant recordings would have been identified as waves from a nuclear explosion if the source data had not been released. From the seismic point of view, the explosion was principally useful in supplying further information on crustal structure in Western United States.

Seismologists hope that in due course it will be possible to utilize nuclear explosions to sharpen many of their inferences on the earth's interior. At the same time, seismologists appreciate that all such controlled experiments that are carried out at their instigation must be subject to total scrutiny on the score of human welfare, genetical and otherwise.

Earthquakes and atom bombs both have great potentialities as destructive agents. But both can, nevertheless, be turned to great advantage in enabling us to understand the properties of our planet earth.

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The Darwin-Wallace Centenary[1]

By Sir Gavin de Beer
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FROM SPECIAL CREATION TO TRANSFORMISM

Only one hundred years have gone by since the concept of evolution was brought to the attention of thinking men in a manner which has compelled its acceptance. The demonstration that the members of the plant and animal kingdoms are as they are because they have become what they are, and that change, not immutability, is the rule of living things, is one of the most important contributions ever made to knowledge, and its effects have been felt in every field of human thought.

That plants and animals constitute natural kinds, or species, had become clear by the end of the seventeenth century, when John Ray defined them as groups of individuals that breed among themselves. In general, species were accepted as being the result of special creation in each case, and there was little incentive to inquire further.

In the eighteenth century doubts began to arise concerning the immutability of species. Some philosophers arguing theoretically, and a small number of naturalists who encountered difficulty in distinguishing between varieties of cultivated plants and of domestic animals, which were recognized as the diversified products of species, found difficulty in accepting the view that species were unchangeable. Some naturalists, including Linnaeus himself in his later years, adopted a compromise, allowing that species could have descended with modification from genera, but that genera were immutable.

With the increase in detailed knowledge of the flora and fauna of the world consequent upon the final stages of exploration, the problem of the distinction between varieties and species became acute. With boldness, and a breadth of vision amounting to genius, the French naturalist Lamarck cut the knot by proclaiming that there was no essential difference between species and varieties, that both species and varieties were subject to change, and that "transformism," not

[1] Reprinted by permission from Endeavour, vol. 17, No. 66, April 1958.

immutability of species, was the basis of life. As it happened, there were two reasons why Lamarck's ideas were unacceptable. The first was that he undertook no analysis to provide evidence for his notion of evolution: it flashed across his mind, and he assumed its truth without taking the trouble to prove it. Secondly, he attempted to give an explanation of the causes of evolution which, unfortunately, raised opposition to the acceptance of the concept of evolution itself. He supposed that as a result of new needs experienced by the animal, its "inner feelings" or subconscious activities produced new organs which satisfied those needs. Not only was such a supposition unacceptable for the solution of the problem of the origin of species of animals, but it was totally inapplicable to plants. On the other hand, Lamarck elaborated a view which for a long time was accepted but which is now known to be without foundation, namely that the effects of use and disuse were transmitted by inheritance. There for a time the matter rested.

THE FACT OF EVOLUTION

When Darwin started on the voyage of the *Beagle* in 1831, he had no reason to doubt the immutability of species. The speculations of his grandfather Erasmus counted for nothing with him, because they were not supported by evidence. Those of Lamarck on the causes of evolution had the additional demerit of bringing the subject into disrepute by their fanciful nature. It must be added that in Lyell's "Principles of Geology," to which Darwin owed so much because of the general background of uniformitarianism in place of catastrophism that it advocated, the possibility of evolution was firmly rejected.

Three sets of observations started Darwin's revolt against the immutability of species. The first was occasioned by his studies of the fauna of the Galápagos Islands, where he found that species of finches differed slightly from island to island, while showing general resemblances not only to each other but to the finches on the adjacent mainland of South America. If these species had been separately created, why should there have been such a prodigal expenditure of "creation" just there; why should geographical propinquity have caused these "creations" to resemble each other so closely; why, in spite of the similarity in physical conditions between the islands of the Galápagos Archipelago and the Cape Verde Islands, are their faunas totally different, the former resembling that of South America while the fauna of the latter resembles that of Africa?

The second set of observations related to the fact that as he traveled over South America he noticed that the species occupying a particular niche in some regions were replaced in neighboring regions by other species that were different, yet closely similar. Why are the rabbitlike animals on the savannahs of La Plata built on the plan of the peculiar

South American type of rodent and not on that of North America or the Old World?

The third set of observations was concerned with the fact that in the pampas he found fossil remains of large mammals covered with armor like that of the armadillos now living on that continent. Why were these extinct animals built on the same plan as those now living?

On the view that species were immutable and had not changed since they were severally created, there was no rational answer to any of these questions, which would have had to remain as unfathomable mysteries. On the other hand, if species, like varieties, were subject to modification during descent and to divergence into different lines of descent, all these questions could be satisfactorily and simply answered. The finches of the Galápagos resemble each other and those of South America because they are descended from a common ancestor; they differ from one another because they are each adapted to modes of life restricted to their own particular island, one, for instance, feeding on seeds on the ground and another on insects in trees. The volcanic nature and physical conditions of the Galápagos Islands resemble those of the Cape Verde Islands, and yet the Galápagos birds all differ from the birds of the Cape Verde Islands: therefore it is not the physical conditions of the islands that determine their differences. These differences arose because the Cape Verde Islands birds share a common ancestor with the birds of Africa, whereas the Galápagos birds share a common ancestor with those of South America. The hares of South America are built on the South American rodent plan because all South American rodents are descended from a common ancestor. The fossil *Glyptodon* resembles the living armadillos because they also share a common ancestor; this case is particularly important because, if living species show affinity with extinct species, there is no necessity to believe that extinct types of animals have left no living descendants. They may have representatives alive today, and this means that the whole wealth of the paleontological record of fossils is available as material for the study of the problem of evolution.

In possession of a working hypothesis that species have undergone evolution and successive origination by descent, with modification, from ancestral species shared in common with other species, Darwin next proceeded to search the whole field of botanical and zoological knowledge for evidence bearing on his hypothesis. He realized that no general principle that explained the evolution of animals was acceptable unless it also applied to plants. The result was one of the most remarkable attacks on a problem ever made by the inductive method of searching for facts, whatever their import might be.

In the first place, in cultivated plants and domestic animals such as the dahlia, the potato, the pigeon, and the rabbit, a large number

of varieties have in each case been produced from a single original stock. Descent with modification and divergence into several lines is therefore certainly possible within the species.

Comparative anatomy reveals the existence of similar plans of structure in large groups of organisms. Plants may have vegetative leaves, and in some cases these are modified into parts of flowers. Vertebrate animals have forelimbs that may be used for walking, running, swimming, or flying, but in which the various parts of the skeleton correspond, bone for bone, from the upper arm to the last joints of the fingers, whether the animal is a frog, a lizard, a turtle, a bird, a rabbit, a seal, a bat, or a man. This is what is meant by saying that such structures are homologous, and these correspondences are inexplicable unless the animals are descended from a common ancestor. Fundamental resemblance is therefore evidence of genetic affinity.

The study of comparative behavior proves that related forms show gradations in their instincts, such as shamming death in insects and nest building in birds. At the same time, related species inhabiting different parts of the earth under very different conditions retain similar instincts. Examples are the habit of thrushes in England and in South America of lining nests with mud, and that of wrens in England and North America of the males building "cock nests." Why should this be, unless the different species of thrushes and wrens are descended from common ancestors in each case?

Embryology reveals remarkable similarity in structure between young embryos of animals which in the adult stage are as different as fish, lizard, fowl, and man. This similarity even extends to such details as the manner in which the blood vessels run from the heart to the dorsal aorta, a plan which is of obvious significance in the case of the fish that breathes by means of gills, but not so obvious in that of lizard, chick, or man, where gill pouches are formed in the embryo but soon become transformed into different structures, and breathing is carried out by other means. This similarity between embryos is explained by the affinity and descent from a common ancestor of the groups to which they belong.

Embryology also provides evidence of vestiges of structures which once performed important functions in the ancestors but now either perform different functions or none at all. Examples of such organs are the teeth of whalebone whales, the limbs of snakes, the wings of ostriches and penguins, and the flowers of the feather-hyacinth. Since Darwin's time countless other examples have been discovered. The most striking of these are the pineal gland which is a vestigial eye, and vestiges of the egg tooth still found in marsupials, although it is 75 million years since their ancestors had to use an egg tooth to crack the shell and hatch out of their eggs. Here again, descent from common ancestral forms explains all these cases.

Knowledge of the fossil record in Darwin's time was so imperfect that nothing was then available in the way of series illustrating the course of evolution. Nevertheless, he noticed that in Tertiary strata the lower the horizon the fewer fossils there were belonging to species alive today. Paleontology therefore showed that new species had appeared and old species become extinct, not all at the same time, but in succession and gradually. Why should this be so unless new species have come into existence from time to time by descent with modification from other species?

Plants and animals are classified according to their resemblance, and they are placed in one or another of a not very large number of groups, such as ferns, conifers, mollusks, or mammals. But within each of these groups there is subdivision into other smaller groups, mammals being so subdivided into rodents, carnivores, ungulates, and primates for example. Within these again there is further subdivision, and the important point to notice is that classification always places species in groups that are contained within other larger groups. This is such a commonplace that its significance is often overlooked. Why do organisms have to be classified like this? Why are they not strewn in single file up the ladder of the plant and animal kingdoms, or fortuitously like pebbles on a beach, or arbitrarily like the stars in imaginary constellations? The reason is that the arrangement of groups within groups is a natural classification reflecting the course of evolution. It is the result of descent from common ancestors and an indication of affinity; the differences between the groups are due to modification and divergence during such descent.

Darwin also investigated the problem of interspecific sterility and saw that it was by no means absolute, because numerous examples can be found of different species that produce hybrids, and in some cases these hybrids are themselves fertile. From the point of view of breeding, therefore, such species behave like varieties. Why, then, can species not have originated as varieties, by descent and modification from other species?

From the evidence provided by all these sources Darwin built up an irrefutable argument that species have changed and originated from other species and that evolution has occurred. That he should have been able to do so from such few data is a mark of genius, for at the time when he worked out his conclusions, none of the cases had been discovered which would now be used as the most striking examples with which to illustrate the fact and the course of evolution. Chief among these are the beautiful series of fossils which reveal the evolution of the ammonites or of the horses, step by step, and those which represent the precursors of the various classes and groups of vertebrates such as *Archaeopteryx* or *Pithecanthropus*.

The main steps in Darwin's proof of the fact of evolution were established by 1842, when he committed them to paper in the form of a Sketch which he expanded into an Essay in 1844, though neither was published by him. Soon after this, another naturalist, Alfred Russel Wallace, was led to explore similar lines of research. From some simple observations on the distribution of organisms, both geographically over the world and geologically in the fossil record, Wallace drew some equally simple conclusions that are of great importance in the history of thought that led to the realization of evolution. They show that, independently of Darwin and in complete ignorance of his work, Wallace had hit upon the same solution of the problem of the mutability of species.

Wallace's observations were based on the facts, first, that large systematic groups such as classes and orders are usually distributed over the whole of the earth, whereas groups of low systematic value such as families, genera, and species frequently have a very small localized distribution. Second, "when a group is confined to one district, and is rich in species, it is almost invariably the case that the most closely allied species are found in the same locality or in closely adjoining localities, and that therefore the natural sequence of the species by affinity is also geographical." Third, in the fossil record large groups extend through several geological formations, and "no group or species has come into existence twice."

The conclusion which Wallace drew from these observations was that "Every species has come into existence coincident both in space and time with a pre-existing closely allied species." Thought out about 1845, written at Sarawak in 1855, and published in the same year, Wallace's theory already allowed him to say that "the natural series of affinities will also represent the order in which the several species came into existence, each one having had for its immediate antitype a closely allied species existing at the time of its origin. It is evidently possible that two or three distinct species may have had a common antitype, and that each of these may again have become the antitype from which other closely allied species were created."

With the help of this principle, in which it is only necessary to substitute "ancestor" for "antitype" for the formulation of evolution to be complete, Wallace showed that it was possible to give a simple explanation of natural classification, of the geographical distribution of plants and animals, including those of the Galápagos Islands, of the succession of forms in the fossil record, and of rudimentary organs which would be inexplicable "if each species had been created independently, and without any necessary relations with preexisting species."

So much of the credit for the establishment of the fact of evolution has, rightly, been accorded to Darwin that it is only just that Wallace's contribution to this problem should be recognized and honored.

The evidence on which Darwin and Wallace based their demonstration that evolution was a fact is not only valid to this day, but has been confirmed in all the branches of science concerned as well as in many new fields. There was in their day not even an inkling of the possibilities of research opened up by comparative physiology and biochemistry, or of serology as a quantitative indicator of the amount of divergence that has taken place between related forms. Why should the chemical substance involved in the mechanism of muscular contraction in most invertebrates be arginine, whereas it is creatine in vertebrates and echinoderms, which on independent evidence are regarded as related? Why should serum immunized against man give precipitations of 64 percent when mixed with blood of a gorilla, but 42 percent with that of an orangutan, 29 percent with that of a baboon, and only 10 percent with that of an ox? Why should syphilis attack the chimpanzee more seriously than the orangutan, and the latter more seriously than the baboon? Why should the human ABO blood-group system also be found in the apes? The answer to all these questions is that the organisms concerned have undergone evolution from common ancestors, as a result of which members of the various lines of descent share not only structural, mental, and genetical characters, but also physiological and biochemical mechanisms and immunological reactions.

THE MECHANISM OF NATURAL SELECTION

Although Darwin already knew in 1837 that evolution was an inescapable conclusion to be drawn from the evidence, he did not allow himself to proceed any further with his discovery until he had found an explanation of the fact of adaptation. In a general way, all plants and animals are adapted to their environment, for otherwise they could not live. A man drowns in the sea; a fish dies out of water. But there are some structures which show a particularly intimate relationship between the organism and its conditions of life. Mistletoe is a parasite that requires a tree of certain species to live on, a particular insect to pollinate its flowers, and a thrush to eat its berries and deposit its seeds on branches of the same species of tree. A woodpecker has two of its toes turned backward with which it grips the bark of tree; it has stiff tail feathers with which it props itself against the tree; it has a very stout beak with which it bores holes in the tree trunk; and it has an abnormally long tongue with which it takes the grubs at the bottom of the holes. Other plants than mistletoe and other birds than woodpeckers do not have all these adaptations, and

therefore, if evolution has occurred, it is necessary to give an objective explanation of how these adaptations arose.

Darwin knew that all members of a species are not identical but show variation in size, strength, health, fertility, longevity, instincts, habits, mental attributes, and countless other characters. He soon perceived that such variation could be, and in fact was, turned to good account by man in the course of artificial selection, which he has practiced in the production of cultivated plants and domestic animals since the New Stone Age. The key was selection, the practice of breeding only from those parents that possess the desired qualities. But how could selection have operated on wild plants and animals in nature since the beginning of life on earth without man or a conscious being to direct it? The solution of this puzzle occurred to Darwin accidentally when he read Malthus's "Essay on the Principles of Population" and realized that under the conditions of competition in which plants and animals live, any variations would be preserved which increased the organisms' ability to leave fertile offspring, while those variations which decreased it would be eliminated. In a state of nature, selection works automatically, which is why Darwin called it natural selection.

Darwin was then able to formulate a complete theory providing a rational explanation of the causes as well as of the fact of evolution in plants and animals. It is formally based on four propositions which he already knew to be true, and three deductions which are now also known to be true. They may be enumerated as follows:

1. Organisms produce a far greater number of reproductive cells than ever give rise to mature individuals.
2. The numbers of individuals in species remain more or less constant.
3. Therefore there must be a high rate of mortality.
4. The individuals in a species are not all identical, but show variation in all characters.
5. Therefore some variants will succeed better and others less well in the competition for survival, and the parents of the next generation will be naturally selected from among those members of the species that show variation in the direction of more effective adaptation to the conditions of their environment.
6. Hereditary resemblance between parent and offspring is a fact.
7. Therefore subsequent generations will by gradual change maintain and improve on the degree of adaptation realized by their parents.

This is the formal theory of evolution by natural selection, first announced jointly on July 1, 1958, by Darwin and Alfred Russel Wallace, who had, again independently, come to the identical conclusion. It represents a step in knowledge comparable to Newton's discovery of the law of gravitation.

THE INTEGRATION OF MENDELIAN GENETICS WITH SELECTION

When Darwin wrote, nothing whatever was known about the laws of heredity, and all that he had to go on was the vague notion that offspring tended to strike an average between the characters of their parents. This supposition went by the name of "blending inheritance," and it occasioned for Darwin the greatest difficulty with which he had to contend in formulating his theory. In the first place, if blending inheritance were true, it would mean that any new variation which appeared, even if heritable, would be rapidly diluted by "swamping," and in about 10 generations would have been obliterated. To compensate for this it would be necessary to suppose that new variations were extremely frequent. Since whole brothers, sons of the same father and mother, share an identical heredity, any difference between them would have to be due to new variation that had arisen during their own early lives, and variation would have to affect practically all members of a species. This problem of the supply of variation was a difficulty which Darwin felt so acutely that it even led him to look for a source of this supply in the supposed hereditary effects of use and disuse.

This reliance on the effects of use and disuse as a source of variation, without any effect on his main argument, is the only part of Darwin's demonstration that has had to be abandoned, and he would have welcomed the reasons for it. If only Darwin had realized it, the solution to all these difficulties was at that very time being provided by Gregor Mendel, but his results were unknown until 1900, eighteen years after Darwin's death.

The Mendelian theory of the gene was worked out by T. H. Morgan and his colleagues with an unprecedented wealth of experimental evidence from the breeding pen and from cytological studies on the structure of the cell and its chromosomes. It has established, as firmly as Newton's laws of motion or the atomic theory, that hereditary resemblances are determined by discrete particles, the genes, situated in the chromosomes of the cells, which are transmitted to offspring in accordance with the mechanism of germ-cell formation and fertilization, and conform to distributional patterns known as Mendelian inheritance. The researches of C. D. Darlington and others on the structure and behavior of the chromosomes have reached such a degree of refinement and precision that each step in the mechanism of Mendelian inheritance can actually be seen under the microscope.

The genes preserve their separate identity; they collaborate in the production of the characters of the individual that possesses them, but they never contaminate each other; they remain constant for long periods, but from time to time they undergo a change, known as mutation, which involves a change in the characters which they control; after this they remain constant in their new condition until they mu-

tate again. It has been conclusively proved that the theory of the gene applies to all plants and all animals investigated, and that the mutation of genes is the only known way in which heritable variation arises. The modifications resulting from good or bad food supply, or from the climatic conditions in which plants and animals live, are not inherited and are therefore without significance in evolution.

The history of the reception of Mendelian genetics after its discovery has been peculiar. The earliest mutations discovered, often called "sports," were usually deleterious and showed marked and discontinuous steps instead of the gradual and continuous variation which Darwinian selectionists looked for as the raw material of evolution. Selectionists therefore rejected Mendelian genetics as the source of variation. On the other hand, the Mendelian geneticists, knowing that their mutations were the only source of heritable variation, thought that as they showed wide discontinuous steps and arose suddenly, readymade and apparently without long-continued selection, selection was inoperative in evolution, and they rejected it.

With the progress of knowledge it gradually became obvious that each of these two schools of research objected to the other for reasons which were baseless. As more and more genes were identified and their effects studied, it became clear that the wide and discontinuous mutations first observed were the more easily detected extremes of a range in which the majority exert only slight effects. For the same reason, these mutations were deleterious because organisms are delicately adjusted systems, more likely to be upset by large and discontinuous changes than by small and gradual steps.

The Mendelian geneticists also had to learn two lessons. On the one hand they discovered that although individual genes are associated with particular characters, their control of those characters is also affected by all the other genes, which constitute an organized gene complex. As a result of previous mutations, gene complexes of plants and animals in nature contain many genes, and these are sorted out and recombined at fertilization in astronomically numerous possibilities of permutations. These recombinations have been shown to bring about gradual and continuous changes in the characters under the major control of individual genes. Sir Ronald Fisher demonstrated the significance of this by showing that a mutant gene that now exhibits the quality known as dominance has gradually become dominant from a previous intermediate condition. This is what has happened to those mutations that confer a benefit on their possessors, and in their case there has been a selection of gene complexes in favor of those which accentuate the effects of a favorable mutant, so that these effects are manifested even if the mutant gene is inherited from only one parent, which is the definition of dominance. Conversely, with genes that place a handicap on their possessors, there has been a selec-

tion of gene complexes in favor of those which suppress the effects of such genes so that they are manifested only when the mutant gene is inherited from both parents, which is the definition of recessiveness. They may be suppressed even further, as when the effects of such a gene are obliterated and the gene becomes what is known as a "modifier," without major control over characters. It has even been demonstrated by E. B. Ford, under rigorous experimental conditions, that one and the same mutant gene can be made to become dominant in one strain and recessive in another, simply by selecting as parents those individuals whose gene complexes accentuate or diminish the effects of the gene.

The second lesson that Mendelian geneticists had to learn was that although the effects of the mutations which they first observed appeared to be clear-cut, they were already the results of past gene complexes. For these mutations have occurred before, and the gene complexes have become adjusted to them. The fact that a single gene may now act as a switch controlling the production of one or another character difference does not mean that this character difference originally arose at one stroke by one mutation of such a switch gene, because it has probably been built up gradually as a result of past selection in the gene complex.

It is therefore clear that mutations and recombinations of genes provide the supply of variation on which selection acts to cause evolution exactly in the way Darwin's theory requires. Its requirements are exacting, for, as T. H. Huxley pointed out, some organisms have evolved slowly and others have evolved fast; he saw that natural selection was the only mechanism that could satisfy both those requirements. It is able to do so because Mendelian inheritance is capable of producing both diversity and stability. As Ford has said, an immense range of types must be available for natural selection to act upon, and this is provided by mutation and recombination of genes. Yet when a favorable gene complex has been achieved it must not be dissipated and broken down, and this is provided against by the facts that the genes do not blend or contaminate one another, and that they mutate only rarely.

THE SIGNIFICANCE OF PARTICULATE INHERITANCE IN EVOLUTION

The particulate theory of inheritance which Mendelian genetics has established involves a number of consequences of fundamental importance for the problem of evolution. In the first place, the substitution of this quantitative and deterministic science for the vague and baseless notion of "blending inheritance" completely disposes of the difficulty under which Darwin labored to account for the necessary supply of variation on which natural selection could act. The

most characteristic feature of the Mendelian gene is that it never blends, but retains its identity and properties intact for long periods of time until it mutates, after which it remains intact in its new condition until it eventually mutates again. This means that the amount of variation, or variance, present in a population resulting from previous mutations, is not only conserved through generation after generation, but is actually increased as a result of the recombinations of the gene complexes in their innumerable possible permutations. This power of increase is one of the most important results of the biparental method of reproduction and is the reason why organisms possessed of this mechanism have evolved further than those that lack it.

This conservation of variance is to be considered in relation to the rate at which mutation normally occurs. It has been calculated that in organisms as diverse as a bacterium, a maize plant, a fruit fly, and in man, any given gene mutates in one in about half a million individuals. It is also clear that this rate is itself the result of selection, and that although seemingly slow, it has been adequate to provide the requisite basic heritable variation which the mechanism of germ-cell formation and fertilization has multiplied, and on which selection has worked to produce whatever evolution has taken place. In other words, mutation not only need not, but must not be more rapid than a slow rate. This rate is immeasurably slower than what it would have to be if "blending inheritance" were a fact, and Darwin's difficulty in accounting for an adequate supply of variation is lightened by that amount.

As the originating mechanism for basic heritable variation, mutation has naturally been intensively studied. It has been found that certain physical and chemical agents, including radioactivity, can accelerate the rate at which mutation would naturally occur, but that these induced mutations are similar to those which occur and recur normally, and no correlation whatever exists between the mutagenic agents and the quality or "direction" of the mutations. Mutations take place with "blindness and molar indeterminacy," as H. J. Muller has expressed it. This is a finding of capital importance, for it shows that there is no basis for attempts to explain the origin of heritable variation by appealing to environmental factors to evoke appropriate responses, or to the internal factors to make such responses. Nor is there any basis for the view that the environment would evoke appropriate heritable responses if its actions were continued for a sufficient time, because, as J. B. S. Haldane showed, such responses as might be significant in evolution would be detected within the period of the experiment carried out.

In organisms that reproduce by simple division of the whole body, such as bacteria, special conditions apply because reproduction in them

involves not only transmission of genetic material in the form of genes, but also transmission of bodily characters, since the latter are carried over wholesale from "parent" to offspring. Adaptation to new environments can take place in bacteria. Furthermore, in bacteria, and perhaps also in higher organisms, it is possible for organic molecules such as bacteriophage particles to enter organisms and become incorporated in the genetic mechanisms so as to behave like genes. These results are full of promise as a field of research into the nature of genes, and perhaps of mutations, but they do not in any way invalidate the principles of Mendelian genetics and inheritance.

Mutations are chemical changes in the gene molecule, and since chemical stability is not absolute, the puzzle about mutations is not so much that they occur as that they occur so infrequently. This ignorance of the causes which determine the directions in which mutations take place, if such causes indeed exist, is, strange to relate, no handicap to the understanding of the mechanism of evolution, because it is emphatically selection, not mutation, that determines the direction of evolution. This all-important conclusion is based not only on detailed experimental studies on the effects of selection in nature, but also on the demonstration by Sir Ronald Fisher of a general principle. The effects of selection in changing the frequency of genes in a population have been calculated for various percentage benefits in survival value conferred by such genes. It has been found by calculation that at the observed natural average mutation rate of one in half a million, no mutant gene has the slightest chance of maintaining itself against even the faintest degree of adverse selection. Furthermore, if the direction of evolution were determined by the direction of mutation, it would be necessary to suppose that such mutations must be predominantly favorable. In fact, the vast majority of mutations have been unfavorable, and natural selection has acted against them by converting the resulting mutant genes into recessives, or by suppressing them into the condition of mere modifiers, or by exacting the more drastic price of abolition consequent on the rapid death of the organisms containing them. It is natural selection, not mutation, that has governed the direction as well as the amount of evolution, and it has been estimated that if mutation were to stop now, there is already sufficient variation in the plant and animal kingdoms for evolution to continue for as long in the future as it has continued hitherto in the past.

The bearing of this demonstration on hypotheses that attempt to explain evolution by postulating the existence of agencies capable of directing mutation is plain. It means that all such theories as invoke the effects of use and disuse, "inheritance of acquired characters," environmental stimuli, "organic selection," "inner feelings," inherited memory," momentum along particular directions, orthogenesis, nomogenesis, and others, which assume that mutation can be made to follow

adaptively desirable directions, are not only devoid of any known mechanism by which the direction of mutation might be brought about, and devoid of evidence for the existence of such mechanisms, but they involve a cause "which demonstrably would not work even if it were known to exist." It is therefore not surprising that in spite of repeated attempts, many undertaken with impure and insufficiently standardized genetic material, and others in which the results were simply faked, no evidence has been provided that the effects of use and disuse or adaptive response to environmental conditions are inherited or induce appropriate mutations. From the evidence provided by genetics, natural selection is the only mechanism capable of explaining evolution.

NATURAL SELECTION, "IMPROBABILITY," AND "CHANCE"

An argument sometimes used against the efficacy of natural selection involves the claim that the initial stages in the evolution of complex structures or functions could not have been favored by natural selection until such structures or functions had reached a certain level of perfection. Like all other arguments of the *non possumus* type, this one melts away before the progress of knowledge. A case in point is that of the electric organs of fish, developed out of muscles which are capable of discharges strong enough to catch prey and defend the fish against its enemies. These organs are clearly adaptive and confer survival value on their possessors, but the question arises what functions they could perform in the initial stages of their evolution, when it must be supposed that their power was too weak to kill prey or to deter predators. Darwin himself was well aware of this problem, and he met the argument by pointing out that "it would be extremely bold to maintain that no serviceable transitions are possible by which these organs might have been gradually developed." He has been proved to be right, because of the discovery by H. W. Lissmann that weak electric discharges given off by certain fish function in a manner analogous to those of radar equipment, and serve to convey information of the proximity of objects in the water. Electric organs can therefore be adaptive even when they are too weak to kill prey or deter predators.

Another case may be cited because it illustrates the manner in which an adaptive result may be achieved without itself being a direct object of selection. Color vision has been evolved independently in many groups of animals. Among the light-sensitive elements in the eye, some are specially sensitive in dim illumination; others confer acuteness of vision in bright light when they are individually innervated, with the result that light stimuli are perceived separately by very small areas of the retina. In each of the two functions of seeing in relative darkness and seeing accurately in the light, increased efficiency

confers survival value from the very start of the improvement. But when both these functions have been achieved in the same eye a mechanism is produced, as E. N. Willmer has indicated, in which the visual elements are differentially sensitive to light of different wave-lengths, and this is the basis of color vision. The emergence of color vision as an unexpected "bonus" resulting from the perfection of two other functions is a concrete example of the principle to which Lloyd Morgan applied the term "emergent evolution."

It has also been objected that natural selection is a difficult concept to apply to the evolution of very complex adaptations involving co-ordinated variations either in one and the same organism, or even in two different organisms. It is not necessary to go far afield to find examples of this, for in all animals with separate sexes and internal fertilization there has been a separate yet harmonious evolution of the reproductive organs in the two sexes. It has been supposed that such situations argued so high a degree of "mathematical improbability" that they could not be explained as a result of natural selection, which was, very erroneously, called "chance." To this objection there are several answers.

In the first place, those who invoke mathematical improbability against natural selection can be refuted out of their own mouths. Muller has estimated that on the existing knowledge of the percentage of mutations that are beneficial, and a reasoned estimate of the number of mutations that would be necessary to convert an amoeba into a horse, based on the average magnitude of the effects of mutations, the number of mutations required on the basis of chance alone, if there were no natural selection, would be of the order of one thousand raised to the power of one million. This impossible and meaningless figure serves to illustrate the power of natural selection in collecting favorable mutations and minimizing waste of variation, for horses do exist and they have evolved.

It is worth while to study the question of improbability more closely. As Fisher has pointed out, improbability has a different aspect when considered from time before or time after the event. The probability that any man alive today will have sons, grandsons, and successive descendants in the male line uninterruptedly for one hundred generations is infinitesimally small. Yet every man today is the living proof that this contingency, so highly improbable as it may have seemed one hundred generations ago, has nevertheless occurred. Similarly, the effects of natural selection are the reverse of chance when considered ex post facto; they are rigorously determined, and what they have done is to channel random variations into adaptive directions and thereby simulate the appearance of purposive change. This is why natural selection has been paradoxically defined as "a

mechanism for generating an exceedingly high degree of improbability."

Mention of purpose introduces the notion of teleology or fulfillment of design which has sometimes been invoked to explain the production of complex adaptations. Teleology and providential guidance are double-edged weapons with which to attack the problem of evolution, because it can be shown that the more detailed the adaptation, the more "improbable" it may appear as a product of "chance," the more likely its possessor is to be doomed to extinction through inability to become adapted to changed conditions.

Structures may be developed which at first benefit individuals in their competition to survive; but by continued selection such structures may become exaggerated and lead to the extinction of the species. This seems to have been what happened to the huia bird, where mated pairs constantly remained in company together, and the beaks of the male and female reached an extraordinary disparity of size in adaptation to their very special feeding, but failed to enable the birds to obtain ordinary food when their special diet was unavailable. Excess, even of adaptation, is harmful, and the fossil record shows that the vast majority of lines of evolution have led to extinction.

From the undoubted fact that many of the products of the plant and animal kingdom convey to man the aesthetic quality of beauty, it has been supposed that beauty is an end in itself to which the criterion of usefulness and survival value could not be applied, and therefore that it could not be imagined as a product of evolution. To this argument Wallace opposed the demonstration that if the quality of beauty were an exception to the principle of evolution by natural selection, it would be necessary to find an explanation for the existence of so much in plants and animals that is positively ugly.

Darwin showed it to be an invariable rule that "When a flower is fertilised by the wind it never has a gaily-coloured corolla." The beauty of flowers has been gradually achieved because of the survival value of cross fertilization (consequent upon the attraction of insects to such flowers) conferred on plants possessing them. The beautiful colors and structures of birds and some other animals have resulted from the survival value conferred on successful competitors in sexual selection.

This demonstration of what may be called the natural nature of beauty has been developed still further by Ray Lankester in the course of a soliloquy on alpine flowers: "All beauty of living things, it seems, is due to Nature's selection, and not only all beauty of color and form, but that beauty of behavior and excellence of inner quality which we call 'goodness.' The fittest, that which has survived and will survive in the struggle of organic growth, is (we see it in these flowers), in

man's estimation, the beautiful. Is it possible to doubt that just as we approve and delightedly revel in the beauty created by 'natural selection,' so we give our admiration and reverence, without question, to 'goodness,' which also is the creation of Nature's great unfolding?"

In many of the higher animals, parental care and self-sacrifice, in the interest of other members of the family such as incubating or gravid females and young, have been favored by natural selection and conferred benefit on the species. From earliest human times, the survival value of altruistic behavior has been enhanced because of the prolongation of childhood and the consolidation of the family that have characterized the evolution of man. The size of the unit within which altruistic behavior conferred survival value has grown progressively larger, but fitfully, as history and anthropology have shown, from the family to the clan, the tribe, and the nation. In this manner, ethical standards of conduct and morality have arisen which can be seen to develop in individuals and have been seen to evolve in societies. Between these units, competition on the subhuman level of natural selection has persisted. With the development of man's higher mental faculties, conscious choice and purposiveness became factors in evolution, and for this reason the subsequent evolution of man has been of a nature different from that of other organisms because it was no longer governed solely by natural selection.

NATURAL SELECTION IN ACTION

Natural selection can be seen to be at work here and now in directing evolution. Modern techniques of study of genetics in populations in the field developed by T. Dobzhansky and E. B. Ford have shown that the relative longevities of variants in different environments can be directly measured, and that the effects of such differential mortality have been to produce evolutionary change. An example of this type of research is that of H. B. D. Kettlewell on "industrial melanism" in moths. Up to 1850 the British peppered moth existed in its typical gray form known as *Biston betularia*, which is remarkably well adapted to resemble the lichens on the bark of trees. From that date a dark melanic variety appeared, known as *carbonaria*, which is extremely conspicuous against the natural bark of trees. The melanic variation is controlled by a single dominant Mendelian gene and is slightly more vigorous than the normal gray type. Nevertheless, because of its conspicuous color the *carbonaria* variety was constantly eliminated, and this variety persisted in the populations of the peppered moth only because the same mutation kept on occurring again and again. The industrial revolution brought about a marked change in the environment, since the pollution of the air by increasing quantities of carbon dust killed the lichens on the trees and rendered

their trunks and branches black. Under these conditions it is the *carbonaria* variety which is favored and the *betularia* penalized. This has been proved by direct observation of the feeding of birds, and by measurement of the survival rates of the different forms in the different environments. The dark *carbonaria* form survives 17 percent less well in an unpolluted area and 10 percent better in a polluted area. One hundred years ago the dark variety of the peppered moth formed less than 1 percent of the population; today in industrial areas it forms 99 percent, and selection has made it more intensively black than when it first appeared.

The case of melanism in the peppered moth also introduces a principle to which L. Cuénot drew attention and gave the name of "preadaptation." The melanic form of the peppered moth happened to be "preadapted" to conditions which were only subsequently realized, or in other words, if the industrial revolution had not taken place, the melanic variety would never have become adaptive at all, and would have suffered the same fate as the countless other mutations resulting in variations which, whether "preadapted" or not, have been eliminated because they fell short of the requirements imposed by natural selection.

The evolutionary change actually witnessed in the peppered moth is directly attributable to selection, and it is matched by similar studies on other forms. Experiments by A. J. Cain and P. M. Sheppard on the survival rate of snails with shells of different colors and banding patterns, living on dark- or light-colored backgrounds, have shown that selection does not act like an all-obliterating steamroller going in one direction. As the seasons change, the adaptive value of the color of a shell changes from disadvantageous to advantageous and back again. This proves that the effects of selection vary from place to place and from season to season, and that the balance between an organism and its environment is delicate, changing, and dynamic.

The phenomenon of Batesian mimicry has also been proved not only to be adaptive and to confer survival value, but to have been achieved by selection. Ford has shown that the degree of perfection with which the mimics copy their models is a function of the prevalence of the models. The percentage of imperfect mimics in the populations of *Papilio dardanus* is only 4 at places like Entebbe, where models are numerous. At Nairobi, on the other hand, where the models are 70 times less numerous than at Entebbe, the imperfect mimics are 8 times more numerous and constitute 32 percent of the population. Less survival value is conferred by resemblance to a model when the latter is too infrequent to teach predators to shun it, and there is then less selection pressure on the mimic to resemble it.

While the overriding importance of the effects of selection is now generally realized, it has been suggested that when populations are

split up into very small isolated colonies, changes in the relative frequencies of different genes might result from the errors of random sampling in the formation of the germ cells and their fertilization, without involving selection. This concept, advanced by Sewall Wright and known as "random genetic drift," has been invoked as a possible cause of nonselective, nonadaptive evolution. It has, however, been invalidated by the results of experimental studies in the field such as those of Fisher and Ford on moths, which have shown that selective factors are much more important than casual nonadaptive factors in determining the relative frequency of genes and in bringing about close adaptation to local environmental conditions. Even in comparatively numerous populations, from one generation to the next there are fluctuations in gene ratio larger than can be attributed to random sampling and which are controlled by selection. Such effects as may be due to random sampling in small populations can only be of negligible significance in evolution.

Selection frequently works on a basis of compromise. Among the natives of Africa there is a condition known as sickle-cell anemia, in which the red blood corpuscles are deformed and shaped like the blades of sickles. This is controlled by a Mendelian gene which, when inherited from both parents (homozygous), produces an extreme effect which frequently kills the subject by thrombosis. When inherited from only one parent (heterozygous), the danger from thrombosis is not so great. In areas where malaria is present, however, there is a positive advantage in possessing the sickle-cell gene, because the malaria parasite cannot enter the abnormal red blood corpuscles. In accordance with the prevalence of malaria in the environment, therefore, a balance is automatically struck in the population between the danger of dying from malaria if the individual has no sickle-cell gene, and the danger of dying of thrombosis if the individual has two sickle-cell genes. Survival value and ability to leave more offspring therefore accrue to the possessors of one sickle-cell gene up to a certain frequency, and this example shows in what unexpected ways selection is able to make the best even of a bad gene complex.

NATURAL SELECTION AND PALEONTOLOGY

The paleontological record provides the evidence of the course which evolution has followed in the past. The fossil material is in places now so rich that it can be used for quantitative studies in evolution. First, the radioactive time clocks enable various levels of evolutionary lineage to be dated and the time measured during which certain changes have occurred. This provides quantitative evidence of evolution rates. From such data estimates can be obtained of the duration times of genera and species. Statistical study of large samples of fossil materials enables the variability of the different species to be

assessed. By methods such as these, G. G. Simpson has worked out that the evolution from *Hyracotherium* to *Equus* occupied 60 million years. This involved passage through 8 genera, the duration of each being on the average 7.5 million years; 30 species of a duration time of 2 million years each; and 15 million generations each reaching maturity in 4 years. These data can be compared with those obtained from other groups of animals, from which they differ considerably. The results show that evolution rate is not correlated with variability, nor with generation time, and that it is selection that controls the direction and intensity of evolution.

These results are all the more important because in the past some paleontologists, unequipped with knowledge of modern genetics, have imagined that, from tracing the course of evolution in the lineage of fossils which they established, they were in a position to draw conclusions about the cause of such evolution. Some have thought that they had found support for the inheritance of acquired characters, although they knew nothing about inheritance; others imagined that as the lineage of some fossils showed linear progression of certain characters, they were justified in concluding that evolution involved an innate directional component, an expression of "momentum" leading to evolution in "straight lines," which they called orthogenesis. They failed to realize that if selection in a particular direction benefits an organism, continued selection in the same direction will, up to a certain point, benefit it further. Others again have concluded from their materials that a distinction in principle could be made out between "big" evolution leading to large evolutionary changes, and "small" evolution producing trifling results. None of these speculations can stand up to the evidence that selection determines the course of evolution, its speed or its slowness, the greatness or smallness of the effects produced, and its direction, which if constant for any length of time simulates orthogenesis.

It is of interest to consider how far it is possible to extrapolate the results of modern genetics into the paleontological past. C. R. Diver has shown that in snails the patterns of banding found today were already in existence in Pleistocene times. It is necessary, however, to beware of concluding that because characters are similar they must be controlled by the same genes. Even in one and the same species today, the gene complex can undergo permutations which reproduce the same structures with different genes. An example is provided by the gene "eyeless" in *Drosophila* which produces flies with very small or no eyes; this is, of course, extremely harmful. Eyeless flies can, however, be made to breed, and although the mortality is very high, progeny can be reared which after a few generations have eyes like normal flies. In such a stock the "eyeless" gene is nevertheless present unaltered, as can be proved by mating these flies with normal

flies, when the effects of the "eyeless" gene manifest themselves in all their force, though in the second generation, because "eyeless" is recessive. This result is therefore in perfect accordance with the principle that Mendelian genes do not become contaminated. What has happened during the inbreeding of "eyeless" flies is that the reshuffling of the other genes has produced a gene complex in which the harmful effects of "eyeless" have been suppressed.

The gene complex is therefore a dynamic system, as S. C. Harland concluded from his researches on cotton. Genes compete, i.e., are selected in the gene complex, old genes being dropped and new genes incorporated. During the course of evolution the effective membership of the gene complex must have changed, and it is not legitimate to conclude that because a character or a structure like the eye of vertebrates was in existence 400 million years ago, it was then controlled by the same genes as control it now. The evidence is entirely opposed to such a static view. It is precisely because the gene complexes change that characters, structures, and organisms have evolved.

THE NEW SYSTEMATICS AND THE ORIGIN OF SPECIES

The researches on industrial melanism in the peppered moth, banding and color of snails, mimicry in butterflies, local adaptation in moths, and sickle cell in man, which have here been briefly described, are examples of new techniques of experimental study of evolution in the field. They have grown out of what Julian Huxley has aptly called "The New Systematics," to which he has himself contributed so much. Systematics, the study of species and of the higher groups of classification, began by the recognition of differences between species, defined from type specimens preserved in museums. But with the realization that species now or in the past are or were populations of live plants and animals in nature, living under varying conditions of equilibrium with each other and with the inorganic factors of the environments—themselves showing geographical variation in space, and undergoing variation in time, subject to mutation and recombination of their genes, constantly under the influence of selection—species can no longer be considered as static milestones of evolution, for they are themselves the dynamic systems by which the roads of evolution are trodden. As genes mutate and are reshuffled, and geographical races invade new ecological niches, advance and retreat, it is already possible on a map to mark out lines of gene flow, as R. C. Stebbins has suggested from his researches on Californian newts. It may become possible to plot the areas of gene complex alteration, as can to a certain extent already be done for the origin of cultivated plants such as wheat; but such maps will be continually changing, like the species themselves.

Nobody would have welcomed these developments of biological science more than Darwin himself, as a glance at the last few pages of "The Origin of Species" will show. It is therefore appropriate to return to the problem with which this article began. As is now certain, species are not immutable but have undergone change, and many examples have been given above. Evolution can take place up to a point without the production of new species, but if this process continues the time must come when new species originate, and it is legitimate to ask whether modern research has revealed any evidence of this. The answer is that new species can be seen originating in nature here and now, and new species have been artificially produced in the laboratory.

Speciation takes place when, for various reasons, populations cease to breed with neighboring populations and, under different conditions of selection, accumulate heritable variations by mutation and recombination of genes in different directions. As E. Mayr has shown, some form of biological isolation between portions of populations is a necessary condition for divergence leading to the formation of new species and higher groups.

Among the kinds of isolation that are chiefly responsible for the origination of species, geographical isolation is the most important; it involves physical barriers such as oceans, mountain ranges, or deserts which separate whole populations. Geographical races are the chief raw materials from which new species are formed, and it was the different finches on the different Galápagos Islands which first suggested to Darwin that evolution had occurred. Here, to various extents, geographical isolation has assisted the origination of a number of species.

A case in which geographical isolation may be expected to produce its effects at almost any moment now is provided by the gulls. These birds occupy a zone shaped like a ring around the North Pole and form what B. Rensch has called a chain of races. Starting with the British lesser black-backed gull, with its dark mantle and yellow legs, this is found to grade into the Scandinavian lesser black-backed gull, and, continuing in an easterly direction around the chain, this in turn grades into the Siberian Vega gull with its lighter mantle and dull flesh-colored legs. The Siberian gull grades into the American herring gull, which in turn grades into the British herring gull, with its light mantle and pinkish legs. Although the British lesser black-backed gull may be regarded as belonging to the same species as all the other gulls in the chain to the east of it, when it is compared with the other end of the chain represented by the British herring gull the two may almost be regarded as separate species. Already they differ not only in color but in habits, for the latter nests on cliffs and is dispersive in winter, whereas the former breeds inland

on moors and is migratory in winter. If at any time the chain becomes severed by the erection of a sterility barrier at any point, either through inability to breed or through a rupture of the chain by local extinction of the gull population, the two British gulls will effectively have originated new species.

Geographical isolation is important for the origin of species of plants as well as of animals, but there is another form of isolation which appears to be restricted to plants and involves the sudden erection of sterility barriers between individuals in the same population as a result of changes in the chromosome mechanism. This is known as genetic isolation. When *Primula verticillata* is crossed with *Primula floribunda*, hybrid offspring are produced, but they are sterile because the chromosomes of one parent species are incompatible with those of the other, and the intricate machinery involved in the formation of germ cells is thrown out of gear. Occasionally, however, the hybrid plant undergoes doubling of its chromosomes, a condition known as polyploidy, and when that has occurred the hybrid is able to breed with hybrids similar to itself because all the chromosomes have compatible partners, but it is sterile in respect to both parent species. Furthermore, the hybrid is not only true breeding but is different in structure and in habit from each of its parent species. It therefore fulfills all the criteria of a species and has been called *Primula kewensis*. Many other new species have originated by intentional hybridization and accidental polyploidy in this way. Some of these artificially produced species have been found to be identical with, and to breed with, wild species, and this is the proof that this method of species formation occurs in nature.

THE CENTENARY OF EVOLUTION BY NATURAL SELECTION

In conclusion, it may be said that during the hundred years that have elapsed since Darwin and Wallace first published their theory, the fact of organic evolution is now universally accepted and its mechanism has been formally explained.

The alternative to evolution is so naïve that it comes as a shock to realize that as recently as one hundred years ago, ideas such as called for the following questions could still be current: "Do they really believe that at innumerable periods in the earth's history certain elemental atoms have been commanded suddenly to flash into living tissues? Do they believe that at each supposed act of creation one individual or many were produced? Were all the infinitely numerous kinds of animals and plants created as eggs or seeds, or as full grown? And in the case of mammals, were they created bearing the false marks of nourishment from the mother's womb?" Darwin might well allow himself to ask these questions, for he and Wallace had found the answer to them.

So soundly was the theory of evolution by natural selection grounded that research does nothing but confirm the links in its chain of evidence and the inferences to be drawn from them. Its field has extended from the explanation of the production of plants and animals to every aspect of the intellectual life of man, and it would be imprudent to doubt that its greatest triumph may yet lie in the highest aspect of that life. Some persons have attempted to discredit natural selection, on the grounds that being a destructive agent it cannot produce anything new or make the fit fitter. Such persons have only demonstrated that they have neither understood the problem nor studied "The Origin of Species," in which Darwin carefully pointed out that "several writers have misapprehended or objected to the term 'Natural Selection.' Some have even imagined that natural selection induces variability, whereas it implies only the preservation of such variations as arise and are beneficial to the being under its conditions of life." Variation produces novelties at random, but selection determines which are preserved. Only a genius could have discovered a key of such simplicity to so great a problem. Only ignorance, neglect of truth, or prejudice could actuate those who, in the present state of knowledge, without discovering new facts in the laboratory or in the field, seek to impugn the scientific evidence for evolution.

With such new formulations as may be required, the concept of evolution by natural selection continues and will continue to provide what Darwin hoped when he wrote in 1837 in his Notebook: "My theory would give zest to recent and fossil comparative anatomy; it would lead to the study of instincts, heredity and mind . . . to closest examination of hybridity—to what circumstances favour crossing and what prevents it—and generation, causes of change in order to know what we have come from and to what we tend. This and direct examination of direct passages of structure of species, might lead to laws of change, which would then be the main object of study, to guide our speculations."

With the same confidence as it accepts Copernicus's demonstration of the movement of the earth around the sun and Newton's formulation of the laws of this movement, science can now celebrate the centenary of the first general principle to be discovered applicable to the entire realm of living beings.

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Does Natural Selection Continue to Operate in Modern Mankind?[1]

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THE PROBLEM

THE PURPOSE of the present article is to examine the validity of the assertion, frequently made in medical, biological, and sociological writings, that natural selection has been relaxed or even done away with altogether in modern mankind, particularly in advanced industrial societies. With this assertion as a premise, dire predictions of biological decadence of the human species have been uttered, especially in popular scientific literature. It is of course not our intention in this article to grapple with this immense problem in its entirety, and we mean neither to affirm nor to refute the predictions of decadence. We feel, however, that the thinking in this field may gain in clarity from a reexamination of the concepts of natural selection and adaptation, particularly as they apply to man. Such a reexamination is the more needed since these concepts have not remained stable even in biology since they were advanced by Darwin. Particularly rapid change has taken place in recent years in connection with the development of population genetics.

Natural selection is regarded in modern biology as the directing agent of organic evolution. The process of mutation yields the genetic variants which are the raw materials of evolutionary change. Sexual reproduction then gives rise to innumerable gene combinations or genotypes. However, which mutants arise, and when, have nothing to do with their possible usefulness or harmfulness to the species. Natural selection, nevertheless, so maneuvers the genetic variability that living species become fitted to their habitats and to their modes

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of life. Organic evolution consists of a succession of threatened losses and recapturings of the adaptedness of living matter to its environment. But the environment does not change the genotype of a living species directly, as some evolutionists of the past have wrongly assumed. The role of the environment consists rather in that it constantly presents challenges to the species; to these challenges the species may respond either by adaptive modification or by extinction.

It would be an exaggeration to say that the above view of the evolutionary process is universally accepted. Few biological theories really are. However, the importance of natural selection, at least as an agent which guards against degenerative changes in populations, is denied by scarcely anyone. We need not labor the point that the evolution of the ancestors of the human species was brought about by the operation of the same fundamental biological processes which act elsewhere in the living world. A new situation has arisen with the advent of the human phase. Species other than man become adapted to their environment by changing their genes. In man, the adaptation to the environment occurs in part through development and modification of his learned tradition and culture. Man is able to adapt by changing either his genes or his culture, or both.

Another innovation has also occurred in the evolutionary pattern of the human species. Owing to the protection conferred upon certain weaker genotypes by civilization, natural selection against these genotypes has become weakened or removed. Individuals and populations which would die out under allegedly "natural" conditions survive and procreate in civilized societies. A large share of the blame for this interference with "normal" evolutionary processes is laid at the door of modern medicine. Although man possesses methods of adaptation which are peculiar to his species, he is still subject to general biological laws. Biological evolutionary processes operate in the human species within the unique evolutionary pattern conditioned by human intellectual powers; yet it would certainly be a dangerous matter to abolish the controlling influence of the processes of selection.

STRUGGLE FOR EXISTENCE AND SURVIVAL OF THE FITTEST

According to Darwin's own testimony, the theory of natural selection was suggested to him in 1838, when he "happened to read for amusement" Malthus's "Essay on the Principles of Population." Any living species is able to multiply in geometric progression, and hence to increase in numbers until it outgrows its food supply. In reality this happens quite rarely, and populations of most species are stable within relatively narrow limits. The causes which bring about the relative constancy of numbers are by no means well known even at

present (see Andrewartha and Birch, 1955, and Lack, 1954, for relevant information).

Nineteenth-century authors said simply that excessive production of progeny was balanced by wholesale destruction in the "struggle for existence," in which "famine, war, and pestilence" were the principal factors. Actually, things are more complex. Thus, with many species of birds, the number of eggs in a clutch is such that under average environmental conditions the greatest number of young survives to maturity. Larger clutches produce fewer, not more, survivors, since the parents are unable to take proper care of their brood. Among insects, starving females or females that develop from underfed larvae deposit fewer eggs than do well-fed females. Scarcity of food, destruction by predators, disease, unfavorable weather conditions, and accidents of every kind are all involved. One or more of these factors may occasionally be decisive in different species or at different times and places in the same species. Struggle, in the sense of actual combat, is a rare occurrence among members of the same species, although it doubtless exists. To give just one example: adults and larvae of ladybird beetles, which normally feed as predators on other insects, resort to cannibalism when the food is scarce.

Destruction of a large proportion of the progeny certainly does not by itself guarantee that natural selection will take place. The contrary may be the case. When death or survival and production or nonproduction of offspring are due mainly to chance, large-scale destruction actually hampers selection for anything except fecundity. Selection as an evolutionary force is most effective where each individual's success or failure in life is a consequence of his over-all excellence or imperfection. In precisely this situation, most nearly approached by higher animals, the number of young produced is usually small and survival rates are high (Schmalhausen, 1949).

To put it simply, in order to be effective natural selection must be selective. On the average, survivors must be better fitted to live than nonsurvivors. The survivors must be stronger, or more intelligent, or better able to get along on little food, or more resistant to weather, or better able to escape from diseases, parasites, or predators. But not even all these virtues combined will improve the quality of the progeny unless the fitness of the survivors and the unfitness of the nonsurvivors are due to their genes. This proviso is obviously most important in human evolution. In man, individual and group success is often due to better means rather than to better genes.

Natural selection is, then, brought about by the survival of the genetically fit, not of the genetically fittest. Spencer's "survival of the fittest" was an effective slogan in the struggle for acceptance of

the evolution theory. But the rhetorical superlative misrepresents the actual situation by overstating the ferocity of the struggle for existence. Nietzschean superman is biologically a dubious foundation on which to build the future of the species. In nature, even under most stringent conditions, the survivors are usually fairly numerous and possess a variety of genetic equipment. Without going into the details of this matter, it can be stated that too severe a selection is likely to be less effective than a moderate one, because severe selection tends to deplete too soon the reserves of genetic variability.

REPRODUCTIVE SUCCESS

The version of the theory of natural selection which invokes survival of the fittest in the competitive struggle for life was remarkably well suited to the intellectual climate of Darwin's times. It has often been pointed out (e.g., Barzun, 1941) that the popularity of Darwinism had more to do with the social and political implications which some people read into the theory than with its scientific validity. Those who believed that limitless progress will inevitably result from unrestricted competition of private enterprise were beguiled to learn that their economic views found support in a universal law of nature. With colonial empires in the expansion stage, it was a comforting thought that the exploitation of the weak by the strong was merely a part of "the stern discipline of nature which eliminates the unfit." An eminent anthropologist was able to advocate withholding education from most people, in order that competition might occur under "natural" conditions. This "social Darwinism" continues to exist even today, and it has recently been given a modern biological dress by Darlington (1953).

With the development of genetics, and particularly of population genetics, the theory of natural selection has been recast in a more exact, though emotionally less impressive form. Consider a population of a sexually reproducing and cross-fertilizing species, such as man. A Mendelian population of this sort consists of individuals which differ from one another in certain genes. The population has a gene pool, in which different gene variants are represented with different frequencies. Now, in any one generation, the carriers of the different genes are likely to make unequal average contributions to the gene pool of the next generation. Therefore, the gene frequencies in the gene pool will change from generation to generation. Some genes will be perpetuated at rates greater than their alternative genes. The former are, then, favored by selection, and the latter are discriminated against. The genes which are selected for may eventually be established in the population, while those selected against may be lost.

Selection consists in differential perpetuation of genetic variants in the gene pool of a population. Selective success is reproductive success. The Darwinian fitness, or adaptive value of a genotype, is measured by the mean contribution of the carriers of this genotype, relative to other genotypes, to the gene pool of the succeeding generations. The highly fit genotypes are those which transmit their genes most efficiently; the less fit ones have a mediocre reproductive efficiency; the unfit ones leave no surviving and fertile progeny.

Under this sober appraisal, the "fittest" is nothing more spectacular than a parent of the largest family. He is no longer the mighty conqueror who has subdued countless competitors in mortal combat. He need not necessarily be even particularly hale and hearty; strength and toughness increase Darwinian fitness only insofar as they contribute to reproductive success. Mules are at least as vigorous and resistant to harsh conditions as their parents, horses and donkeys. But the Darwinian fitness of mules is zero, because of their sterility. Conversely, a hereditary disease which strikes after the close of the reproductive period does not diminish the adaptive value of the genotype. An example of this is Huntington's chorea. This is a dominant disease due to a single gene, the incapacitating effects of which do not usually appear until its carrier has passed most or all of the reproductive period. There has even been a suspicion that the carriers of this gene have on the average a greater number of children than their normal siblings. The infirmities of old age are easily accounted for by the theory of natural selection. What happens to the organism after the reproductive age is of no concern to natural selection, or only insofar as the condition in old age is correlated with some traits which appear during the reproductive age. In a social organism like man, natural selection may, however, control survival in later years, because what happens to the older members of the family or community also affects the welfare of its younger members. The tendency of this control might be to shorten the interval between the close of the reproductive period and death because, as Haldane has pointed out, in some societies the oldsters prove a useless drain on the resources of the group. But comparison of the postreproductive years in man with those in other primates would probably show that the net effect of selection has been to lengthen this period.

The question whether modern man is subject to natural selection can now be answered. He certainly is. Natural selection would cease only if all human genotypes produced numbers of surviving children in exact proportion to the frequencies of these genotypes in the population. This does not, and never did, occur in recorded history. Quite apart from the hereditary diseases and malformations for which no remedies are known and which decrease the reproductive fitness,

the inhabitants of different parts of the world have different reproductive rates.

The selective forces which now act on the human species are natural, rather than artificial, selection. It is of course conceivable that natural selection may some day be replaced by artificial selection. Indeed, "To replace natural selection by other processes that are more merciful and not less effective" (Galton) was the original theme of eugenics. To make this dream a reality, the contributions which various genotypes made to the gene pool of the next generation would have to be decided on the basis of genetic considerations either by parents themselves or by some outside authority. An alternative idea has been developed, especially by Osborn (1951); instead of substituting artificial selection for natural selection, he suggests a reorganization of social and economic institutions so that natural selection could be relied upon to favor intelligence and social adaptability.

The frequent allegation that the selective processes in the human species are no longer "natural" is due to persistence of the obsolete 19th-century concept of "natural" selection. The error of this view is made clear when we ask its proponents such questions as, why should the "surviving fittest" be able to withstand cold and inclement weather without the benefit of fire and clothing? Is it not ludicrous to expect selection to make us good at defending ourselves against wild beasts when wild beasts are getting to be so rare that it is a privilege to see one outside of a zoo? Is it necessary to eliminate everyone who has poor teeth when our dentists stand ready to provide us with artificial ones? Is it a great virtue to be able to endure pain when anesthetics are available?

The words "fitness" and "adaptedness" are meaningless except in relation to some environment. Natural selection involves interaction between the genotype and the environment, and this interaction leads to furtherance of congruity between the interacting entities. For this reason, organic evolution has on the whole been adaptive. It is, nevertheless, a function of an imperfect world. One of its limitations is that it is opportunistic. Selection enhances the adaptedness of genotypes only to the currently existing environments. Therefore, the direction and the intensity of natural selection are as changeable as the environment. Selection in modern man cannot maintain our fitness for the conditions of the Old Stone Age, nor can it prepare us for novel conditions of the distant future except by increasing our general adaptability.

Man's environments are decisively influenced by his cultural developments. For good or for ill, natural selection fits man to live in the environments created by his own culture and technology. In these environments, the ability to subsist on uncooked foods is probably now less important than it once was; the ability to resist certain

infections prevalent in crowded towns is probably more important than it was. So is the ability to learn, to become educated, and to live in reasonable accommodation with one's neighbors. Natural selection now works in what some may call unnatural conditions, but it is still natural selection.

RELAXATION OF SELECTION

The hoary fallacy which is perpetuated by some modern writers is that for a genetic variation to be selected it must be important enough to decide between the life and death of the creature. In reality, even a slight advantage or disadvantage which increases the probability of one genotype leaving more offspring than another will be effective in the long run. It has recently been found (Aird, Bentall, Mehigan, and Roberts, 1954) that the proportion of people with blood group O is slightly higher among patients suffering from duodenal ulcer than it is in the general population. This does not mean either that everybody with O blood gets a duodenal ulcer, or that those with other blood groups are immune. But the possibility that the frequencies of O bloods in human populations may be influenced by the greater susceptibility of O persons to duodenal ulcer is a real one.

The fitness, the adaptive capacity of the carriers of a given genotype is continuously changing. Suppose that the contribution of one genotype to the gene pool of the following generation is equal to unity. The contribution of a different genotype may then be represented as $1-s$. The value s is the difference in reproductive success between the two genotypes and is called the selection coefficient. Now, the magnitude of the selection coefficient depends upon the environment. Selection coefficients grow larger as selection becomes more stringent and they diminish as selection is relaxed. When s is zero, the genotypes are equal in fitness, and selection does not operate upon them.

There can be no doubt that modern technology, and especially modern medicine, have greatly mitigated the disadvantages of many genetic weaknesses and disabilities: In other words, in an environment which includes modern technology and medicine, selection coefficients operating against certain human genotypes are smaller than in a primitive environment. But this amounts to saying that the fitness of the carriers of these genotypes has increased. A person afflicted with hereditary diabetes mellitus can live reasonably happily and may even raise a family if his environment includes proper doses of insulin administered at proper intervals. Genetically considered, a disability that can be corrected by environmental means so that it no longer causes an impairment of reproductive efficiency ceases to be a disability when a suitable environment is provided.

This reasoning applies also to any relaxation of selection that may result from sociological progress. There is supposed to exist a danger of loss or "erosion" of genes for high intelligence, owing to the higher reproductive rates of the social classes in which such genes are supposedly rare. Cook (1951, p. 260) describes this danger in the following way:

> As this process continues . . . the average level of intelligence and the proportion of gifted individuals decline. Should the feeble-minded level be reached, most of the plus-genes will have been eliminated. But before that time growing inefficiency and incompetence would cause the collapse of modern industrial society. The Dark Ages which spread over Europe with the fall of Rome were a cultural blackout that lasted for a thousand years. The Dark Ages which would be caused by continued gene erosion could last five to ten times as long.

It would not be appropriate here to discuss how far this eschatology is justified by available evidence. It should, however, be pointed out that the fearsome process, if it actually occurs, means that in our society high intelligence decreases the average biological fitness of its possessors, while less intelligent people tend to be more fit. This appalling circumstance would be due not to the cessation of natural selection, but to the relative intensification of selection for personality traits other than intelligence. It would be unfortunate only insofar as the most favored genotypes gave rise to certain characteristics which could be regarded as undesirable on other grounds. If the humble and the meek inherit the earth, it will mean simply that under social conditions which obtain in modern industrial civilizations humility and meekness are favored by natural selection, while pride and egotism are discriminated against.

It should be noted that relaxation of natural selection does not by itself change the genetic composition of populations; it does so only in conjunction with mutation. The process of mutation constantly and irresistibly generates genetic variations, and most of the mutants are deleterious to the organism. Increase of mutation rates would, then, lower the fitness of the population even if the selection pressure remained constant. But the relaxation of selection would necessarily mean that the "bad" genes will have become rather less dreadful than they were.

SELECTION AND ADAPTEDNESS

More than half a century ago, in the heat of polemics, Weissmann wrote about the "omnipotence of natural selection." This unfortunate exaggeration is not wholly absent in the writings of some modern authors. Natural selection is a remarkable enough phenomenon, since it is the sole method known at present which begets adaptedness to the environment in living matter. But it has its limitations. As pointed out above, it is opportunistic and lacking in foresight. More-

over, any genotype which possesses a higher net reproductive efficiency has a higher Darwinian fitness, and is, by definition, favored by natural selection. Higher Darwinian fitness usually goes together with superior adaptedness to the environment; however, the correlation is not perfect.

A single example will suffice to illustrate the occasional miscarriages of natural selection. Dunn (1953) found a recessive gene in the house mouse which is lethal when homozygous. A population of mice in which this gene occurs in a certain proportion of individuals produces, then, some inviable embryos. The gene is clearly deleterious. But this gene possesses the curious property that a male which is heterozygous for it and for its normal allele yields more spermatozoa carrying the abnormal than the normal gene. This automatically confers upon the abnormal gene an advantage in the population, and causes it to spread until its lethal effect in homozygotes checks its propensity to increase in frequency. Dunn has found that the lethal is actually common in many "normal" mouse populations, outside of genetic laboratories. Up to a point, therefore, natural selection favors the spread of a lethal gene in mouse populations because this gene happens to be able to subvert the male reproductive processes in its own favor. The reproductive success of a genotype is, in this case, opposed to adaptive success of the population.

This discrepancy between reproductive and adaptive success arises because the former has but one dimension: the rate of perpetuation of a gene from generation to generation relative to that of an alternative gene. Adaptation is multidimensional, and herein lie some unresolved problems about natural selection, particularly as it occurs in the human species. The pioneers of Darwinism were already aware that, in a social animal, the qualities which promote success in an individual are not necessarily those which are most useful to the society in which the individual lives. A gene for altruism (if such existed) might be discriminated against by natural selection on the individual level, but favored on the population level. The outcome of selection would, therefore, be difficult to predict. One might speculate that it would depend on the population structure of the species. A gene for altruism might be lost in large undivided populations, but might become frequent in a species subdivided into numerous competing colonies or tribes. Moreover, adaptedness to a certain environment, however perfect, need not go together with adaptability to changeable environments (flexibility, according to Thoday, 1953). For example, it is to be expected that of all the genotypes which are successful in times of abundant food supply, relatively few will be adaptable to periodic starvation; genotypes which can resist a large variety of infections are not necessarily the most successful ones in disease-free environments.

It can be granted that some genotypes which were being eliminated under primitive conditions are enabled to survive and to perpetuate themselves in civilized environments. As pointed out above, this necessarily means that the Darwinian fitness of these genotypes under civilized conditions has risen relative to what it was under primitive ones. The possessors of such genotypes, if they take proper care of themselves, may even be able to secure their share of the joy of living. Does it follow, however, that these genotypes may now be considered desirable in the human species? The answer may, unfortunately, be in the negative. Muller (1950) has portrayed the state of mankind which might result from failure to eliminate weakening mutant genes in the following way:

> This means that despite all the improved methods and facilities which will be in use at that time the population will nevertheless be undergoing as much genetic extinction as it did under the most primitive conditions. In correspondence with this, the amount of genetically caused impairment suffered by the average individual, even though he has all the techniques of civilization working to mitigate it, must by that time have grown to be as great in the presence of these techniques as it had been in paleolithic times without them. But instead of people's time and energy being mainly spent in the struggle with external enemies of a primitive kind such as famine, climatic difficulties and wild beasts, they would be devoted chiefly to the effort to live carefully, to spare and to prop up their own feeblenesses, to soothe their inner disharmonies and, in general, to doctor themselves as effectively as possible. For everyone would be an invalid, with his own special familial twists.

The outlook seems grim. Natural selection under civilized conditions may lead mankind to evolve toward a state of genetic overspecialization for living in gadget-ridden environments. It is certainly up to man to decide whether this direction of his evolution is or is not desirable. If it is not, man has, or soon will have, the knowledge requisite to redirect the evolution of his species pretty much as he sees fit. Perhaps we should not be too dogmatic about this choice of direction. We may be awfully soft compared to paleolithic men when it comes to struggling, unaided by gadgets, with climatic difficulties and wild beasts. Most of us feel most of the time that this is not a very great loss. If our remote descendants grow to be even more effete than we are, they may conceivably be compensated by acquiring genotypes conducive to kindlier dispositions and greater intellectual capacities than those prevalent in mankind today.

SELECTION OF WHOLE GENOTYPES

The propensity of evolution to produce unfavorable changes in plants and animals may at first sight appear astonishing. Consider the absurd difficulty which the human female has in giving birth to her young. Here is a process which is assuredly essential for the perpetuation of the species. Natural selection could be expected to make it

pleasant, or at least painless. Instead, childbirth is attended with intense pain, and often imperils the life of the mother, of the fetus, or of both. Although the later stages of pregnancy and parturition are to some extent incapacitating in all mammalian females, they are much more so in the human species. This and the other flaws in our biological organization Mechnikov called "the disharmonies of human nature." We cannot but suppose that these disharmonies have arisen during the natural course of human evolution.

The situation will appear less incomprehensible if the mechanics of natural selection are considered. Natural selection cannot develop this or that organ apart from the rest of the body, nor can it foster this or that gene apart from the rest of the genotype. What is selected in the process of evolution is the genotype as a whole. It is the whole organism which survives or dies, and successfully reproduces or remains barren. The genotype is a mosaic of genes, but it is wrong to think of the organism as though it were a mechanical sum of parts, each determined by a single gene. In the process of individual development all genes act in concert. The whole genotype, not just some genes, decides what an individual will be like as a fetus, in childhood, in adolescence, in maturity, and in old age. Moreover, the development of different individuals takes place in different environments; and the genotype may be required to adapt its carrier to any one of the possible environments. Certain differences between individuals (such as differences between some blood groups) are ascribable to single genes, but even the expression of these differences may vary; what an individual is like is always due to all the genes this individual carries.

The evolutionary success or failure of a species is determined by the fitness of its entire genotype, and of its entire developmental pattern, in those environments which the species inhabits. An observer may discern, however, that some particular feature or aspect of the organization is most instrumental in bringing about success or failure. Thus with man: his body is remarkable neither by its strength nor by its endurance. The evolutionary success of our species has been due to brain power, not to body power. Evidently, some genotypes which enhance brain power have been selected in spite of their tendency to decrease body power. Darwinian fitness is the resultant of all the advantages and disadvantages which one genotype may have compared to other genotypes. In man, the ability to learn and to invent and use tools influenced this balance more significantly than did muscular strength or resistance to inclement weather, although these were not negligible.

It is certainly reasonable to suppose that genotypes which combined the greatest brain power with the greatest body power would yield the highest fitness. Why, then, is man not always as wise as Socrates, as

strong as a lion, and as hardy as a dog? If we had unrestricted power to plan the evolution of the human genotype we would probably equip it with all these qualities and some others besides. But natural selection does not work according to any plan. Selection is opportunistic; whatever can survive does. Man's evolution was not designed or arranged beforehand. It took the course which it did because man's genotype, imperfect as it was, was good enough to survive, and in fact good enough to make our species a tremendous biological success.

Specialization is a common feature of the evolutionary pattern in many kinds of organisms at the expense of all-around perfection. The former is evidently more easily achieved than the latter. This is true not only of unplanned evolution which occurs in the state of nature but also of evolution under domestication, which to some extent is planned. Among cattle, there exist dairy breeds and beef breeds; there exist also some unspecialized breeds, but no breed combines the maximal performances of the best dairy and the best beef breeds. Why this is so is hard to tell; it may be that a combination of the above sort is a physiological impossibility, since the qualities which one may wish to combine may be antagonistic. On the other hand, it may be that a perfect breed of cattle is simply yet to be obtained.

Perhaps the most impressive example, other than man, of an organism whose biological success appears to be due to an outstanding development of just one ability, and a mediocre development of others, is the man-of-war bird (*Fregata*). Those who have had the opportunity to observe these superb fliers procure their food from the tropical seas can hardly imagine a more perfect flying machine. Yet, the legs of these birds are so weak that they cannot rise into the air from a flat surface, nor can they alight on water since their plumage becomes waterlogged. Man is certainly the best thinking machine which protoplasm has produced. This confers upon him a biological adaptedness so great that he continues to prosper as a species despite his relatively weak body, his several biological disharmonies, and his many follies. He need not fear biological extinction so long as his genotype as a whole enables him to live in some environments, either "natural" or devised by his own ingenuity.

EVOLUTIONARY PROCESSES ACCENTUATED BY CIVILIZATION

Many traits that were essential for bare survival in a paleolithic culture are unnecessary in New York City, but we have emphasized that natural selection is not restricted to the struggle for survival. For all organisms, reproduction is the essential step in selection, and reproduction in man involves not only bearing children, but rearing them to maturity. In modern civilization, furthermore, parental influence may often be decisive in determining the success of children

in their own marriage and reproduction. If so, the reproductive success of an individual may be more adequately gaged by the number of his grandchildren than by the number of his children. Also, if parental influence is so important, the existing negative correlation between intelligence and family size may be compensated in some cultural groups by a positive correlation between intelligence and successful preparation of one's offspring for adult adjustment. This extension of parental functions appears to represent a trend in human cultural evolution; in our own society, as class differentials in fertility diminish, it may restore some of the biological value which intelligence seems to have lost.

Under civilization, reproduction and successful child rearing have come to depend more upon individual adjustment patterns and less on survival or reproductive capacity. Individual and family adjustment is the modern theater of the "struggle for existence." In our culture biological adaptedness, that is, optimal reproduction and child rearing, seems to bear no direct relation to economic or educational status, but probably depends in part upon personal and social adjustment patterns. Though physical and mental handicaps rarely eliminate persons completely, they probably affect such adjustment. Among the traits capable in this way of influencing reproduction, the relative importance of physical health is presumably diminished and that of mental health magnified in comparison with selection in primitive man. In addition, some physiological defects would appear to contribute to personal maladjustments more frequently in a modern than in a primitive culture. Likely examples of such defects are color-blindness, left-handedness, and allergic diathesis. With respect to genetic factors underlying these traits, present-day natural selection may be reinforced both relatively and absolutely. Finally, the capacity to compensate for gross physical or sensory handicaps probably has more selective value now than it did under conditions of existence which eliminated most cripples completely.

Further speculation is unwarranted here, but it seems safe to assume that most sensory or mental characteristics that were developed in our primate ancestors in response to the demands of an increasingly complex, variable environment, are even more important to civilized man. If so, they surely play some role in determining which persons shall marry, which shall have stable families, and which shall raise more children. When handicapped individuals defy these determinants and become parents, their children pay the price in a relatively severe selection by the adverse physical and social environment. As a result of this stringent selection in such families, on the average, survivors in the third generation are probably superior to the grandparents genetically.

Selection for many traits at once always makes slower progress than selection for one or a few traits. Insofar as natural selection formerly maintained genetic traits that have now become useless, civilization has eliminated a probable source of interference that impeded selection for cultural adaptability. Whether selection in the latter respect is in an absolute sense stronger or weaker than formerly, it is probably operating more efficiently.

Whatever emphasis is placed here on the positive aspects of natural selection under civilization is not intended as a denial of all negative aspects. Man's increasing physical dependence on his cultural heritage, beginning with clothing and cooked food, can be taken as a historical fact, and accelerated specialization in this direction is to some extent inevitable. Conflicts in our present culture between reproduction and higher education, or between reproduction and self-control, are almost completely new selective forces in human evolution. It is not at all apparent how these conflicts would be resolved in the natural course of cultural progress. On the other hand, artificial attempts to counter such selection by "eugenic" support of culturally desirable types would inevitably lead to another type of dangerous specialization; the very need of these types for such support, insofar as the need exists, proves their failure to adapt biologically to civilization. Dependence of society upon complex reproductive controls seems to be a higher order of specialization, whether better or worse, than dependence of the individual on medical and technical aids.

From a long-term point of view, another effect of civilization may be more important than changes in selection pressures per se. Individual genetic variation is the basis for selection, and this has been accentuated in modern man for several reasons. First, relaxation of selection in any respect immediately increases the proportion of minor and extreme abnormalities in the surviving population. Second, new environments, as well as the increasing proportion of deviant individuals, permit fuller expression of genetic differences formerly masked in uniform phenotypes. An example of this is perhaps to be seen in some childhood reading disorders, which would make little or no difference in an illiterate population. Third, migration and intermarriage of formerly separate races or groups produce a great new diversity of genotypes. Fourth, increased survival of mutations results, to a small extent, in greater prevalence of genes that raise the mutation rate.

Even if selection should be reversed for a brief period of time the above sources of increased genetic variation will, in Schmalhausen's words, mobilize the variability of the species. Thus, civilization is now preparing man for rapid evolution in whatever direction long-term selection may determine. As long as populations remain large, and as long as competition exists in any form, degenerative evolution-

ary trends are likely to be outweighed by adaptive changes, but the direction of these changes is uncertain.

CONCLUSIONS AND SUMMARY

The idea explicit or implicit in many writings, that all would be well with the human species if obstructions to natural selection were removed, does not stand critical examination. Man, like any other biological species, is constantly subject to natural selection. The genotypes which possess the highest Darwinian fitness in the environments created by man's inventive genius are, however, not the ones which were most favored by selection in the past. Natural selection cannot maintain the adaptedness of modern human populations to environments which no longer exist, nor can it preadapt them to environments of the future.

Natural selection is opportunistic; it does not always lead to improved adaptedness. After all, extinction has been the fate of countless biological species which lived in the state of nature and which were at all times subject to natural selection. It would be folly for our species to risk the same fate for the juggernaut of blind biological force. One of the causes of extinction is too narrow an adaptedness to a circumscribed biological opportunity which proves only temporary. Man has reached a solitary pinnacle of evolutionary success by having evolved a novel method of adapting to the environment, that by means of culture. Having ventured on this biological experiment, our species cannot any longer rely entirely on forces of natural selection as they operate on the biological level. Man must carefully survey the course that lies ahead and constantly study his genetic progress. He can then prepare to take over the controls from nature if it should become necessary to correct the deficiencies of natural selection. Only thus can he insure for himself continued evolutionary advance.

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The Ecology of Man[1]

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[With 10 plates]

MAN THE NEWCOMER

The Living Landscape and a New Tenant

Man is a newcomer into our earth that is old. This being true, prudence suggests that man ought not be too self-centered. Instead of devoting himself completely to taking advantage of his surroundings, he might do well to spend some effort getting his bearings. Unfortunately, as matters stand now, science is being applied to competitive and exploitive ends in far greater measure than it is to establishing perspective. Even the humane and laudable business of prolonging life and increasing food supply through science seems to be raising as many questions as it solves.

We hear much these days about man's conquest of nature. Suppose as a first step we examine the record. It is longer than we of the Western World had thought, for our ideas of eternity have reached into the future rather than the past, giving us a curiously bobtailed notion of time. We may thank the astronomer, the geologist, the evolutionist, and more recently the physicist for setting us straight. Owing especially to measurements of radioactive change we now have some fairly good approximations of the age of the earth and the antiquity of various geological events.

What we know can be made graphic by taking a thick book of some 3,000 pages and assigning to each page the value of 1 million years, since the planet earth seems to be some 3 billion (3,000 million) years old. We would scan the first half of this book before we came to any very clear evidence of life. Then we would begin to read the fragments that tell us of slow and painful development—

[1] Condon Lecture, 1957, reprinted by permission of the Oregon State System of Higher Education, Eugene, Oreg.

marine to terrestrial, nonvascular to vascular, invertebrate to vertebrate, fish to mammal, marsupial to man. This is not all. We would read how, as old forms died out and new ones came on, there arose, both in plants and animals, not only more effective relations to environment, but more elaborate mechanisms whereby the parent assured the safety of the young.

We would see too an increasing interdependence among living things, and between them and their physical surroundings. The fossil hunters of today are not content merely to describe single species. They go beyond this to identify social groups of extinct plants and animals. Yet in spite of this increasing fitness of living organisms we read no evidence in the record that any form of life ever had things completely its own way. All were subject to some great principle of give and take, leading toward a balance or equilibrium.

And finally if we took account of sediments and earth forms, of the chemistry and geometry of rocks, we would find clear evidence that living organisms have played an increasing part in geological processes as time has gone on. We should see how the exclusively physical processes of erosion, deposition, and crustal readjustments came to be supplemented by organic sedimentation, the stabilization of land forms by vegetation, and the modification of the flow of energy and interchange of materials by many activities of plants and animals.

Since such interrelationships between life and environment are the peculiar business of ecology, a few words on that branch of biological study are in order. In 1959 we shall celebrate the centennial of a landmark in man's intellectual progress—the publication of Darwin's "Origin of Species by Natural Selection." You will recall that the problem to which Darwin had addressed himself many years earlier was that of trying to account for the bewildering variety and astonishing fitness of living organisms, both plants and animals. Some measure of this task may be had if we recall that perhaps 300,000 species of plants and nearly a million of animals have been identified.

Darwin had at hand two powerful intellectual tools, one borrowed from geology, the other from political economy. The first was the principle of uniformity, which assumed that in nature events of the past have been determined by those forces that we see in operation today. The second was the idea that living beings have a far greater capacity to reproduce than to survive. Somehow their numbers, through the generations, are kept in balance with the space and means of subsistence available. Many are born that do not mature, or if you prefer to be Scriptural, many are called but few are chosen.

Fortunately Darwin was a naturalist, trained to observe nature in all her aspects. He noted, although he could not explain, the tend-

ency of plants and animals to vary and showed that not all variations were equally well fitted to particular environments. And so he concluded that environment tends to eliminate the less fit while favoring their more suitable competitors.

Thus were the seeds of two new sciences planted—genetics to deal with variation and inheritance, ecology to investigate the interrelation between life and environment. Curiously, a generation was to elapse before either gained much headway and when they did genetics raced ahead much the faster, for various reasons. Toward the close of the 19th century, the pioneer work in ecology filtered across the Atlantic to receive its warmest welcome at two youthful universities, both in the Midwest, Chicago and Nebraska. First to be developed was plant ecology, later came animal ecology and their combination, bioecology. Human ecology, our present concern, is still in a tentative stage, but the ultimate goal is a general ecology, embracing that of all forms of life.

By this time ecology has proved its value in forestry, range, fish, and game management, where specialists are free to employ it. Its greatest potential service to mankind, however, can only be possible through voluntary public policy, based on widespread common knowledge and consent. Ecology is, above all, a source of perspective in time and space and a means of understanding the great processes of which we are necessarily a part. We now face urgent problems in the allocation of population pressures, the use and care of environmental materials and energy, the planning of space, and the elimination of war and other forms of waste. These all call for an ecological understanding beyond that now possessed by engineers, and leaders in finance, industry, and politics.

Since increasing numbers are exposed to courses in biology in high school or college or both, it seems quite possible that the emphasis of these courses should be reviewed, to insure a proper presentation of important ecological principles. It is all very well to learn about anatomy and physiology in plants, animals, and man. But no one would expect, for example, to deal through a knowledge of mechanics alone with the many public problems raised by the automobile. Indeed, viewing the extravagant missilelike design and immense waste power of the modern automobile, I wonder whether automotive engineering couldn't do with a little ecology of its own!

In any event, a practical way to test some of these notions and to prepare us for considering man's place in nature is to examine some of the more elementary findings of the ecologist. Doing so, we must keep in mind that his essential business is to study process, in particular the process wherein life and environment interact. Obviously he must understand both living organisms and their environment—a task

complicated by the fact that living organisms are themselves a part of the environment of other living things.

Now environment, any way we consider it, is a mighty complex system in itself. But there is an old rule and a good one that the way to tackle a complicated problem (in science, business, or personal relations) is to take it a bit at a time, provided one doesn't ever lose sight of the whole. Perhaps as useful a breakdown as any is the following:

Earth: Lithosphere, studied by geologists, geographers, soil scientists.
Air: Atmosphere, studied by climatologists, meteorologists, etc.
Water: Hydrosphere, studied by oceanographers, limnologists, hydrologists, etc.
Life: Biosphere, studied by biologists.

To these might be added *Mind*—the Psychosphere, studied by psychologists, anthropologists, and other social scientists.

Clearly no ecologist can become all these various specialists rolled into one. But he must be enough at home in their various fields to draw upon them as he needs, and even to contribute what he can. In particular he must learn to work the borderlines between them and in some degree become what has been called a "specialist in the general." To do this at the sacrifice of thoroughness or the ability to do scrupulously accurate, detailed work when necessary, would, however, be as fatal to him as to any other scientist.

By way of examples of some of the things that are of especial concern to him from each of these several aspects of environment let us take:

Earth (the solid lithosphere).—Here he is interested in the obvious irregularity of surface forms and chemistry, both so significant for life. Mountains and valleys, ores and nutrient minerals are where we find them, not predictable on any simple geometrical plan. This means that the ecologist cannot, to the same extent as the chemist, safely rely upon universal formulas. Each situation must be studied on its merits. The rainfall which suffices to produce forest in a cool region may mark desert nearer the Equator. The failure of one plant to form seed in a given locality may be due to temperature or mineral deficiency; in another to the absence of a particular insect.

Yet behind all the diversity and irregularity there exist certain trends toward order and equilibrium. Rivers tend to seek base level, extreme differences in elevation and mineral content to be reduced, soils to develop toward maximum fertility, and so on. Frequently though such trends may be interrupted or reversed, they are not to be ignored.

Air (the gaseous atmosphere).—Gas, or spiritus in classical language, long the most mysterious and elusive of the states of matter proved in the end to be most amenable to experiment and the simplest for mathematical treatment. It was the study of gases that unlocked the gate to modern chemistry and physiology. The gaseous envelope

of our planet is, like the soil, a reservoir of materials needed by plants and animals. It is also the medium through which solar energy reaches vegetation. But more than this, it is in constant turmoil, due primarily to that same solar energy. Its dynamic activity provides us with our daily weather while its behavior pattern in time and space we designate as climate, so important to the distribution and activity of living organisms.

Although atmospheric behavior is based upon the geometrically regular relations of sun and earth, the irregular pattern of land and water causes many interesting and important variations from place to place, from time to time. Great shifts have taken place over long periods of time as witnessed by the presence of coal in the polar regions and evidence of continental ice masses as far south as the Ohio River. Lesser fluctuations, for example the recurrence of dry years in groups, are known to be normal events and should be so regarded in planning regional economy, notably in the High Plains.

Water (the hydrosphere).—Here we deal with three states of matter, liquid, solid, and gaseous. Although the prevailing temperatures on earth lie between the melting and boiling points of water—a very fortunate circumstance for life as we know it—of the utmost importance is the ability of water to form vapor at temperatures below its boiling point. Thus water rises from the oceans and moves inland as vapor, to fall upon the land as rain or snow, then flows back to sea. The rate of this return is of great ecological moment. In general the more gradual it is, the greater its opportunity to sustain life on land and the less it disturbs land forms through erosion and deposition. And here we encounter one of those many mutual relations that abound in the living landscape, for it is vegetation which, once established, chiefly restrains the rush and destructiveness of flowing water.

Truly, water, one of the most familiar of substances, is yet one of the most amazing; and its presence in atmosphere, lithosphere, and living organisms as well, serves to remind us that environment is a great interwoven complex which we can take apart only mentally in our effort to understand it better.

Life (the living biosphere of plants, animals, and some simple forms that may be either, or both).—In the old days when physical scientists were called natural philosophers, and geologists and biologists were not ashamed to be called naturalists, it used to be said that nature abhors a vacuum. It might be said with equal truth that nature abhors the absence of life on earth, in air or water. Life, whether visible to us or not, abounds everywhere, thanks to the variation, reproductive vigor, and fitness through natural selection that Darwin pointed out to us.

Let us say that environment abounds in niches or opportunities for particular organisms to carry on, and that the course of evolution has been a process of filling these niches, meanwhile creating new ones at every step. Thus the oak tree, once established in its own niche, possibly a sunny, well-drained slope facing southwest, affords suitable niches to woodpecker, squirrel, fungi, and insects that find on it food or shelter, or both. We ourselves create niches for dogs, poultry, rats, maize, and wheat, and an impressive list of smaller organisms whose number may vary inversely with our use of soap and water.

Any species moving into a niche has an effect or reaction upon the situation. Let us call this its role. The effect of this role may vary widely. Thus the squirrel's habit of burying acorns is a means of planting many oaks, while its fondness for buds in early spring must be a more or less efficient substitute for the self-pruning that we see in the cottonwood. The role of coyote in keeping a balance among rodents and thus protecting the grasses and other plants that sustain the whole native menagerie of the Yellowstone area I have observed myself. From years of studying such remnants of undisturbed nature as I could, I have concluded that, on the whole and in the long course of time, unless an organism in its niche performs a role that contributes to the balance of nature, it is likely to be eliminated.

Every organism we know about, with one interesting exception to be discussed later, is confined to a limited geographical area known as its range. Within that range it is usually restricted to certain favorable habitats that afford it an appropriate niche. These patterns are set by the operation of what are called limiting factors. Thus the commercial growth of maize is limited in the north by cold, in the west by dryness, and to the east by a combination of topography, soil chemistry, and economics. Any plant or animal requires a certain constellation of favorable conditions to survive and does not thrive beyond the point where any one of these conditions becomes unfavorable or, as we say, limiting.

Some of the most interesting cases are those in which the limiting factor is the presence or absence of another species. Orchids may require certain fungi, cowbirds and cattle egrets follow grazing herds, walnut roots poison tomato plants, and tsetse flies carry sleeping sickness, thus keeping people out of an area and favoring certain African mammals which otherwise man would exterminate.

The hunter and naturalist have long known that plants and animals occur in characteristic communities or groups. To speak of jack rabbits or prairie dogs is to suggest grassland. We would expect to see squirrels in a woodland of oak and hickory, ptarmigan and conies in the beautiful flowered alpine meadows above timber line. Even insects and microscopic forms of life may be known by the company they keep.

Any community has both structure and composition. Structure depends on the form of dominant plant life, as forest, grassland, or scrub. This tells us a good deal about local conditions such as moisture and length of growing season. Grass requires more moisture than scrub, trees more than grass, as a rule.

To get further information we have to see what kinds of trees make up a forest, what kinds of grass and other herbs form a given prairie or steppe. Desert plants look much alike the world over but are very different botanically, cactuses being 100 percent American; or rather they were until misguided people took them to North Africa and Australia where they have become an unbounded nuisance. It has become necessary, in fact, to send back to America for insects that serve to keep cactuses in hand in Mexico and our own Southwest. As we have said earlier, plants and animals through occupying niches and performing roles have a general tendency to maintain a balance among themselves and with the physical conditions around them.

This balance is not a perfect thing, nor is it achieved immediately. The living organisms that first occupy a particular site change it by shading, enriching, and in other ways, so that they actually write their own finis, being succeeded by other species. This process, appropriately known as ecological succession, continues up to the point where members of the community can perpetuate themselves as hemlock does under hemlock, which for its part may have come in under fir or spruce. And perhaps the fir or spruce has followed pine after the latter had occupied bare ground. Thus it is that one can read climate, soil moisture and quality, and history to boot by observing living communities. It is important, not only to human enjoyment, but to human understanding that we do not destroy completely the natural communities which have preceded us and literally prepared the way for us.

These communities have built up the soil to sustain far more life than could the original bare ground, virgin soil being notably rich. They have also regulated the flow of water and held the ground in place. They are the homes of plants and animals that are useful, interesting, and enjoyable. They serve, far better than any instruments man has devised, to give us a measure of the capacity of an environment to sustain life. And, believe it or not, they afford us models for our own use of land. The most destructive practices, such as growing single crops in rows, are a far cry from what we find in nature. But grass and legume farming with livestock to consume the product and enrich the soil, winter cover crops to protect fields that otherwise would be bare, and forests on rough ground are far better for the land and, in the long run, for the man who lives on it. They accord better, too, with certain fundamental laws that govern the efficient use of energy and materials.

What we have tried to say thus far is that man has enjoyed the advantage of an earth that was, so to speak, a long time getting ready for him. More specifically put, he has evolved in relation to and by virtue of a highly organized and specialized environment. The earth is fit for him and he for it not only because of what he found here but of what went on here during the millions of years before his advent. Surely it behooves him to think twice before causing too much disruption.

Now let us look at man himself more closely. He is often called a Pleistocene mammal, which means that he appeared during the great glacial period in geological history. This was a time of storm and stress. Evaporation lowered the oceans to feed the growing polar and alpine ice. As the ice expanded it narrowed the biosphere into an equatorial girdle and within that girdle rainfall was probably heavy, favoring forests. At times the ice retreated, as it is doing now. Moisture lessened, temperatures rose, the living girdle widened toward the poles, and places which had been humid forest became desert. Such have been conditions during the past million years or so, the time that human beings have existed.

We are a novelty, if we do say so. Reach up to chin yourself, note the articulation of your shoulder joint and the ability of your hands to grasp a bar (or branch) strong enough to sustain your weight. Then ask yourself "What kind of a community—desert, grassland, or forest—did early men, my own ancestors, probably come from?" It seems clear that at first man, like other species, was restricted in range and habitat by certain limiting factors, temperature and suitable food being among them.

But not for long. Why? Look again at your hands. Note the opposing thumb and fingers and compare their manipulative range with that of any bird or beast you know. Think of your erect spine that frees your forelimbs from serving as legs, your head pivoted for swinging about the horizon, and your eyes set to form between them the base of a triangle. Any object you look at becomes the apex of that triangle enabling you unconsciously to form some judgment of its size or distance, or both. With such equipment an astonishing range of experience becomes possible.

That is not all. You have a central nervous system that is large to begin with and can continue its growth. Any experience, we know, registers in this central nervous system, to be recalled or reconsidered in future. Over and above what is called the "old brain" in mammals, you possess a powerfully developed "new brain," the busy nerve center of conscious activity. The "old brain" for its part attends to many routine matters without bothering headquarters.

Finally, human beings are equipped with a remarkably versatile vocal system, capable of producing an infinite variety of sound com-

binations. It is thus possible to have spoken symbols enough to communicate our experiences and thoughts to others. In this way knowledge can be exchanged and accumulated, and handed down through the generations, an immense advantage over the old do-it-yourself, learn-the-hard-way system that prevails so widely in nature. The upshot was a true biological revolution, the birth of culture, carrying with it the awful gift of conscious responsibility.

Man's unique power to manipulate things and accumulate experience presently enabled him to break through the barriers of temperature, aridity, space, seas, and mountains that have always restricted other species to specific habitats within a limited range. With the cultural devices of fire, clothing, shelter, and tools he was able to do what no other organism could do without changing its original character. Cultural change was, for the first time, substituted for biological evolution as a means of adapting an organism to new habitats in a widening range that eventually came to include the whole earth.

There is not much doubt that man is an Old World product and great interest centers just now on research in Africa where very early humanoid primate material keeps turning up. We reason that at first man was a gatherer, eating what he could find and digest. To judge by the thoroughness with which eatables, poisons, and drugs were known before the days of modern science, man must have tried nearly everything—plant, animal, and inanimate—that he found. We can be fairly certain of one thing—early man had to have considerable space to pick over if he survived. Even when he had developed tools and weapons for hunting it is estimated that some 4 square miles per person were required to sustain a family. Until the domestication of cereals and other food plants mankind was spread thin. The State of Ohio, an area of about 40,000 square miles and now holding 7 to 9 million people, is estimated to have been populated by only 12,000 to 15,000 Indians even when some agriculture was combined with hunting, gathering, and fishing in that very fertile land.

Now spacing is a crucial and constant problem with living organisms, plants as well as animals. It has a twofold aspect. We might say that it involves both contact and elbowroom. The individual must not become completely out of touch with his own kind. No matter how unsocial the species, there must be communication for reproduction at the very least. Beyond that one finds all degrees up to the highly social and cooperative.

On the other hand the most dangerous potential competition of a species is that with precisely the same needs, namely its own kind. The sweet song of the nesting robin is more often a No Trespass sign than a love call. The jaeger, an Alaskan bird of prey that feeds on rodents, gets along very well when food is scarce. But when the rodent population builds up, the jaegers behave like a lot of claim

jumpers around a gold strike. They encroach on each other's territory, and between fighting over the abundance of food and squabbling over nesting space they fail to raise the normal broods to maturity and their population starts to decline before food runs out.

It seems reasonable to suppose that man's progress over the earth was a matter of families or small groups living together for protection and cooperation, but spreading out and away from too close competition with other groups. If so, it affords a beautiful illustration of the principle that "competition with other species has a centripetal effect, driving each back into its own territory, while competition within a species is a centrifugal force, causing the species to scatter."

Man has always had to reckon with both kinds of competition. In the beginning, and until fire and weapons were available, the now extinct Pleistocene mammals doubtless kept him in bounds, never far from caves, perhaps treetops, and other citadels. The effect was clearly centripetal. But the recent finding of extinct mammal remains in association with stone weapons shows clearly that he had discovered another refuge—the devices of his culture. He needed no longer to defend himself within a certain stronghold, but within a way of life. Modern man, having pretty well disposed of his larger competitors, now finds himself pitted against rodents, insects, and fungi for control of food and other organic materials. He has also long been engaged in a confused competition for space with forests, of which more later.

It is a safe guess that as he overcame pressure from other species, that from his own increased, thus setting the weaker and more venturesome both on the road. What he accomplished, on foot, with only the dog, fire, and stone tools to aid him, is one of the most remarkable of human achievements. It happened during the accordionlike action of the glacial age, when climate compressed the habitable regions as the ice advanced, releasing them to expand as it retreated. Through this experience man learned to adjust himself to new vicissitudes of temperature and to utilize new forms of animal life from colder regions. The warm interglacials opened his path to the far north. Our observations in Greenland show us that glaciers can form only where both cold and moisture are present. There are and were many dry cold areas where early man, by now accustomed to the cold, could hang on in spite of the relentless advance of the continental ice masses.

This had spectacular consequences. As the ice grew from the moisture that fed it, the sea level was correspondingly lowered, until it was some 300 feet below where it is now. Then, of course, sea bottom was exposed in places, creating migration pathways. These served man as they had served various Old World animals for an entry into the New World and allowed the horse, evolved in the Americas, to move westward into Asia. Just how and when these

various shifts occurred is one of the intriguing problems of science, but we can say they did happen.

At any rate man had spread his wide-meshed net of sparse populations into every continent before the next revolutionary step, his domestication of the cereals. We are pretty sure of our ground here because we can, by various methods, trace the use of cultivated plants outward from the centers of first use, and we know the general location of three such independent centers. These are Asia Minor (wheat), southeastern Asia (rice), and Mesoamerica (maize). In each instance a grass of weedlike readiness to grow in open bare ground and with fruits of good size and nutritious character played the star role. Around each was developed a complex of other plants (in America, squash, beans, peppers, tomatoes, etc.). It has been suggested, with good arguments, that the rich bare surface of household dumps, where bones, scraps, seeds, and doubtless manure accumulated, were man's first gardens. The readiness with which tomato and melon vines spring up today out of garbage heaps makes this seem reasonable. So, too, does the fact that certain weeds of the amaranth and goosefoot family not only appear at the beginnings of agriculture in the Old and New Worlds both, but are still used as food in places. And, unfortunately, the average single-crop field happens to be the ecological equivalent of the pioneer, or weed stage in community development. If you will recall that at this stage of succession living organisms have, unlike the mature forest or prairie, a minimum stabilizing effect on the habitat, you will see why unskillful agriculture has often been its own undoing.

But the important thing is that by domesticating food plants, man reduced enormously the space required for sustaining each individual by a factor of the order of 500 at least. This meant that people could live closer together and in larger groups. It also meant that time was available for something beside the constant search for food. Cities and leisure for the arts were born, the offspring of agriculture. And yet, by a wry twist of fate, we see in history that repeatedly the status of the farmer has been lowered and with it the quality of his work and the response of the soil. Bad as it is for the offspring to look down on his parent, it is far worse for him to destroy that parent. Today, as a result of the present population explosion and resultant urban spread, choice garden, orchard, and farm land is being converted into suburbs and lost to the production of food and fiber. But we are ahead of our story.

The human record becomes less vague—more continuous and clear—following the invention of agriculture and cities. Technical improvements in the use of minerals, fabrication of tools and utensils, the arts of writing, sculpture, and architecture, and civic and military organization came on in succession, either by independent invention

or often by transfusion. Much has been lost, much may be misunderstood, but the main trends are clear and growing more so every year.

It is not enough, however, to know the record. We need to know its meaning as well. Until very recently history told us much about man, little about environment and practically nothing about their interrelation. In other words, moral history was a thing completely apart from natural history. This, let us add, could scarcely be helped, for our discovery of the method of discovery, that is science, is something quite new, old though its roots may be.

What can and must be helped, however, is any further continuance of a bad situation. Now that we stand committed to universal education and the political responsibility of the individual we must close the gap between the humanities and the sciences. We must rewrite history and restudy human values with an eye to man's long evolutionary background and his growing role as a natural force. What environment does to him and what he in turn does to it are of far more significance than the loves of monarchs and the quirks of generals. Conquests and migrations, campaigns and battles, creative arts and religious philosophies all take on a fuller meaning in the context of ecology.

Environment and life are inseparable, as Darwin showed them to be.

MAN THE DOMINANT

A Tenant Becomes Landlord

Our discussion up to this point might be summarized by saying that man has enjoyed the benefits of a highly developed and organized environment. As for the environment itself, it can be described as a whole that is more than the sum of its parts, thanks to its organization. The same thing is true of the human being, whose peculiar bodily characters do not increase his power by simple addition as each layer of boards increases the height of a pile of lumber. Instead his facility of manipulation, vision, speech, and thought resulting finally in culture, increase his basic animal powers in a manner truly exponential.

For an analogy we need only think of a company of say 100 men. Add another individual and if he be vested with authority and endowed with certain qualities of character and personality you will have not 101 percent of what you had before, but perhaps 500 or even 1,000 percent.

Precisely such an instance occurred when hunting was replaced by an efficient agriculture. There were, of course, many degrees of effectiveness in various cultures as there still are. The most notable perfection was, curiously enough, where difficulties had to be overcome, particularly where the control of moisture conditions was in-

volved. Here something like a sedentary system developed, while the technical stimulus of dealing with water by storage, ditching, flooding, and draining, had its impact not only on food production but on engineering, mathematics, and physics. It was in such places as the empires of Mesopotamia, the kingdoms of the Nile, the terraced highlands of Peru, and the lake-margin gardens of Mexico that the arts really flourished.

By contrast there developed within forest regions an exploitive and transient type of land use, resting upon removal and destruction of the original cover by chopping and burning. Planting with simple tools might yield returns for a year or two, but grass and weeds would presently come in. If domestic animals were at hand, the area might then be pastured for a time while fresh clearings were made and the process repeated. In the absence of grazing animals such areas would revert to brush and then to forest, as they would ultimately through the growth of briers even if pastured. This type of use is not too bad so long as the cycle permits some recuperation. But it cannot sustain a dense population for any great period of time. In contrast to the control of water, which enhanced the potential of environment and encouraged the concentration of people, forest clearance destroyed the very constructive agency that had made the area productive in the first place, without substituting any proper equivalent.

Therefore the effect of clearing and burning, whether in Neolithic Europe, Mexico and Honduras, or the Southern United States, was to encourage a shifting economy and produce a scattered population. On the whole, the occurrence of large permanent metropolitan centers in humid forest regions is usually due to something other than the efficient local production of food.

Where men followed their flocks and herds instead of tilling the soil it was likewise not possible to accumulate large sedentary concentrations of people. Because this type of culture neither enhanced the environment as did irrigation, nor destroyed its cover as did clearing, but rather utilized that cover directly, it was immediately dependent upon favorable seasons and places. These nomads tended likewise to be alert, aggressive, mobile, and accustomed to the sight of blood. When continued drought or neighborly pressure threatened they sought relief by movement—with or without raiding and plundering. Much history has its explanation in this fact.

These early phases of human culture can speak to us only in snatches, through their more durable remains and their effects on the landscape. But the lesson they leave is clear enough. Only where the effort was made to maintain and improve the environment was anything like an efficient and sustained relationship achieved. Even here the balance could be destroyed, as when invaders ruined

the ancient irrigation works of Asia Minor and when Spain wrecked the efficient chinampa or lake-margin garden system of Mexico. But where man attempted to take without return, as nomadic grazier or burner of the forest, he created nothing for an invader to destroy and was himself obliged to keep moving or settle for a declining level of living.

With the invention of written records in the more stable population centers the past can speak to us more explicitly, mind to mind. We can at last begin to see, not merely how cultures operate, but what gives them direction. Always there is the compelling framework of immediate environment—the sunny valley of the ordered Nile, the violence of the Tigris and Euphrates, the stormy northern seas, abode of vast schools of fish and pathway to rich plunder, the swampy ricelands of southern Asia, the lofty terraced potato fields of the Incas. Man can no more avoid coming to terms with such stern realities than he can dispense with his skin.

But these physical or natural conditions are only part of the system. Interacting with them are the intangible values, ideals and beliefs of the resident culture. Here we find the cultural basis not only of character and personality, but even of technical advance. For assuredly what is esteemed will be achieved, in some measure at least. If you would understand a people study their heroes, their art, and their faith. "Let me sing the songs of a people and I care not who makes their laws."

Now a lot of these matters are intuitive in origin. Yet I for one am inclined to set much store by the force of ideas more or less consciously evolved—a process greatly favored by the invention of written symbols. "Reading maketh a full man, conversation a ready man, and writing an exact man." There is something quite sobering in the thought that men a century from now, perhaps 20 centuries from now, reading what you have written, will be at liberty to pronounce you what they will—a fool, a liar, a sage, or a man of taste.

Thanks to the record, we know many of the ideas that, evolving, have shaped Western culture. Coming from the Greeks we have the right of the free mind to inquire. From the Jews we have a two-edged gift—the notion of consistent universal law along with the idea of man apart from nature. There was also more than a little suggestion that prosperity is among the rewards of virtue—a notion particularly congenial to our Puritan and (dare I say so) our Quaker ancestors.

Christian thought laid the groundwork for universal brotherhood and freedom, but by emphasizing the transient character of this earth as a vale of tears did little to encourage our curiosity about it. Human dignity as first asserted applied to the immortal soul rather than to intellectual and political rights, although I suspect the first ultimately made the last two possible. To this we probably owe science and the

means to advance it. We should not be deceived by the fact that despotism can foster science to its own ends. Neither should we assume that our own use of science is beyond scrutiny.

Indeed, I suggested in the beginning that we are employing science in a somewhat peculiar way, for short- rather than long-term objectives. This is curious, for capitalism itself is based on the idea of benefits postponed and Christian ethics upon ultimate rather than immediate reward.

Since science is only possible because of confidence that the universe is an expression of consistent processes or laws, we need not be surprised that a culture which has enjoyed some of the fruits of science should regard science itself with a great deal of confidence, or faith, if you will. More than this, the faith in miracles dies hard. Having discarded the idea of miracles outside of nature, we yet may choose to expect them within nature.

For nature itself we retain the ancient Western idea that it exists solely for man's edification and use—a conviction that leads directly to abuse. We have been accused of being materialistic. This is true only in a sense, for our besetting sin is lack of respect for the materials and the energy that sustain us. Still influenced by the old idea that prosperity is the reward of virtue, we feel that prosperity is itself a virtue. Poverty becomes a crime and by transfer those occupations whose price is poverty fall into disrepute. But since some worthy individuals are clearly not responsible for their poverty we tend to make the existence of poverty a crime of the culture. This leads us to issue a blanket pardon to all who lack thrift and to encourage in society a rate of fabrication and a kind of product that may distribute benefits but which intensifies the pressure on our environment at the expense of the future.

Our ideal then becomes a society where each has everything he could possibly use. Fords expand into Lincolns, Chevrolets into Cadillacs, and Lincolns and Cadillacs into God-knows-whats. We maintain the system less by reserving our present income than by mortgaging our future earnings, much of which comes from making other things that people may not need, but may either desire or be made to. At present, a high percentage of bank loans in the average bank are for the time purchase of automobiles and these are not by any means lifetime investments, as we know. Clearly the effect of this trend is to distract our attention from thinking of how the environment will stand up under pressure through the long future.

Imagine if you will a species—any species—that suddenly increases manyfold its range and speed of travel, the demands it makes upon environment for material and energy, and that has found a way to prolong life and lower the death rate while continuing to reproduce in excess of that death rate. Imagine, too, that the resource base of this

species does not increase relatively to its numbers. Then recall that we are just such a species, *Homo sapiens*.

Actually we have brought about a paradox, so far as space is concerned. As our numbers increase, so does our space per capita. Each urban citizen is getting about double the space he had 50 years ago, and so is each rural person—that is, each rural person who stays in the country. The average farmer operates twice the acreage he would have done 50 years ago. The answer to our paradox lies in the fact that urban growth is due to immigration from the country. The new city man doesn't get twice the space he had in the country—he just gets twice the space he would have had if he had moved into the city 50 years ago!

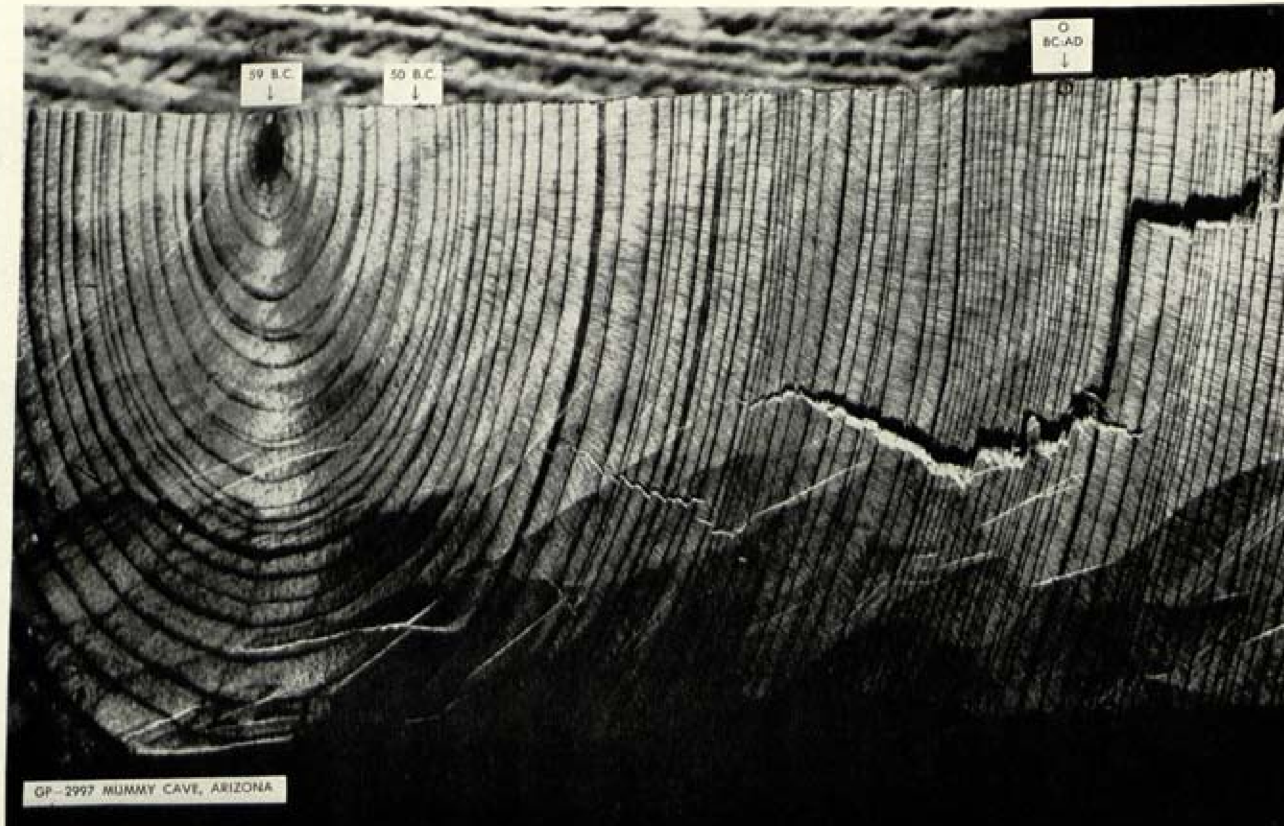
Very likely we are suffering from a population-pressure neurosis much like that of the jaegers at the high point of the rodent cycle. The fact that no great city maintains its numbers by its own birth rate suggests this. We surrender our right to cross a street at will, to keep poultry, and drink unchlorinated water from our own well. We may spend an hour and a half traveling between home and work each day.

Whatever the psychological effects of this on personality may be, we can be sure of other effects that are not to be laughed off. The intimate, sensitive contact between man and the resource base is broken. Milk comes from wagons, other foods from shelves, and how they get there is someone else's business. If history gives us any guide, the very congestion of numbers submerges the individual and exacts its toll in the creeping loss both of liberty and sense of responsibility. The chain of dependence upon technology lengthens and with it the distance between the individual and the physical basis of survival. Competition intensifies and can no longer be met by moving away from it. Instead the individual seeks protection from it in hiding within his specialty and then seeking to protect his specialty by devices of organization and monopoly. Specialization is no longer just a device to increase efficiency but a cultural refuge from intolerable pressures as well.

I pass no judgment here on the ethics and esthetics of this situation. I merely suggest that the problem is with us and we ought not blunder further into it with our eyes closed. Unfortunately the issue is clouded by a serious cleavage of opinion among those to whom we look for guidance. Perhaps the prevailing idea is that both population and our economy must continue to expand indefinitely or go under. Sustaining this view is a confidence in the power of modern science and technology to meet and conquer any shortages or other obstacles that may develop. A familiar expression is that "the only essential resource is human resourcefulness itself."

1. Four soils separated by three periods of erosion, probably arid. South Canadian River, Oklahoma. Photograph by C. W. Thornthwaite.

2. Stump of spruce overridden by recent glaciation and exposed by last retreat. Photograph courtesy of U. S. Forest Service, Alaska.



Early ring record in GP–2997, a Douglas-fir beam from Mummy Cave, Navajo Reservation. The cutting date of this beam is A.D. 304, but the very long ring record goes back to 59 B.C. (*Tree-Ring Bulletin*, April 1952.) The recurrent series of narrow rings (annual growth rings) or patterns shows that periods of drought were interspersed with "good" periods, a basic character of climate. Photograph by Edmund Schulman.

1. Women of the Sonjo tribe in Africa gardening with digging sticks. Photograph by Oliver Milton.

2. The rectangular patches, or milpas, have been cleared by fire and farmed repeatedly until the soil is stripped by erosion, as in the lightest patches. Photograph by A. J. Sharp.

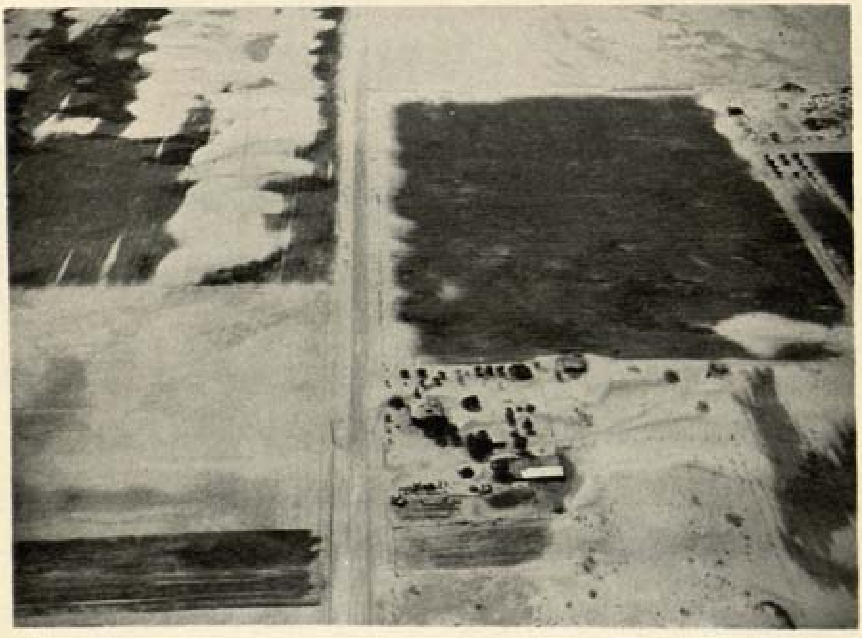
1. Mexican plowing with wooden plow and oxen.

2. Modern power machinery being used to clear, drain, and contour a New England farm in one day. Photograph by the author.

1. Damage due to an engineering construction planned without attention to geology and soil science.

2. Flood damage due to invasion of flood plain by industry. Photograph courtesy of Sikorsky Co.

1. Dust storm. Effect of plowing up semiarid grasslands. Photograph by the author.

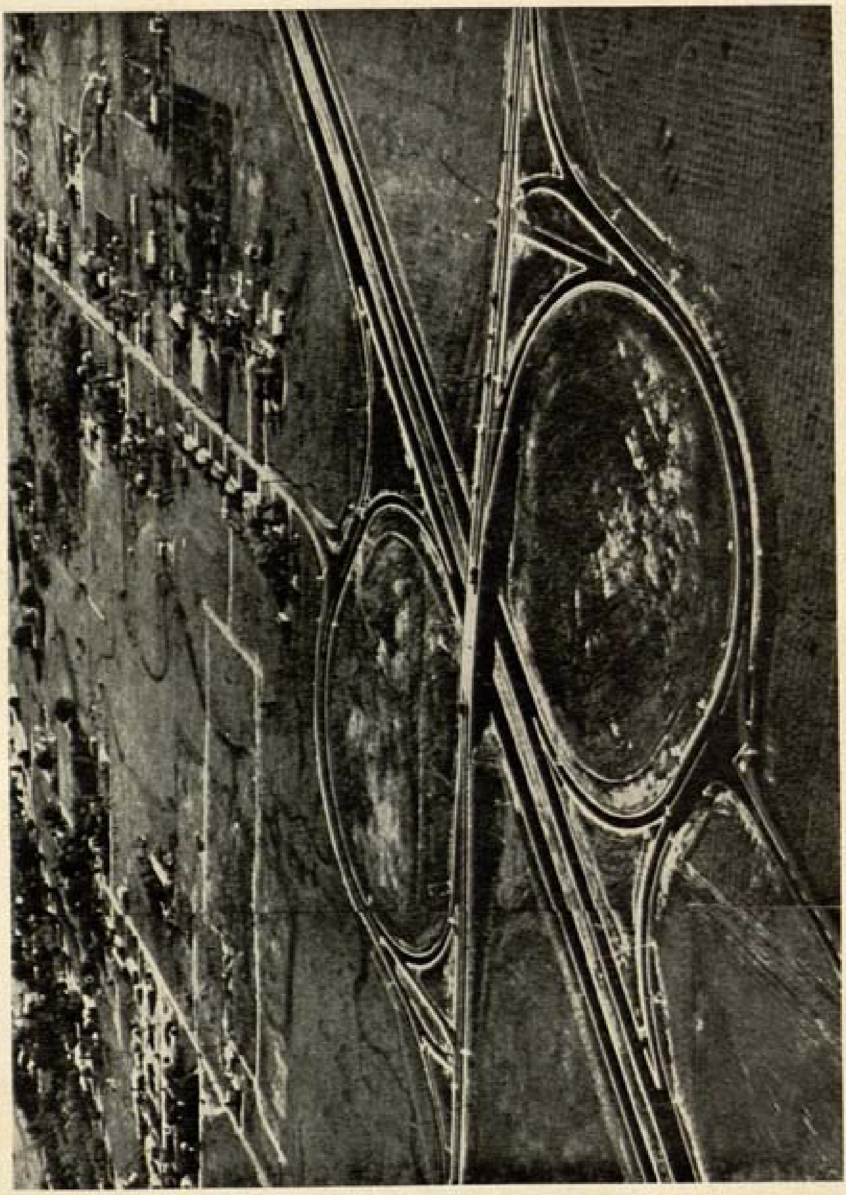


2. Farm buried in drifts due to wind erosion from plowed fields. Photograph courtesy of Soil Conservation Service.

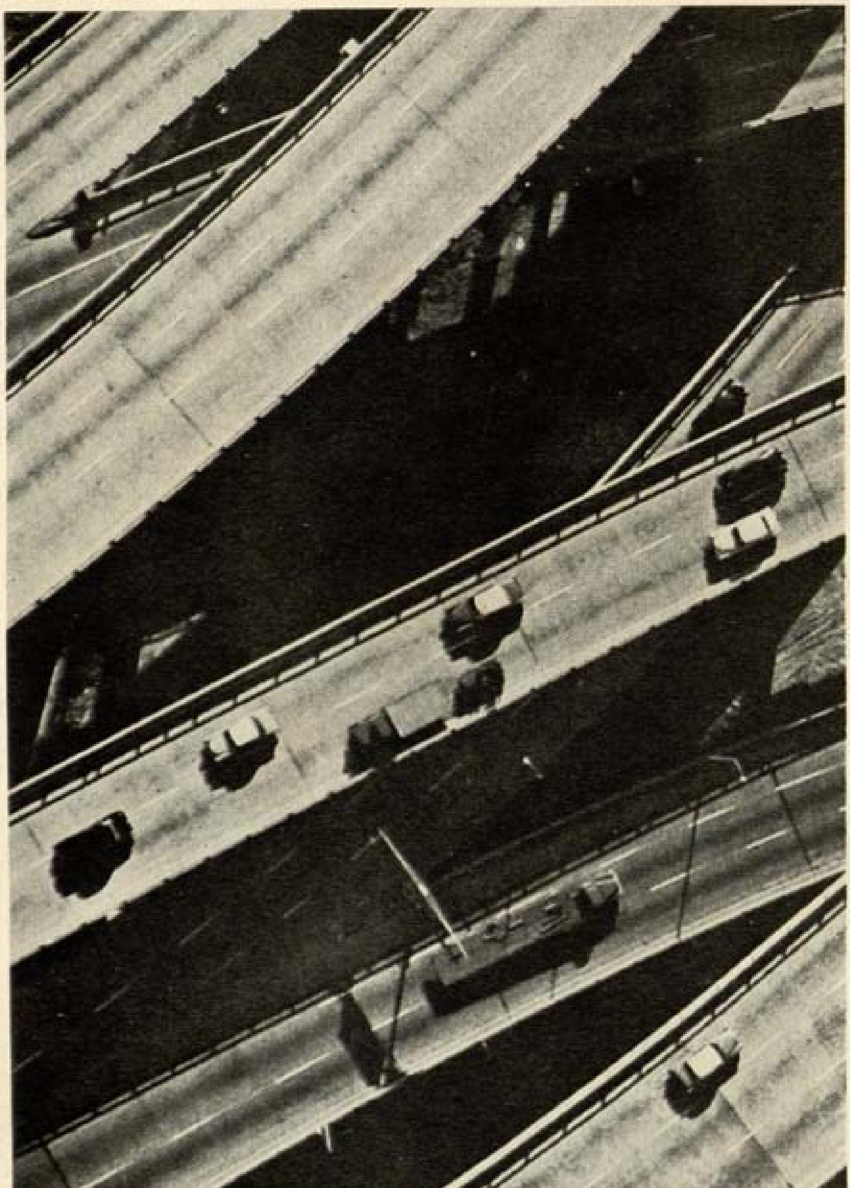
Rice terraces in the Philippines that have persisted for 1,200 years or more. Adjacent forest is protected by religious taboos. Photograph by D. L. Sears.

1. Example of good land use. Modern Danish farms. Photograph courtesy of Godsejer M. Dinesen, Eskildstrup, Denmark.

2. Modern soil conservation measures in Pennsylvania. Photograph courtesy of Soil Conservation Service.



Destruction of orange groves by suburban and traffic developments. Photograph courtesy of Standard Oil Co. of California.



Bird's-eye view of traffic construction in a metropolitan area. Photograph courtesy of Standard Oil Co. of California.

In support we hear further of the sparsely settled Tropics, the vast reaches of the sea, the present (United States) agricultural surplus, the continuing progress of synthetic chemistry, and the possibilities of energy from sun and atom. The extreme advocates have even been known to say without a smile that overpopulation is not a menace because we'll soon have space travel. Anyone who has traveled bumper to bumper trying to get out of a great metropolis on a holiday or to get an inexpensive reservation on a transatlantic steamer on short notice might reserve judgment on this latter point, especially if he recalled that perhaps 120,000 people are added daily to the world's population. Incidentally, to provide adequate food, fiber, and living space for these new guests would require the equivalent of one Ohio county—some 400 square miles—added to the productive land of our planet each 24 hours. This, of course, is not happening and in consequence many, perhaps most, of those born in ancient and overcrowded lands are doomed to lifetimes of want and privation. In the past these lifetimes have been, on the average, brief, owing to high infant mortality and the incidence of disease.

Recently, however, the effects of modern medicine and public health measures have been extended over the earth. More people are now living for a longer time. To some extent the production of food in overcrowded nations has been improved, but this contributes to greater numbers surviving rather than a better dietary for all. Meanwhile there has been little adjustment, outside of Europe, in the birth rate. So we see doubling of the population of Ceylon—an inelastic island—in less than a score of years, and agonizing pressures in another island, Puerto Rico. In our own country the net rate of increase is actually higher than in the overpopulated Orient owing to better sanitation, more food, more space, and other advantages that protect us for the present. I suspect that we now have the best chance we shall have to avoid the fate of older nations, for we still have a freedom of choice and action that they have lost.

A convenient way to show the process in which modern man, no less than his ancestors, is involved is by means of the following memorandum. Using R for resources from the environment, P for population in numbers of individuals in a given group, and C for the culture of that group, we first write a fraction

$$\frac{R}{P}$$

This means plainly enough that the per capita share of resources, or any of them (space, water, minerals, timber, etc.), increases with their abundance and decreases with rising population. But if we compare, say, Brazil rich in resources and Denmark with few, we see that our

expression is not complete. The thrifty, highly literate, self-disciplined Danes not only take excellent care of the resources they have but make an effort to stabilize their population. In other words the third factor, culture, is involved, too. We express this relationship by using the symbol for function, or relationship, thus:

$$\left(\frac{R}{P}\right) f\ (C)$$

This of course can be read forward or backward, for the *f* represents *interrelation*. Doubtless in primitive society R was the big thing, shaping culture and ruthlessly controlling population. With simple arts man is highly dependent on the kind and amount of readily available resources about him. But as culture advances new resources and new methods of using them develop, while population adjusts itself—or fails to do so—by virtue of cultural attitudes and practices.

Then in turn the culture responds and the ways in which it does so would offer an intriguing approach to the study of man's history. As the fraction R/P increases, to what extent is this reflected in wealth, leisure, creative work, and the good life? As it decreases, to what extent do we have poverty, social injustice, abuse of power and human disintegration? Such a study would not be easy. One would have to avoid oversimplification and the tendency to judge other cultures in terms of his own. He would confront the problem of rugged and infertile Scotland with its perennial contributions of human greatness as well as that of the fair Pacific isles where the necessities of life are more generously offered and where one may echo the words "Happy the land that has no history!"

Yet he would have to scratch deep in both instances to get at the truth. In doing so he would certainly see that some elements of Scotch character are based upon self-discipline in relation to meager resources. He would find that strict monogamy, combined with the control of male numbers by clan warfare and later by emigration, had afforded some measure of cultural control of population.

Among the less austere Polynesians he would find evidence of genuine, if unrecorded, human greatness of a different order, and plenty of concern with resources and population. The daily business of getting food from the sea was not for weaklings. Even less was the making and manning of great canoes that evidently put off from time to time on long voyages that in the end peopled all the distant habitable islands. And there is a persistent belief that the people of the Pacific had some means of regulating population pressures other than abortion, infanticide, cannibalism, and warfare. At any rate, they developed a way of life that worked and was good enough for us to envy even as we were trying to change it. How else can we describe our efforts to get them to switch from grass skirts to

Mother Hubbards, to drink beer, and to buy things from us instead of gathering them from sea and strand or making them from the simple materials about them? I even suspect that the average individual, given a shot of truth serum and asked to describe the architecture of his own personal Heaven, would have less to say of a city of jasper, golden streets, and gates of pearl than of blue seas, waving palms, gentle breezes, and gentle people.

One of the newer achievements of science is the means of judging fairly cultures other than our own. How new this is may be judged from the prevalence of chauvinism, assorted snobberies such as racism, and such durable terms as barbarian, gentile, provincial, and heathen. Even among trained observers the traditional approach has long been to judge other groups in terms of one's own culture as a standard. This might lead to contempt if not pity, or as in the French glorification of the American Indian during the 17th century, to a sentimental appraisal equally far from the truth. The Hebrews who had, we must admit, a precious ethical concept at stake, had harsh words for those who married outside the nation. Later than this, renascent Europe dubbed Marco Polo a liar for his remarkable account of Cathay. In Mexico, a tough old soldier, Bernal Diaz, came nearer to clear and honest observation than his contemporaries, bent as they were on erasing what they found.

But just as in geology a revolution came about through assuming that the past was to be explained by processes going on today before our eyes, so the study of man has been revolutionized by a simple assumption. This is, in effect, the assumption that any culture has its own internal logic that makes sense, so to speak, from the inside. Differences, per se, are not disgraceful and certainly not pathological. They are instead a means of understanding culture itself, to be approached with respect and in the context of environment, past and present, physical, biological, and social. Working on this assumption for not much more than a generation, anthropologists have given us not only a great deal of information but a most useful perspective on human cultures, including our own.

It follows that in working with any culture, no matter how generous our intent or how advanced our own technical knowledge and practice may be, we must approach the problem with an open mind. For each culture, like each landscape, is in some respects unique, and has its own values, its own rationale, and its own instrumentalities of change.

We are rather given, because of the dazzling achievements of our own culture, to assume that what we regard as good for it must necessarily be good for all. This is even true as we look about us within our own culture. We are inclined to feel sorry for anyone who must drive a small car instead of a big one, and who must take his vacation near home instead of in Bermuda, and to consider such a situation as a flaw

in our system. But much more so do we manifest this attitude toward the "underdeveloped" and "underprivileged" of other lands. Perhaps they do not feel sorry for themselves until we suggest that they should. But whatever their needs, the doctor ought write no prescription until he has seen and understood the patient.

We now have more than a hint that any culture with its system of behavior and sanctions (ultimately expressed in esthetic forms) can be viewed as a dynamic process moving toward reduction of internal strain and external stress. To the extent that this is true it exemplifies the universal trend of process in the inorganic and organic realms. But while inorganic systems of matter and energy tend toward repose, those that involve life exhibit a countertendency so long as energy is available to keep them going. For, through the action of plants in storing solar energy, they have developed a peculiar pattern of flow and transformation—a kind of postponed benefit approximating what is known as a "steady state."

This amounts to a situation in which solar energy is fixed into organic compounds instead of being immediately dissipated as heat and so becoming "bound," that is, unavailable for further work under existing conditions. Bound energy is somewhat analogous to water that has fallen from a high level to such a low one that no further fall is possible. The phenomenon is expressed by saying that the entropy of our system—earth-sun—is increasing as energy flows from the sun's high intensity to the earth's low. Except as energy is intercepted and stored in such a way that it can be made to do work, it becomes bound. It may be intercepted by the evaporation of water into the atmosphere or the creation of atmospheric high-pressure areas. But when the water gets back to sea level and winds have blown themselves out, such energy becomes bound at last.

By comparison, energy impinging on living communities and stored in carbon compounds sustains a variety of forms of life, promoting their individual and group organization, enhancing the capacity of the habitat to sustain life, regulating the economy of water movement and chemical transformations—in short, doing work but maintaining the system at a high level of efficiency at the same time. It suggests an industrial plant plowing back income into maintenance.

Although animals, including man, are consumers of energy-bearing carbon compounds, they can contribute to maintaining the balance of the system so long as they do not disrupt it. Insects pollinate plants and many animals disseminate them. Mineral nutrients are distributed, as for example when hordes of salmon bring scarce nutrient salts from the sea inland when they come up to spawn in regions that,

like our own Northwest, are deficient in iodine and calcium. Beaver dams, retarding the flow of water, tend to equalize it through the year and so enhance its ability to sustain life on land before it returns to the sea. Burrowing animals, vertebrate and invertebrate, aerate and enrich the soil. And so it goes, exemplifying the principle that as life has developed it has achieved an ever-increasing role in modifying the earth. But this it does by virtue of delaying—not reversing, as some would have it—the relentless increase of entropy in our system. In this process lies the margin of life over death.

Now man, at the apex of evolution, is the inheritor and beneficiary of this magnificent pattern. He has at his disposal not merely the fruits of today's biological activity, but of vast, though finite, stores of organic compounds formed by living communities in the past and now available as fossil fuel—coal, oil, and gas. He has had at his disposal, too, fertile soils formed and stabilized through preceding ages. More than this, he has, in modern science, the means to comprehend his position, as well as to intensify his use of what he has found, and devise a multitude of new uses for substances both familiar and previously unknown.

If we may for the moment draw upon the poetic insight of ancient times expressed in the third chapter of Genesis, the promise of the serpent has been fulfilled to a measure undreamed. "Your eyes shall be opened and ye shall be as gods, knowing good and evil." Humanity now has, as never before, the means of knowing the consequences of its actions and the dreadful responsibility for those consequences. Powerful as are the means that science affords in the way of relieving the human body and mind of effort, human beings are still confronted with the necessity of making decisions. And debate as we will as to the freedom of our choices, we have no better means at present than to designate this problem of choice as a moral problem. Even the individual who proclaims himself amoral has made a moral choice, that is a choice of values as well as means.

Now values are qualitative and intuitive, largely, and hence assumed to be beyond the reach of quantitative science and none of its affair. So we have the spectacle of human life now being transformed by dynamics thought to be quite independent of all the traditional controls that have been so painfully worked out through thousands of years of history, prehistory, and even prehuman evolution. It is like a vehicle of tremendous speed and power whose steering mechanism has no functional connection with it, or, at best, one not designed to control it.

The dazzling success of quantitative exact science as an instrument makes matters worse by throwing into deep shadow those aspects of human experience that cannot be expressed by formula and diagram. This is not new. The inherent tendency of every human group has

always been to seek for some kind of order, and there is magic in formulas.

One fact ought not escape notice. Those who have explored most profoundly the field of measurement, calculation, and analysis which is the cornerstone of modern technology have been the first and most vocal group to remind us of what I have called our moral obligation. The physicists and mathematicians have risked social and political disfavor and in some instances incurred its penalties for their insistence that man must be the master, not the slave, of his own technology. And I may add that the distinction of these Condon lectureships has been vastly enhanced by recognition of one such individual, Dr. Oppenheimer.

Perhaps the mathematician understands more clearly than most of us that any enterprise of the human mind must start with certain assumptions. Perhaps, too, mathematicians (leaving skill aside) excel chiefly in the clarity with which they formulate their assumptions and the systematic rigor with which they examine and reexamine them and follow out their consequences. Unless I am mistaken, the assumptions with which mathematics began had their roots deep in human experience.

To what degree can we apply this model to the ecology of man? I make the initial assumption that it is worth trying. Reviewing what has been presented in the earlier part of these lectures, it is clear that man is an expression of an infinitely long process. He is not only a part of that process, but has achieved a unique power to modify it, is affected by what he does in that respect, and is, beyond all previous degree, now able to know what he is doing.

Here, then, comes the first great choice of assumptions. Shall we assume that the human enterprise is worth perpetuating so long as cosmic conditions permit, which is likely to be a long time indeed? Three choices are possible—disregard, denial, and affirmation, each fraught with fateful consequences. Our present culture is a confused expression of all three and could do with some of the discipline of the mathematician.

It would be interesting, if space permitted, to explore the extensive realm of those who disregard or deny. Not all who choose to disregard do so from indifference. Not all who deny lack human compassion. And a considerable portion of both confuse the issue by presenting the world with issue of their own to face its assumed futility in generations to come!

We are left, then, to choose the third assumption—that the human adventure is worth its salt. Not a bad idea, either in theory or prac-

tice, as a basic value for responsible—that is, moral—human conduct. It is the only choice that justifies serious attention to the ecology of man and demands its skillful application to human affairs. It implies concern for mankind in the longest perspective of time. Unfortunately it still does not commit us to an equal concern for all men of all cultures everywhere. The mandate to survive has often been construed as warrant to eliminate or subordinate others.

Here we find ourselves treading near an ancient pitfall, as dangerous today as ever. If we deny full humanity to others, we are in a poor position to claim it for ourselves, let alone for our remote descendants. There is the further and very practical consideration that as in evolution no species of plant or animal has ever had its own way completely, so in history no culture has succeeded in doing so. Now that the world community is ever more tightly linked by new powers of travel, communication, and access to knowledge, it is less likely than ever that any group, ethnic or cultural, will ever have its way without mutual concession and, ultimately, mutual understanding and sympathy.

Indeed the whole lesson of evolutionary history demonstrates that the power of life over nonlife lies not in uniformity, but in diversity within unity. Just so the richness of any human community lies in the diversity of personalities, capacities, and interests within the unity of community spirit. To live is to live and let live.

Indeed it may be that in this old and battered saying we may find a clue to the effective use of what we can learn from ecology. If we desire to preserve our own kind throughout the long future, we must preserve a decent solicitude for life in all its manifestations, for the environment that makes life possible, and for those magnificent processes within the environment that have made it what it is.

Manifestly we cannot get the benefits of ecology merely by leaving matters to the specialist, as we do so largely with other sciences. Rather we must apply the knowledge of the specialist to matters of common consent to our patterns of living. This means that we must to some degree share the knowledge of the ecologist, not so much in details, as in its general aspects. To do this requires a new emphasis in much that we learn throughout the schools. It calls for no new subjects, but rather a reinterpretation of what is now taught, to make clear man's place in nature and his responsibility to guide the new forces he has invoked.

Meanwhile time speeds by. We need not wait for a new and enlightened generation. Each of us can begin quite simply by learning to look about himself, wherever he may be. Let him learn to know his own environment, its history and its components, living and inorganic. Let him conceive of himself, not as a detached watcher, but as an inseparable part of what is around him. And then go on from there.

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Reprints of the various articles in this Report may be obtained, as long as the supply lasts, on request addressed to the Editorial and Publications Division, Smithsonian Institution, Washington 25, D.C.

The Sea Otter[1]

By KARL W. KENYON
United States Fish and Wildlife Service

[With 6 plates]

IN GENERAL FORM the sea otter *Enhydra lutris* resembles the weasel and river otter, of which animals it is a large relative. The male attains a weight of 85 pounds, the female about 65 pounds; the young at birth weigh from 3 to 5 pounds. It is peculiar among members of its family, the Mustelidae, in having deserted dry land and fresh water to take up a marine life. Among marine mammals it is peculiar in its adaptation to the sea. It does not possess an insulating layer of blubber but is protected from the chill of North Pacific waters by a blanket of air trapped among the fine and closely packed fibers of its inch-long delicate fur. Unlike the river otter and fur seal, the sea otter has but little protective coating of guard hair. The fine guard hairs present add to its beauty but do not offer much protection to the soft underfur. Unlike other marine mammals, the sea otter has never taken to the open sea. It usually feeds in shallow water from 5 to 50 feet in depth. Its food consists primarily of such sedentary forms as sea urchins, rock oysters, mussels, a variety of snail-like mollusks and, in California, abalones. Occasionally fish and octopus are eaten.

Although the sea otter is not ideally adapted to its marine environment, it is far more at ease in the water than ashore. The flipper-like hind feet are clumsy on land and the long flexible body, somewhat like a liquid-filled bag, is poorly suited to walking. When otters haul out to sleep or preen, they seldom venture more than a few feet from the water.

Otters come ashore in greatest numbers when storm waves make food diving difficult. When the weather is calm they usually sleep on the surface of the sea, simply pulling a strand of kelp over their bodies, resting the head on the chest and placing their forepaws over their eyes. But often in the Aleutians during calm summer weather,

[1] Printed by permission of The Fauna Preservation Society, with some revision, from Oryx, vol. 4, No. 3, November 1957.

when the tide is low at night, they haul out at favorite spots to sleep. Mothers with young frequently bring their pups ashore about sundown to remain on the rocks until daybreak.

In the Aleutians at least, the breeding season is not well defined. Newly born pups appeared as numerous in early December of 1957 as they had been in the spring and summer of previous years. Present indications are, as early sea otter hunters reported, that breeding is continuous throughout the year. Mating takes place in the water and the mated pair may remain together for several days. During this period they make food dives side by side. They also choose a favorite rock where they haul out in close company to sleep and preen between feeding periods. This postmating association is apparently more desired by the male than the female. Since a male appears to require more food than the female, he sometimes leaves the resting rock to dive for food nearby, while the female remains behind to preen. In several instances I watched the female quietly slip into the water and leave her mate while he was beneath the surface. On discovering her absence, the male became quite excited and began a systematic search of all likely rocks, rising half out of the water to look onto them or actually climbing up to search their tops. In the cases I observed, the female was successful in eluding her mate.

Like other marine mammals the sea otter bears but one pup at a time, but, unlike most of them, the mother otter gives her offspring constant and careful attention over a relatively long period, probably until it is nearly a year old. For several months the pup receives most of its nourishment from its mother's two abdominal nipples, though at an early age it may also beg for and receive parts of sea urchins and mollusks that its mother is eating. She carries her pup on her chest while she herself swims on her back. On this floating platform the pup nurses, sleeps, and receives almost constant preening from its mother's mobile and sensitive forepaws. The mother leaves her pup only when she dives for food and a food dive seldom lasts more than a minute. While the mother is below the surface the pup usually sleeps, buoyed up by the air enclosed in its long, clean, dry fur. After each such dive the mother swims to her pup's side, where she eats the food that she has carried to the surface enclosed by a foreleg and a fold of loose skin across her chest. If her pup has drifted with the wind, she takes it onto her chest and returns it to the area in which she wishes to feed.

Sea otter pups are playful and, if a mother is feeding near sheltered kelp-covered rocks, the pup will often play in the gentle surge among the slippery strands. Once I watched a pup working its way around the rocks until it was hidden from its mother's view. Suddenly it missed her and uttered a harsh, frightened cry. Confused by the echo

of the sound, the mother screamed in distress and swam frantically about. Both animals appeared almost hysterical by the time the mother discovered her wandering offspring; then she clasped it to her chest and swam rapidly away from shore to preen and fondle it before beginning to feed in more open water.

In November and December of 1957 we kept a mother with a newborn pup in an artificial pool on Amchitka. At first the mother was

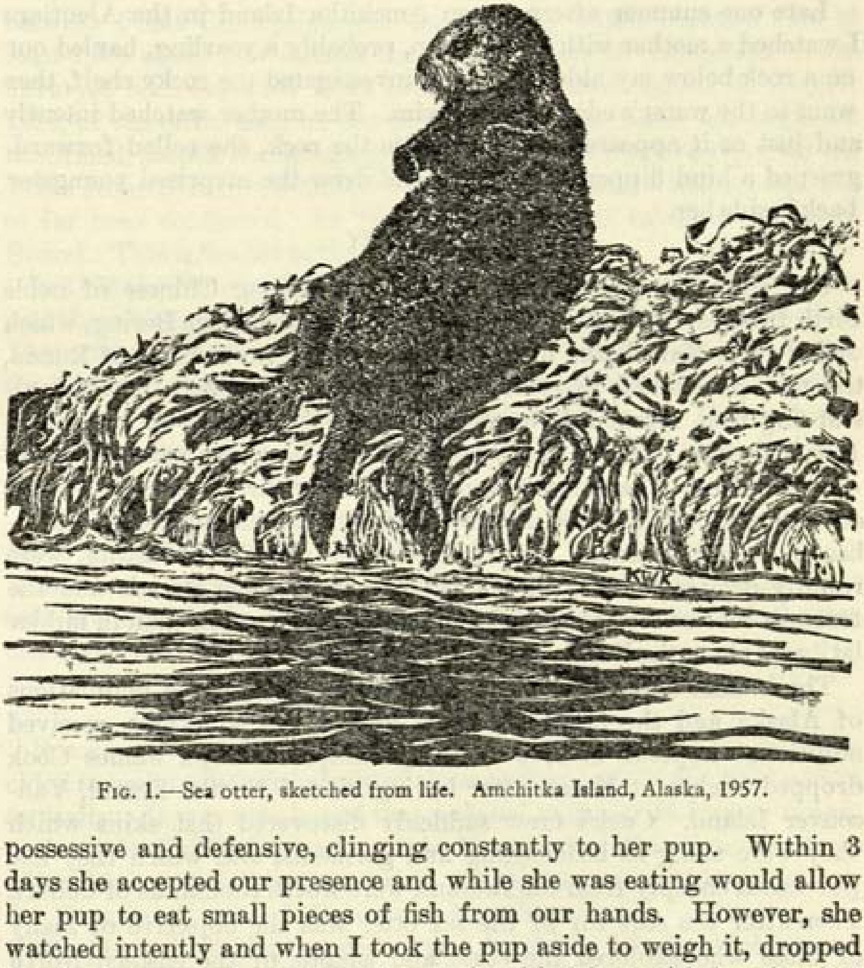


FIG. 1.—Sea otter, sketched from life. Amchitka Island, Alaska, 1957.

possessive and defensive, clinging constantly to her pup. Within 3 days she accepted our presence and while she was eating would allow her pup to eat small pieces of fish from our hands. However, she watched intently and when I took the pup aside to weigh it, dropped her food, screamed, and standing on her hind legs with her forefeet against me attempted to grasp her pup in her teeth. She demonstrated no inclination, however, to bite me. After receiving her pup she refused for some time to let it go again.

One night a blizzard loosened the latch on the enclosure door and it blew open. Leaving her sleeping pup on some dry bedding the mother ventured forth and in the early morning I found her swimming in the sea nearby, calling shrilly to her still sleeping pup. After

getting a helper, I awakened the pup, which immediately answered its mother. She promptly dashed ashore and into waiting hands which returned her to her pup. Early sea otter hunters recounted that if a pup was taken from its mother she would follow, screaming, after the hunting boat. On several occasions at Amchitka I have seen mother otters carrying their dead pups for a number of hours. That a strong maternal instinct continues until the young is nearly fully grown is frequently observed.

Late one summer afternoon on Amchitka Island in the Aleutians I watched a mother with a large pup, probably a yearling, hauled out on a rock below my hide. The pup investigated the rocky shelf, then went to the water's edge as if to swim. The mother watched intently and just as it appeared about to leave the rock, she rolled forward, grasped a hind flipper in her teeth and drew the surprised youngster back beside her.

PAST HISTORY

Sea otter fur was held in high esteem among Chinese of noble birth from early times. The second expedition of Vitus Bering, which sailed from Kamchatka in 1741, opened to the fur hunters of Russia, the *promyshlenniki*, the vast fur resources of Alaska. To Bering's starving men, marooned for the winter on the beaches of the island now known as Bering Island, sea otter flesh became a primary means of sustenance. The rich furs brought home by survivors of this tragic adventure soon stimulated others to seek fortunes among foggy, storm-beaten Alaska islands. Sea otters, being by nature trusting, were rapidly decimated, but the rugged nature of these islands and the frequent violent storms offered more natural protection than in milder latitudes along the Pacific coast.

The human deluge, which to this day is swelling the populations of Alaska and the northwest coast of the United States, received additional impetus in 1779 when the ships of Capt. James Cook dropped anchor at Macao after having visited Nootka Sound, Vancouver Island. Cook's crew suddenly discovered that skins which they were using as bedclothing and garments, and which they had purchased cheaply from the Indians, were worth thousands of dollars. Thereafter the soft fur of the sea otter was the objective of many of those who explored the coast and islands of the eastern North Pacific Ocean and, in 1785, the brig *Sea Otter* became the first ship to engage in the sea otter trade on the Pacific northwest coast.

Under the direction of white fur hunters, sea otters were mercilessly pursued, sometimes by teams of Indians in canoes; in more remote areas by white hunters in light skiffs carried to the otter grounds in larger ships. On bleak shores men waited for weeks among the rocks to shoot any otter that came within rifle range. Others sta-

tioned themselves at the tops of giant tripods, erected near favorite feeding or resting areas. Neither mothers nor pups were spared. A pup skin brought about $60, the skins of adults $200 to $300. So highly was the sea otter prized that by the end of the 19th century it had been hunted almost to extinction. The otters living off the western coasts of the United States were in fact thought to be extinct. However, in 1938 a group of 94 sea otters was discovered near Monterey, Calif. A reported 1957 count by Dr. Boolootian of 644 otters between Point Conception and Carmel Bay might indicate that at least 1,000 otters now inhabit the coastal waters of California. None have yet been reported from Oregon. A recent report, in August 1958, of sea otters seen on the outer Washington coast, although not confirmed, sounds encouraging. Recently observers have reported sea otters from British Columbia waters but their identification has not so far been confirmed. In 1929 a sea otter was taken in Kyuquot Sound. This is the last authentic occurrence.

In 1786 the Pribilof Islands were discovered by Russian fur hunters and their history demonstrates the course of thoughtless exploitation. In the first year of occupation as many as 5,000 sea otters were killed. By 1811 they were scarce animals and during the next 30 years were virtually exterminated. The last recorded skin in the Pribilofs was taken from an otter found dead in 1892. Of this once-thriving colony only scattered bones remain.

Fortunately some sea otters remained in the Aleutian chain of islands and this remnant received protection in 1911, under a treaty whose main purpose was to save the North Pacific fur seals. The seal populations have rapidly recovered; the recovery of the sea otters, on the other hand, has been slow.

SEA OTTER LIFE STUDIES

Some years ago the United States Fish and Wildlife Service decided to make a detailed study of the sea otter, both in the wild and in captivity. It was also hoped that isolated parts of its former range, such as the Pribilof Islands, might be restocked from remote places where high populations now exist. As the sea otter seldom ventures far from land, natural dispersal takes place slowly.

The place chosen for the studies was Amchitka Island which, except for its isolation and its distance of nearly 3,000 miles by the usual route from headquarters at Seattle, was an ideal place for the work. The island is approximately 40 miles long and from 1 to 4 miles wide, with a coastline of about 120 miles. The climate is windswept and fogbound—quite miserable by human standards, but apparently most appealing to sea otters. The otter population appears to be at, or very near, its natural maximum. As with deer on a heavily grazed range, a hard winter may leave many animals dead in its wake. Recent esti-

mates, based on sample field counts, place the population there at between 4,000 and 6,000.

The first stage of the work on the sea otter was done in the late 1940's by Robert D. Jones, manager of the Aleutian Wildlife Refuge. He found that the otters were very difficult to keep in captivity, and as a result of his recommendations, Dr. Donald Stulken and Dr. C. M. Kirkpatrick, both of Purdue University, went to Amchitka with a Fish and Wildlife team to study the physiology of sea otters and their response to conditions in captivity. Meanwhile Dr. Robert Rausch, parasitologist, of the Arctic Health Research Centre, conducted studies of animals found dead on the beaches during winter "die offs." As a result of all this work considerable knowledge was accumulated, and three captive otters were finally brought to Seattle by Mr. Jones in 1954. They were in excellent condition upon arrival but unfortunately succumbed when transferred to the National Zoological Park in Washington, D.C.

In 1955 a Fish and Wildlife team, including the author and under the leadership of Ford Wilke, captured sea otters at Amchitka and liberated 16 of them at Otter Island in the Pribilofs. Unexpectedly frigid weather conditions, with ice floes, complicated by the weakened condition of the captive animals, probably prevented their survival.

Work on Amchitka continues. During World War II the island had been used as a harbor and air base and it offers today disintegrating but usable facilities for our field studies. From the front porch of our salvaged quarters on clear days we watch the sea otters as they dive for food near the mouth of Constantine Harbor or haul out to sleep and preen on the small rocky islets there. But often, during summer months especially, this place of observation becomes useless. Fog banks move in about the island and remain for weeks at a stretch. In order to observe the otters closely it has been necessary to construct a hide on a cliff above a favorite feeding and resting area. From this vantage point, with binoculars and telescope, we may watch the otters on all but the foggiest of days.

In addition to studies on Amchitka a comprehensive aerial population survey in Alaska was undertaken by the Fish and Wildlife Service in the fall of 1957. Unfortunately, remote areas in the Aleutians, where a considerable part of the sea otter population appears to exist, could not be covered because of adverse weather. However, Dr. Calvin J. Lensink, who took a leading part in this project under the Branch of Wildlife Research, prepared total sea otter population estimates which indicate that sea otters have now repopulated a large part of their former range and that their numbers are increasing and spreading at an encouraging rate. Certainly the number in Alaskan waters can be placed conservatively at 30,000 animals. Dr. Lensink plans to publish a detailed report of his work.

Sven Waxell, second in command of Vitus Bering's shipwrecked crew, recorded that when they first reached shore on Bering Island the sea otters were quite tame but became wild after being hunted. It is not surprising, then, that the unmolested otters at Amchitka are not particularly wild, but we were surprised at the degree to which a wild otter could be tamed. In November of 1957 we began tossing fish heads to a young adult male that habitually loitered near our fish-cleaning platform. Within a few days he would come close to the beach at our call and within a week would come to the water's edge to take fish heads from our hands. In another week he became a pest, walking boldly up to us and demanding food. Without the need of a net we caught him and placed a metal tag in the web of his hind flipper. Not in the least upset by this indignity he demanded his fish before returning to the water. Wild sea otters never eat on land, and so our "wild" pet often returned with difficulty over cobbles and boulders to the sea while attempting to walk on three legs, clasping fish heads to his chest with the fourth.

THE SEA OTTER IN CAPTIVITY

The sea otter is a most appealing animal in captivity as well as in the wild. Although individual characteristics of the animals differ, we find that many of them are very tractable and will quietly take food from our hands within a few minutes of capture. On the other hand, a yearling female that we caught in September 1955 was so shy that nearly a week passed before she could be induced to take food that we held out to her. When first captured, she leaned against the back of her cage in a half-sitting position watching our movements wide-eyed, as if in astonishment. When we brought her sea urchins and fish she placed her forepaws on her cheeks and hissed in a very catlike way, or pushed the proffered food away with her paws. After she became accustomed to us she readily took food from our hands, never offering to bite with her strong canine teeth. This animal is now in excellent health at the Woodland Park Zoo in Seattle. By the spring of 1957 she had nearly reached adult size and appears well adapted to life in captivity. In December of 1957 we captured a young male on Amchitka which shared her Seattle quarters until he died in September of 1958. Acute hemorrhagic enteritis appeared to be the immediate cause of death.

Sea otters require a large amount of food, which poses a difficult problem when captives are kept at Amchitka. In order to supply the minimum of 6 to 8 pounds of fresh fish required daily by each adult otter, a dory must be launched, nets set and pulled daily. In the stormy, chilly winds that sweep the Bering Sea such a project is a major undertaking when it must be conducted on a sustained basis. Our captive female in Seattle weighs 39 pounds and eats approxi-

mately 10 pounds of filleted fish, octopus, and clams each day. The male weighed 64 pounds and ate about 15 pounds daily. Thus, food intake amounts to about one-quarter of the body weight for each animal daily. Sea otters are often temperamental and will suddenly refuse to eat one kind of food which previously was preferred, while eating ravenously something entirely different. Dried or canned foods have been consistently rejected. One day, however, a zoo official told a visitor, preparing to toss a slice of bread to the sea otters, not to do it because the animals would not eat bread. The visitor disregarded instructions and, surprisingly, the otter ate the bread.

The use of a rock, held on the chest of an otter, as a base against which to break the hard shells of mollusks, has often been described. When rocks and clams were placed in our captive's pool, she gathered them from the bottom and, holding the clams between her forepaws, banged them against the rock resting on her chest until the shells broke, thus confirming at close range what had previously been observed only at a distance.

The manual dexterity of the sea otter is well illustrated by the unique habit described above, but we found our captives ingenious in other respects. The drain in the zoo pool was covered by metal mesh which fitted snugly in place. This the otter promptly removed when she entered the pool. Apparently the dark hole beneath fascinated her. Since food scraps plugged the open drain, her keeper secured a band of strap iron over the mesh with a bolt that projected above it. Undaunted, the sea otter pounded the bolt with a rock until she succeeded in dislodging it. Rocks have now been removed from the pool, for in addition to attacking the drain she whiled away idle hours by pounding the edges of the pool until the cement was considerably damaged.

The problem of adjusting sea otters to captivity so that they may be successfully transplanted is a challenging one and we still face many difficulties. Captive animals, when held in small cages and deprived of free access to water, often die of enteritis, pneumonia, or infections of the extremities. The difficulty of keeping their soft fur clean and in waterproof condition is complicated by the fact that they like to eat while lying on their backs and that their natural food contains an abundance of slimy fluid. Unless adequate facilities are provided for washing, their fur quickly becomes matted with foreign matter. The animals soon become wet to the skin, chilling results, and, after several hours of distress, death usually follows. After traveling by air in cramped cages the two otters brought to the Seattle zoo required a week of painstaking care before their fur regained its waterproof insulating qualities. Frequent indoor warm-water baths followed by periods of drying in heaps of shredded paper were necessary to prevent chilling. Doses of antibiotics during this critical period prevented the usual infections.

1. While feeding, a mother sea otter allows her young pup to float on the surface. This mother has just finished eating and is about to grasp her pup in her forelegs to place it on her chest.

2. A mother sea otter preens her pup's fur while the pup nurses from her abdominal nipples. Usually a pup nurses while its mother floats on her back, but occasionally, especially in late afternoon, the mother takes her pup ashore where she preens and dries its fur and allows the pup to nurse.

1. During an afternoon resting period a mother sea otter carries her sleeping pup on her chest.

2. While heavy storm waves pound outer reefs off Amchitka beaches, otters frequently retire to sheltered beaches where they sleep. This old male has just been aroused and is about to plunge into the water.

1. Bill Golley, an Aleutian native, has just netted a sea otter. Cal Lensink helps him land it on a slippery kelp-covered rock. The battered hulk in the background is the *Crown Reefer* which was driven on this reef during a storm in 1946.

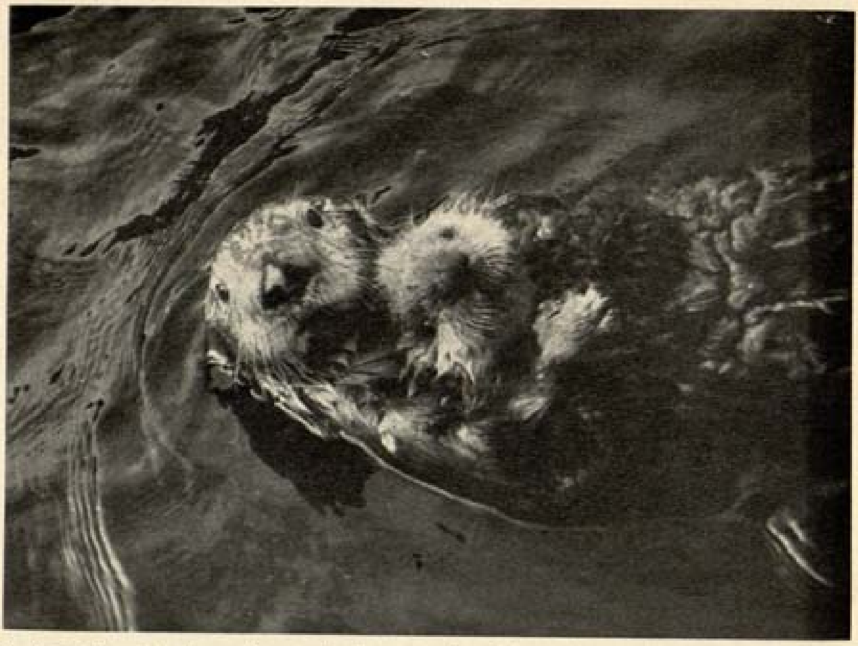
2. A newly captured 70-pound male otter is carried from the beach across tundra to the road. Otters have favorite hauling grounds where they can be approached and netted while they sleep. Although they frantically fight to free themselves from the net when first captured, they quickly accept captivity and become tame.

1. A wild otter accepts a fish head from the hand of Robert Krear. This otter loitered near our fish-cleaning platform where he was given fish scraps. He soon learned to leave the water and follow us to beg for food.

2. A captive female otter pounds a clam held in her paws against one resting on her chest in order to break the shell. A rock may also be held on the chest for use as an anvil on which to break hard-shelled mollusks.

1. A captive sea otter squints as she pounds a clam on the cement edge of her pool. Although the whiskers grow long in captivity, they are characteristically abraded short on wild animals.

2. An adult sea otter, his forepaws pillowing his head, rests among rocks of an Amchitka beach.



1. A mother otter clasps her week-old pup to her chest as both stare in surprise at the photographer.

2. Adult sea otters.

During 1957 field studies on Amchitka we constructed a large artificial pool with a supply of running fresh water. In this we found that otters remained healthy and quickly adjusted to a feeding schedule. But results were disastrous when we attempted to transport them by air, as we had previously done successfully. They became highly excited when suddenly transferred from the pool and large enclosure to small traveling cages and died as a result of lung hemorrhages after a few hours of air travel. This was an unexpected development, since other animals previously carried by air had not died from this cause. Even tranquilizers failed to remedy the situation.

Through our study program, which embraces the keeping of otters in captivity and understanding their habits in the wild, we hope to enlarge our knowledge of their ecology, life history, and populations. We are gratified to know that the sea otter is safe from extermination and hope that it may some day take its place with the northern fur seal as a valuable and renewable natural resource, under a carefully controlled program.

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Screwworm Eradication: Concepts and Research Leading to the Sterile-Male Method

By E. F. Knipling
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[With 6 plates]

A new approach to insect control is now being applied in the Southeastern United States to deal with the screwworm, *Callitroga hominivorax* (Cqrl.), one of our most damaging pests of livestock and game. The procedure involves the use of atomic radiations to produce sexual sterility in millions of insects reared in an insect factory. The sterile screwworm flies are then released against their own kind to defeat the primary purpose for their existence—reproduction.

This unique insect-control program is being conducted by the Animal Disease Eradication Division, Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the Florida Livestock Board. It is the culmination of 8 years of pioneering research, both basic and applied, which was conducted by a group of Department of Agriculture entomologists with the Insects Affecting Man and Animals Research Branch of the Entomology Research Division.

Utilizing knowledge of the effects of atomic radiations on insects and of screwworm life history, habits, and ecology, a method of biocontrol has been developed which probably represents the ultimate in precision and efficiency. The research leading to this development has been described in a number of publications: Bushland and Hopkins (1951 and 1953), Baumhover et al. (1955), Lindquist (1955), and Knipling (1955). It will not be necessary, therefore, to discuss the details. However, it seems desirable to review the most significant features of the investigations and the control program now under way. It seems appropriate also to speculate on the place that the sterile-male method might have in the control of other major insect pests.

SCREWWORM BIOLOGY, ECOLOGY, ECONOMIC SIGNIFICANCE, AND METHODS OF CONTROL

The screwworm fly (pl. 1, fig. 1) is an obligatory parasite of warm-blooded animals. Eggs (pl. 1, fig. 2) numbering 200 to 300 are de-

posited in a compact mass on wounds of these animals. The larvae hatch in less than 24 hours. They begin feeding on the tissues and reach maturity in about 5 days (pl. 2, fig.1). The larvae then leave the wound, drop to the ground, and enter the soil for pupation (pl. 2, fig. 2), emerging as adults in about 8 days during warm weather.

Larvae cause severe destruction of tissues, producing a straw-colored and often a bloody discharge from the wound. An infestation attracts more screwworm flies, resulting in multiple infestations consisting of several hundred to several thousand larvae of all sizes (pl. 6). Feeding by the large number of larvae will kill the host unless the infestation is destroyed and the wound is treated with protective remedies. Several screwworm smears and other preparations are in use to treat or prevent infestations. These remedies and good livestock-management practices which reduce the number of susceptible wounds minimize losses. In spite of these control efforts, the insect causes losses in the United States which are estimated to vary from $20 million to $40 million annually. An additional loss of game animals, particularly deer, cannot be measured in terms of dollars.

The screwworm is largely a subtropical insect. Cold winter weather pushes the infestations into warmer areas. In the Southwest the winter survival area in south Texas usually does not exceed 30,000 to 40,000 square miles. In the Southeast, during normal winters, the survival line is about as far north as Gainesville, Fla. In the spring there is an upsurge of screwworm flies, and the pest spreads rapidly. The rate of natural spread northward may be as much as 25 to 35 miles per week. In addition to natural spread the insect often becomes established early in the season outside of its normal range through shipment of infested animals and increases to damaging levels before frost.

DEVELOPMENT OF CONCEPTS AND RESEARCH LEADING TO THE STERILE-MALE TECHNIQUE FOR CONTROL

A. W. Lindquist (unpublished reports, 1935) obtained data which showed that the total number of screwworm flies in the environment is low in comparison with most insects. This significant feature in screwworm population dynamics has an important bearing on the use of sterile males for their control. Melvin and Bushland (1936) developed a method of rearing the insect on an artificial medium in the laboratory, which provided a vital link in the chain of events leading to the sterile-male technique for control.

The possibilities of screwworm control by utilizing some natural or induced mutant characteristic that would not be detrimental to the insect when reared in the laboratory but would place it at a disadvantage in nature were first considered by the writer in 1937. Of the possible genetic approaches, the one that seemed to warrant

most promise was the use of sterile males for release among a natural population of flies. Several entomologists and geneticians had demonstrated that X-rays would cause sexual sterility in insects.

This approach to screwworm control was proposed to a number of scientists, but little enthusiasm for its posssibilities was generated. The war years, which led to emphasis on medical entomology problems, delayed investigations. However, following the war more serious thought was given to the initiation of research on the problem. Survey records of past years and published data on screwworm incidence, particularly in the Southeast, were studied for the purpose of estimating the number of flies present in an area during periods of low population density. Potential costs of rearing the insect in terms of millions per week were calculated. Theoretical trends in the screwworm population were calculated on the assumption that it might be feasible to dominate the wild male population with sexually vigorous but sterile males. There were many unknowns in screwworm behavior, ecology, population dynamics, and reaction to irradiation, and it was recognized that failure of any one of several seemingly plausible assumptions could demonstrate the impracticability of the method. However, the results of the theoretical calculations were too impressive to ignore.

The decision to commit limited research funds to this approach was made following communications in 1950 with H. J. Muller of Indiana University, noted geneticist, Nobel prize winner, and authority on the effects of X-rays on organisms. When the general plan for screwworm eradication by the release of sexually sterile males was outlined to him, he responded with enthusiasm and encouragement and also offered advice on procedures to follow in determining the effects of X-rays on the insect.

A definite research program on the problem was initiated in 1950. The work was undertaken at the Kerrville, Tex., laboratory, under the able direction of R. C. Bushland. Before the X-ray studies were begun, G. W. Eddy, then with the Kerrville laboratory, made some observations on the frequency of mating among females of the screwworms. These observations, later confirmed by Bushland, indicated that the females were monogamous in mating habits. At that time the frequency of mating by the females was regarded as a vital point in the potential feasibility of effecting control by the sterile-male approach. Information obtained since that time, however, indicates that although multiple mating may reduce the effectiveness of sterile males, this is not necessarily a limiting factor in the successful application of this method.

Bushland and Hopkins (1951) established that screwworm males could be made sterile by exposing pupae near maturity to 2,500 roent-

gens from X-rays. Sterility in the female resulted at a dosage of 5,000 roentgens.

Cage tests, in which irradiated males were in direct competition with normal fertile males, showed that the mating habits of the sterile males were essentially the same as for normal males. There was no evidence of discrimination on the part of females. However, females that had mated with sterile males would not mate subsequently with fertile males. When sterile and fertile males in ratios ranging from 1:1 to 9:1 were present in a cage with normal virgin females, the ratio of sterile to fertile egg masses produced by the females was essentially the same as the ratio of sterile to fertile males. The presence of sterile females in the cages did not seem to alter the results.

Thus numerous laboratory tests by these investigators, using X-ray equipment furnished by the Army at Fort Sam Houston, San Antonio, Tex., and a cobalt-60 irradiation unit provided by the Oak Ridge National Laboratory, indicated promise for screwworm population control through the use of sterile males.

The next stage in the investigations involved field experiments. Would the method reduce the biotic potential of natural screwworm populations? The answer to this question was not easily obtained. How many wild flies were emerging in an area during various seasons of the year? How far and how soon after release would the released insects migrate, and would they disperse uniformly among the natural population? What ratio of sterile to fertile insects would be required to start a downward trend in the natural population?

These were some of the many unknowns. Because of strong migration tendencies of the flies, it proved futile to attempt to obtain reliable information in small to moderate-size areas surrounded by heavily infested territory. It was concluded that small isolated islands offered the best opportunities for valid tests with the research funds available. Consequently, one of the islands off the west coast of Florida, called Sanibel, having an area of 15 square miles, was selected for tests. Fertile flies heavily charged with P^{32} were first released on the island at the rate of 100 females and 100 males per square mile to get some idea of the natural population. Eggs deposited by the released flies on host animals could be distinguished from those deposited by natural wild flies because of the radioactivity. The ratio of radioactive to nonradioactive egg masses obtained suggested that the release of 100 reared males per week provided more released than wild flies in the population. A subsequent program in which sterile males were released at the rate of 100 per square mile per week resulted in virtual elimination of a natural population within a few months, but eradication could not be demonstrated because a few fertile flies were migrating onto the island from the mainland or nearby infested islands.

The opportunity for a more reliable experiment was afforded when arrangements were made for a cooperative program on Curaçao in the Netherlands Antilles, an island of 170 square miles isolated by 40 miles from any other land area. An agreement was developed between the Governor of Curaçao and the Administrator of the Agricultural Research Service to undertake a screwworm eradication experiment. A. H. Baumhover, who was in charge of field tests in Florida, conducted pretreatment surveys. Plans were made to rear and irradiate the screwworms at the Orlando, Fla., laboratory of the Entomology Research Division and then ship the pupae by air express to Curaçao for distribution of the emerging flies. Over-all plans for the experiment were developed by R. C. Bushland, A. W. Lindquist, and the writer. Dr. Bushland was in charge of the entire program. A. H. Baumhover and B. A. Bitter, veterinary officer on Curaçao, were in charge of the work on Curaçao, and A. J. Graham and D. E. Hopkins were in charge of screwworm production in Florida. These individuals, who worked directly on the program, as well as several other assistants deserve great credit for their extraordinary efforts in the conduct of this program.

The eradication attempt was started on August 9, 1954. Sterile screwworm flies were released on Curaçao from airplanes at the rate of about 400 sterile males per square mile per week, which provided an estimated ratio of 3 or 4 sterile to 1 fertile insect in the population.

Table 1 shows the results of egg-mass collections on host animals exposed in 11 locations on the island. The complete life cycle of the screwworm during warm weather requires about 3 weeks. It is indicated, therefore, that eradication was achieved in about four generations. These results were more striking than any of us had hoped for. The population decline followed closely theoretical trends that had been calculated.

TABLE 1.—*Fertility of screwworm fly eggs and decline in number of egg masses in the eradication experiment on Curaçao*

Weeks after start of experiment	Number of egg masses		Percent of sterile egg masses
	Fertile	Sterile	
1	15	34	69
2	17	38	69
3	17	36	68
4	10	37	79
5	7	42	86
6	3	23	88
7	0	10	100
8	0	12	100
9	0	0	-------

Table 2 shows the theoretical population trends when an insect population is assumed to be stable—that is, when one generation in the absence of special control effort would result in equal numbers of progeny in the next generation. The example also assumes that the ratio of two sterile to one fertile insect will result in a maximum theoretical reduction in progeny. The figures show that a rapid and dramatic decline in an insect population is theoretically possible. It is realized that the maximum decline can hardly be expected in most situations. However, calculations indicate that if only 25 percent of the theoretical decline were achieved the end result would still be eradication after about seven generations.

TABLE 2.—*Theoretical population decline in each subsequent generation when a constant number of sterile males are released among a natural population of 1 million females and 1 million males*

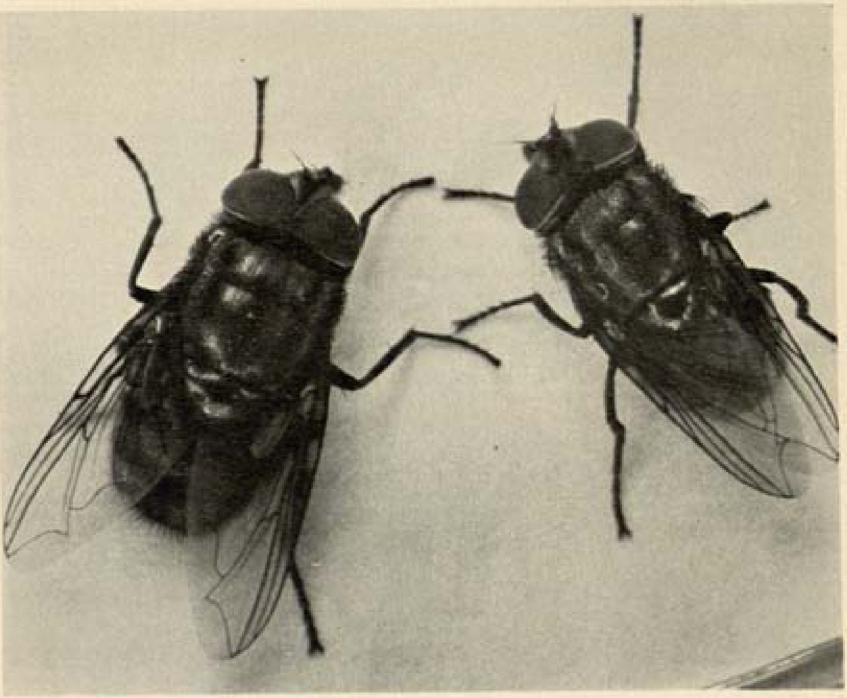
Generation	Number of unmated females in area	Number of sexually sterile males released	Ratio of sterile to fertile males competing for each female	Assumed percentage of females mated to sterile males	Theoretical number of fertile females
1	1,000,000	2,000,000	2:1	66:7	333,333
2	333,333	2,000,000	6:1	85.7	47,619
3	47,619	2,000,000	42:1	97.7	1,107
4	1,107	2,000,000	1,807:1	99.95	[1]

[1] Less than 1.

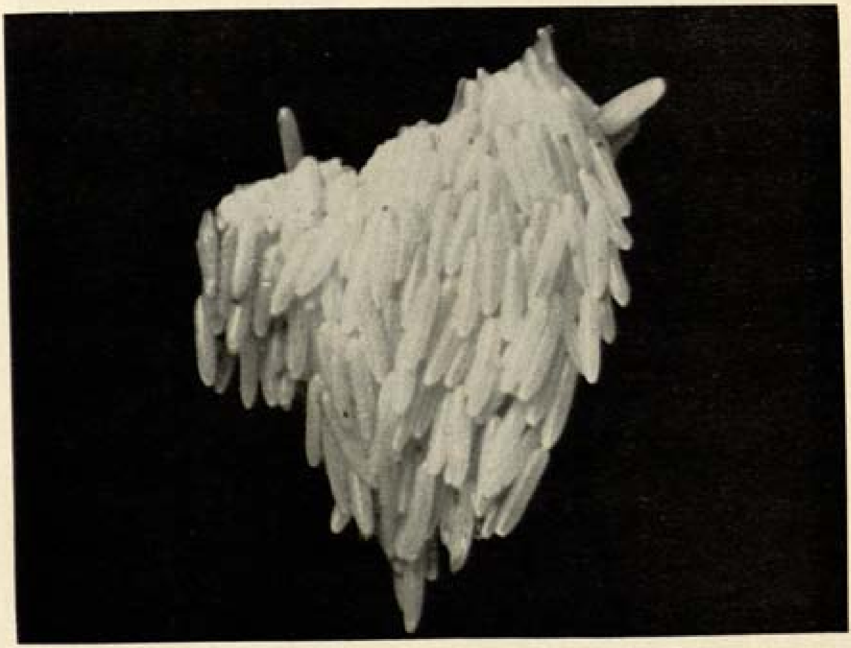
FURTHER RESEARCH POINTING TO SCREWWORM ERADICATION IN THE SOUTHEASTERN UNITED STATES

Following the success on Curaçao, the Florida Livestock Board urged further research to adapt the method for an eradication program for the Southeast and contributed funds to the effort. Additional funds were appropriated by Congress to further support the expanded research program. The Insects Affecting Man and Animals Research Branch, under the direction of A. W. Lindquist, assigned additional members of the research staff to the project. Emphasis was placed on efficient and economical methods of rearing the millions of flies that would be needed for an eradication program, involving an area of 50,000 square miles or more. A small pilot plant having the capacity to produce 2 million flies per week was constructed. Mass rearing methods were developed utilizing various types of media and rearing facilities as well as methods of handling the brood colony of flies to obtain the maximum number of eggs. Procedures were devised for irradiating large numbers of pupae, and for their proper care until adult emergence was completed. Equipment for dispersing the flies from aircraft was designed.

There was little precedent to follow in developing the various procedures required for such a program. Every operation required new techniques, new facilities, new equipment. Credit is due each and



1. Adult screwworm flies, male left, female right. The screwworm is about three times as large as the common house fly.



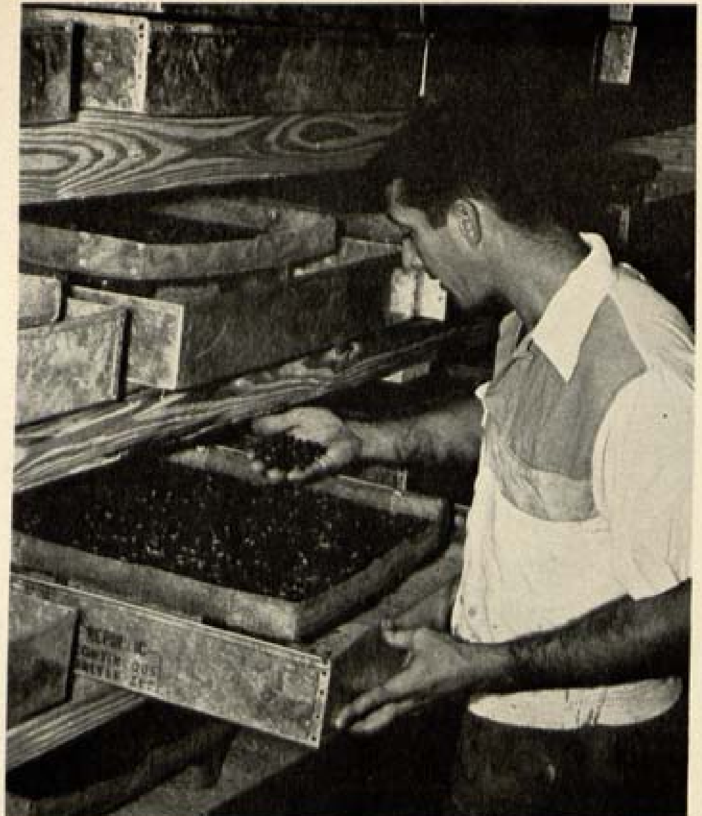
2. Eggs of the screwworm fly. Each female deposits 200 to 300 eggs, usually in a single compact mass, on the edges of wounds on the host. (See pl. 6.)

1. Larvae of the screwworm fly are two-thirds of an inch long when mature and about as thick as a kitchen match.

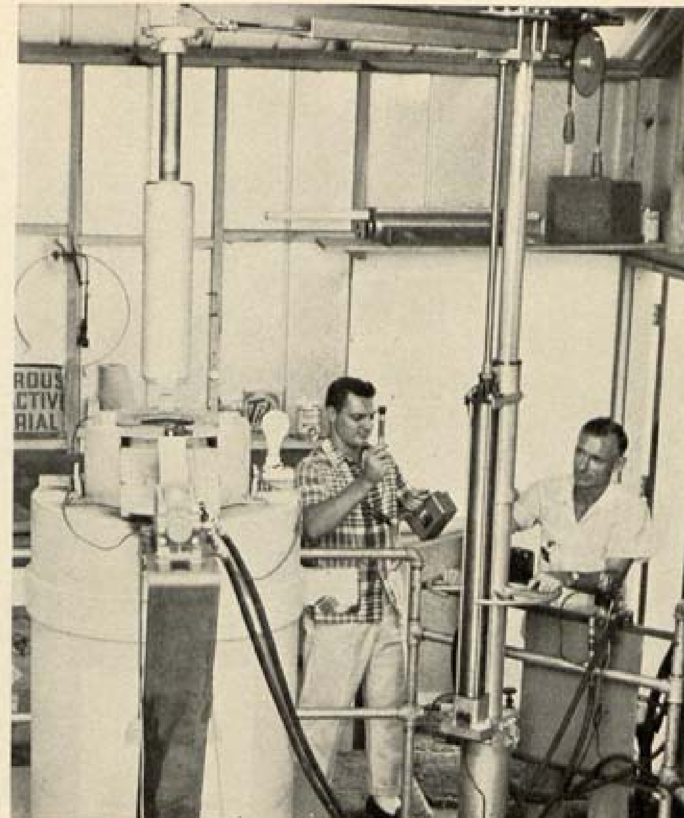
2. Pupae of the screwworm fly form after mature larvae leave the wound and dig into the soil.

1. The production of 50 million screwworm flies per week requires thousands of brood flies. The adults are held in cages of a different design and larger than shown here, and are fed honey and moist ground meat. After about 8 days eggs are obtained by exposing warmed screwworm media in the cages.

2. The screwworm larvae are reared in large flat vats, as shown. About 200,000 larvae are produced in each vat after feeding on the ground meat-blood medium for about 5 days.

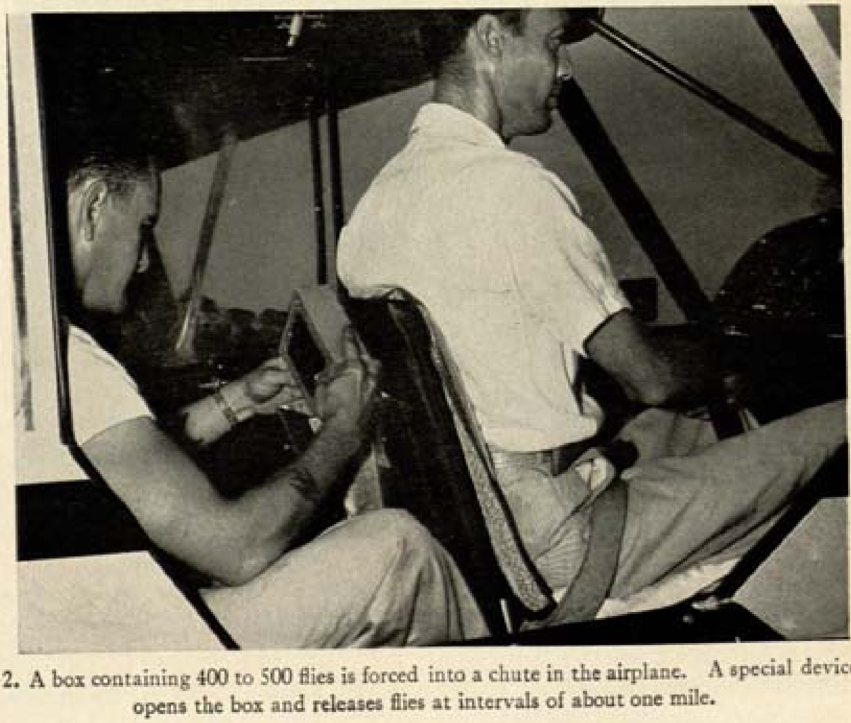


1. Mature larvae transform into pupae in sand within 24 hours. The pupae are then sifted from the sand and held in screen-wire baskets, as shown, until they are ready for exposure to cobalt-60 radiation.

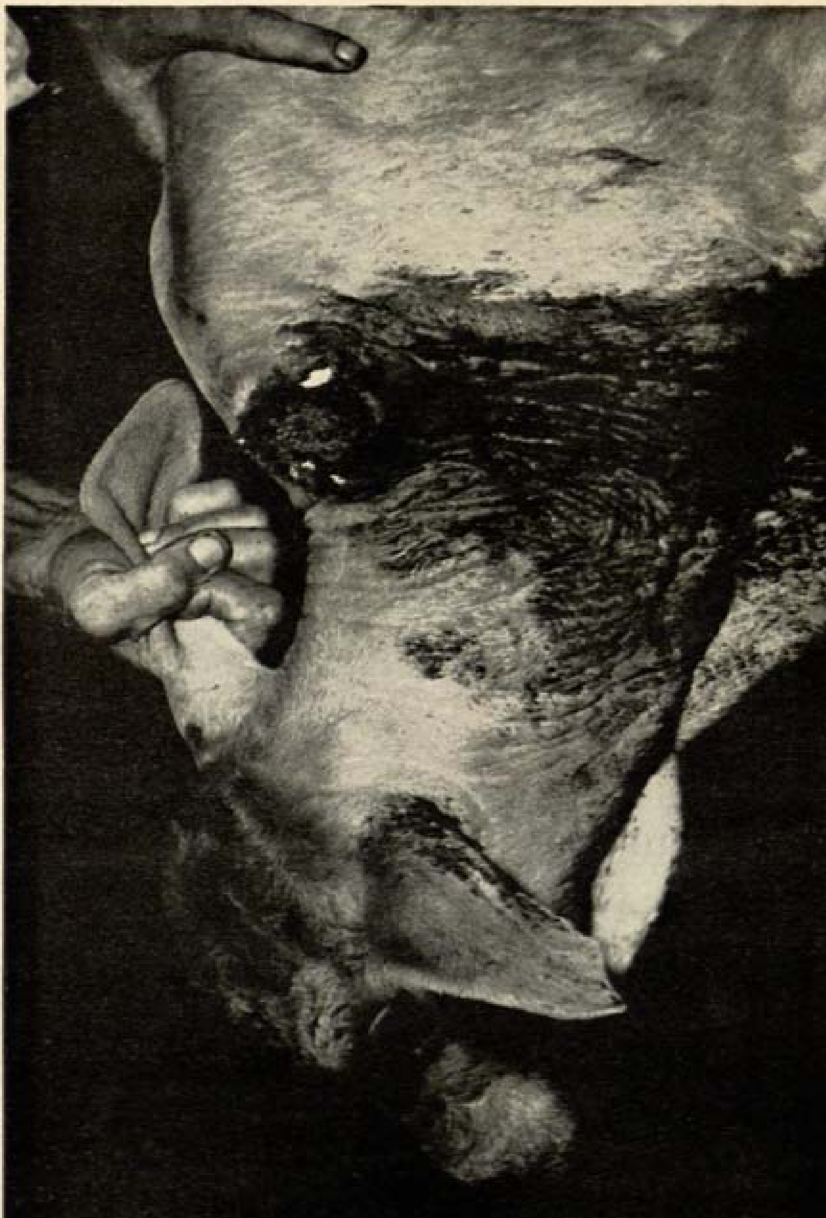


2. On the sixth or seventh day pupae are exposed in the cobalt-60 unit shown. The canister above the unit containing the pupae is lowered into the open chamber long enough to obtain a dosage of 8,000 roentgens.

1. Flies emerge from irradiated pupae in paper boxes, and when ready for release are loaded in the airplane for distribution.



2. A box containing 400 to 500 flies is forced into a chute in the airplane. A special device opens the box and releases flies at intervals of about one mile.



A typical severe screwworm case. Infestations may occur in any part of the body. Note how larvae are packed in the wound and the wound discharge on the neck and shoulders. Note also eggs on the wound margins.

every member of the staff. R. C. Bushland gave over-all direction to the research program which was carried out by C. L. Smith, A. H. Baumhover, A. J. Graham, C. N. Husman, D. E. Hopkins, and F. H. Dudley.

By July 1957 most of the necessary information and procedures had been developed. A report outlining plans, procedures, and facility needs for an eradication program was prepared and considered by Federal and State regulatory officials. The Florida livestock industry was instrumental in obtaining State appropriations and through their Congressmen obtained Federal appropriations for the Department of Agriculture. The responsibility for carrying out the program at the Federal level was assigned to the Animal Disease Eradication Division of the Agricultural Research Service.

In the fall of 1957 construction was started on a large screwworm rearing plant at Sebring, Fla. Plans called for completion of the plant by July 1958.

Then came a real break. The winter of 1957–58 was one of the most severe ever experienced in Florida. By December it was realized that unusually cold weather might push the overwintering screwworm deep into Florida. The Animal Disease Eradication Division proposed the initiation of the eradication as soon as possible with flies produced in the pilot plant. Together with the Entomology Research Division they devised a plan for releasing sterile flies in a zone below the overwintering line to establish a barrier and prevent or delay the normal northward spring migration. Fly production started early in January and the number produced was gradually increased until a maximum of about 12 million per week were released in mid-July when the large rearing plant came into production. This timely release program prevented screwworm buildup in the northern half of Florida. The alertness in putting this program into effect may make it possible to achieve eradication of the insect much sooner than expected.

The eradication program, under the able direction of Drs. R. S. Sharman and D. L. Williams of the Animal Disease Eradication Division and Drs. C. L. Campbell and M. E. Meadows, Jr., of the Florida Sanitary Board, was in full operation by September 1958. By February 1959 few screwworm cases were being found in the entire State of Florida. These men and their staff members are to be commended for their alertness and effectiveness in the conduct of the program. Success in achieving eradication of the screwworm in the Southeast is assured.

The research leading to its development and the eradication program itself are probably the most unusual ever carried out in the annals of insect control. Details of the program and the facilities required have been described in a United States Department of Agriculture publication issued in July 1958 by the Florida Livestock

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Board and the Animal Disease Eradication Division (Illustrated Descriptive Bulletin No. 1) and in Florida Information Office Illustrated Bulletin No. 2, issued November 1958 by the Florida Livestock Board and the U.S. Department of Agriculture. The adult brood colony, consisting of thousands of flies (pl. 3, fig. 1), furnishes eggs to start the fly production. The larvae are reared in a medium consisting of ground meat and blood in large vats (pl. 3, fig. 2). The temperature of the medium is about 99° F., simulating body temperatures of the screwworm's hosts. The pupae are placed in screen-bottom trays (pl. 4, fig. 1) and held at 80° F. for about 6 days. They are then exposed to irradiation in a cobalt-60 gamma-ray unit (pl. 4, fig. 2). The dosage is 8,000 roentgens, which assures sterility of both male and female insects. Several hundred irradiated pupae are then placed in special boxes, where they emerge in about 2 days. The flies from each box are liberated at intervals of about a mile from planes assigned to various sectors in the eradication area (pl. 5, figs. 1 and 2). The number of flies released per square mile varies with the number of sterile flies available and abundance of screwworms in the natural population.

The following are a few statistics which indicate the magnitude of the program. The screwworm rearing plant is designed to produce 50 million flies per week. The sterile insects (both sexes) are released at the average rate of 1,000 per square mile per week in an area of 50,000 square miles. About 80,000 pounds of ground meat and 4,500 gallons of blood are required per week as larval food. Six cobalt-60 units are available to irradiate the pupae. Twenty airplanes are needed to distribute the flies. The staff consists of 200 to 300 workers in the fly-production plant and about 50 inspectors keep check on screwworm abundance and on the results of the operation. A group of scientists supervises the operations, and others are concerned with methods improvement. A quarantine line has been established along the Mississippi River for the inspection and treatment of animals to prevent screwworm establishment from infested hosts shipped from the Southwest.

Results of the program will in time be published, but there is every indication that the objective, as on Curaçao, will be achieved much more rapidly than we had dared to hope for.

WILL THE STERILE-MALE METHOD PROVE USEFUL FOR CONTROLLING OR ERADICATING OTHER INSECTS?

The successes against the screwworm on Curaçao and in Florida have stimulated interest by biologists to explore the sterile-male method for controlling other insects. There is reason to believe that this new biological-control technique might prove practical for eradicating or controlling certain other major pests. A number of require-

ments must be met, however. These have already been discussed in some detail (Knipling, 1955). The major requirements are (1) a method of causing sterility in the insects without seriously affecting survival and mating behavior, (2) practical methods of producing large numbers of sterile insects, (3) adequate dispersal of the insects released so that they will mix with the natural population, and (4) no danger of damage to crops, animals, or man by the insects released. Contrary to statements in the literature, single mating habits of the insect species is not necessarily an essential requirement.

Research on the oriental, Mediterranean, and melon fruitflies, which the Entomology Research Division has had under way for several years at its Honolulu laboratory, is now being intensified to explore the possibility of utilizing the sterile-male method to eradicate or to prevent the spread and establishment of these major pests of fruit and vegetables. The work is being done under the general direction of L. D. Christenson. The research at Honolulu, under the immediate supervision of L. F. Steiner, shows considerable promise. Although all the fruitflies named have multiple mating habits, experiments in cages show that a ratio of about 10 sterile to 1 fertile male insect results in a high reduction in biotic potential of the flies. Methods of rearing fruitflies in the laboratory on a large scale have been developed. The seasonal population trends for fruitflies show wide variations in most infested areas. The use of bait sprays or male lures has been found to reduce existing populations drastically, if necessary. The insects are also of sufficient importance to warrant a substantial investment in eradication programs. These factors all suggest that full exploration of the sterile-male method for fruitfly eradication is justified.

The Mexican fruitfly problem in California and Texas should also lend itself to practical solution by the sterile-male approach, and research to explore the possibilities is under way by the Division's Mexico City fruitfly laboratory under the immediate supervision of W. E. Stone.

NEED FOR ADDITIONAL RESEARCH

Basic information is urgently needed on other major insects before we can estimate the possibilities of the sterile-male method as a practical control or eradication procedure. In some situations the technique might be useful for control or elimination of the pink bollworm, boll weevil, European corn borer, southwestern corn borer, sugarcane borer, codling moth, plum curculio, oriental fruit moth, tobacco and tomato hornworms, yellow fever mosquito, and no doubt other insects in the United States or other countries. The method might be useful in the following types of situations: (1) As an outright eradication measure in areas of low insect populations; (2) as a final eradication procedure following drastic reductions of well-

established infestations by the use of chemicals or other means; (3) as a means of eradicating incipient infestations; (4) as a means of preventing further spread of insects that have not yet reached the limits of the survival area; (5) as a means of preventing or retarding spread of pests from overwintering areas.

For an appraisal of the possibilities of this new approach to insect control, investigations must be conducted along the following lines: (1) The effect of atomic irradiations on the reproductive capacity of the insects; (2) the effects of the irradiations on length of life and sexual behavior of the insect; (3) the mating habits of the insect; (4) population studies, with particular reference to actual numbers of insects in a given area during low points in the seasonal cycle or in areas of new establishment; (5) the biotic potential or normal rate of increase per generation under natural conditions; (6) the nutritional requirements of insects, with particular emphasis on the development of economical means for mass production; (7) the flight range and dispersal habits of insects; and (8) methods of separating sexes at low cost for species in which the released females may cause excessive damage.

These investigations will by no means supply answers to all questions that might arise in considering the possible use of sterile males for controlling specific pests.

However, until we obtain such information we cannot forecast just how useful the method will be in dealing with insect problems in the United States and in other parts of the world. There is every reason to believe that this new approach to insect control is sufficiently promising to warrant exploration for many of our major insect pests.

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Narrative of the 1958 Smithsonian-Bredin Caribbean Expedition

By Waldo L. Schmitt
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[With 10 plates]

This narrative is based on the fieldwork of the second Caribbean expedition sponsored by Mr. and Mrs. J. Bruce Bredin, of Wilmington, Del.[1] The scientific staff assembled in Miami for an airflight rendezvous in St. Thomas, Virgin Islands, whence the expedition departed on March 25, 1958, for a 6-week cruise among those islands, British and American, and the northern British Leewards. The expedition was brought to a close at English Harbor, Antigua, B.W.I., in time for a May 4 return to the States.

The Smithsonian Institution, as before, was primarily interested in building up its study collections and enhancing its representation of the animal and plant life of the West Indian-Caribbean area; and also adding to our knowledge of the zoogeographic distribution of this fauna and flora. In the course of the earlier expedition, 4,000 plant specimens, 18,000 insects, more than 27,000 marine invertebrate animals, and some 1,700 specimens of fishes were collected for the U.S. National Museum. The over-all results of the 1958 expedition are yet to be assessed.

EXPEDITION PERSONNEL

For the 1958 cruise we were most fortunate in having again the *Freelance*, the 86-foot schooner-yacht which served us so well on the 1956 expedition, with Capt. Desmond Nicholson in command. Our professional staff this year included J. Bruce Bredin, sponsor of the expedition; John Finlay, conchologist of Varadero, Cuba; Dr. Carl N. Shuster, Jr., director of the University of Delaware's marine laboratories at Newark and Lewes, Del.; Dr. J. F. Gates Clarke, curator of insects in the U.S. National Museum, entomologist also on the previous Caribbean expedition; and the author, research associate of the Smithsonian Institution, of which Mr. Bredin is also an honorary fellow.

[1] An account of the first Caribbean expedition appeared in the Smithsonian Report for 1956, pp. 443–460, 1957, under the title "A Narrative of the Smithsonian-Bredin Caribbean Expedition, 1956."

Captain Nicholson, aside from being master of the *Freelance*, could also be counted a member of the scientific staff aboard. His nautical know-how, his experience in skin diving, and his consuming interest in the lives and kinds and whereabouts of the animal life of the sea, stemming from the biology studies of his schooldays, all combined to make him an invaluable addition to our staff.

John Finlay knew not only most of the West Indian mollusks at sight, but also where to find and how to collect them. To the latter end he brought along three very successful mollusk traps of his own devising, and personally attended to baiting and setting them out one day and hauling them the next, after an overnight "soak." This was no mean task, as the traps are most successful in deeper waters, 30 to 100 fathoms or more. Dredging, skin diving, and wielding his Weber scoop were other means he employed to add to our take of mollusks. This Weber modification of the original Needham scoop is a rectangular affair about a foot square and 6 inches deep, of galvanized mesh with strongly reinforced edges. Scarifying the sea bottom of sand and mud and weedy flats with one of the sharp sheet-metal corners, he was able to dip up and sift the dislodged bottom material for whatever mollusks it contained.

Dr. Shuster, an authority on horseshoe crabs (which, however, do not live in the area we covered this year), is also keenly interested in molluscan shellfish from an ecological point of view, their relationship to their environment particularly, as well as their rate of growth and manner of shell deposition. He, too, obtained an abundance of material and careful measurements of several species, the analysis of which will occupy him for months to come.

Dr. Clarke is a microlepidopterist, an authority on little moths, those that are brethren, so to speak, of the tiny pests whose larvae destroy our unguarded woolens—clothes and blankets—or infest our cereals. Intimate knowledge of these insects—their kinds and whereabouts, their host plants or favorite foods, and their ways of life—is of extreme economic importance. The codling moth alone causes losses to our apple crops running more than $9 million a year, and the spruce-budworm, representing another microlepidopteran, has been known to destroy over $4 million worth of timber in a year. These are but 2 out of the 40,000 known species of Microlepidoptera. The great majority are not of much economic importance, but some 10 or 15 percent of them are harmful species, injurious to plants and crops and other belongings of man.

The Microlepidoptera are primarily nocturnal and so are best captured at night by means of a light trap. The one employed by Dr. Clarke consists of a sizable 3-foot metal cone suspended from a tree or an improvised tripod. A brilliant light such as a gasoline lantern is hung partly within the wider upper end of this cone; a cyanide

bottle is screwed onto its lower narrow, funnellike end. The light-attracted insects getting or falling within the cone are quickly overcome by the cyanide fumes and so are held until the trap is emptied the next morning. As this was an after-dark operation, Dr. Clarke spent more than one night ashore, mosquito repellent close at hand, He made overnight stays on Barbuda, Anguilla, and Redonda.

EXPLORING ISLAND CAVES

The first cave visited was Dark Cave on the island of Barbuda. From the town of Codrington, the seat of the local Barbudan government and the residence of the administrator of the island's affairs, who is also postmaster, it was a horseback ride over some of the rockiest, shrubbiest, and thorniest terrain that any of us had ever traversed. In my experience only the Galápagos cactus-acacia thickets are denser and more difficult and the lava-rock-strewn ground rougher and more dangerous. Had there not been a previously broken trail on Barbuda, obviously not too well tended, I doubt if we could have made the round trip in a day. As it was, the 8-mile trip by road and trail took us a full 2½ hours each way.

It was well after noon before we reached the entrance to Dark Cave. The descent was 40 feet or more obliquely downward in a tortuous passage, overhung by huge boulders that did not always appear to be too firmly affixed to the "roof" over our heads, and under which we had to stoop at times. At the bottom we found a sizable cavern, or rather several broadly connected chambers, with alcoves on each side. Some of these were at levels above the ground floor, others at or below it. We found the first of a series of five fresh-water pools at the foot of our downward trek, stretching back into utter darkness. Where we stood, on the "shore" of the first pool, the water was little more than ankle deep, increasing to a foot or two farther out. For the last and largest of the series, our guides claimed a depth of 10 feet, which one of them promptly demonstrated by plunging in and going straight down in the middle, feet first with his right arm extended up over his head. The water closed a good 2 feet above his fingers.

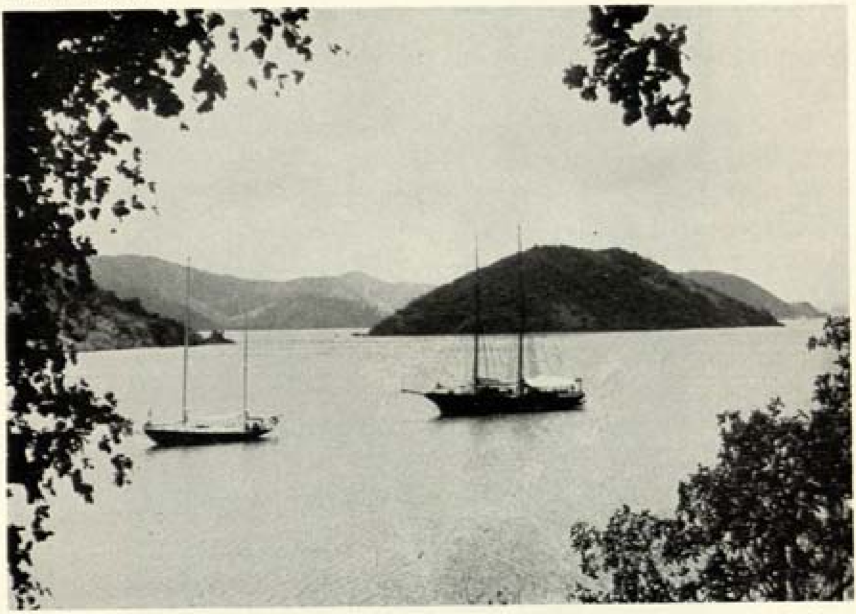
Not the least ray of light filtered in from our crooked entrance passage. For illumination we had two gasoline lanterns and a flashlight apiece. The guides brought along also a ball of heavy cord, which one of them payed out as we went down and in. Lanterns can be upset or accidentally dunked in dark and unknown waters, and flashlights and batteries have been known to fail at times. Without that reassuring "lifeline" for guiding us back among the boulders over which we had to climb, crowd between, or crawl under, it is doubtful if we could have retraced our steps safely had our lights given out. Measured from the loop tied in the line at our last stop, the foreshore of that farthest-in pool, we found we had come 400 feet.

The little minnow seine brought along was much too small for effective use in the deepest pool and useless in the smaller, rock-encumbered ones. Our search for fish was futile, but our 7- by 9-inch nylon dipnet, assiduously wielded by Captain Nicholson, captured two blind shrimps and some three dozen amphipods; from the cave floor we collected more than a hundred inch-long millipedes.

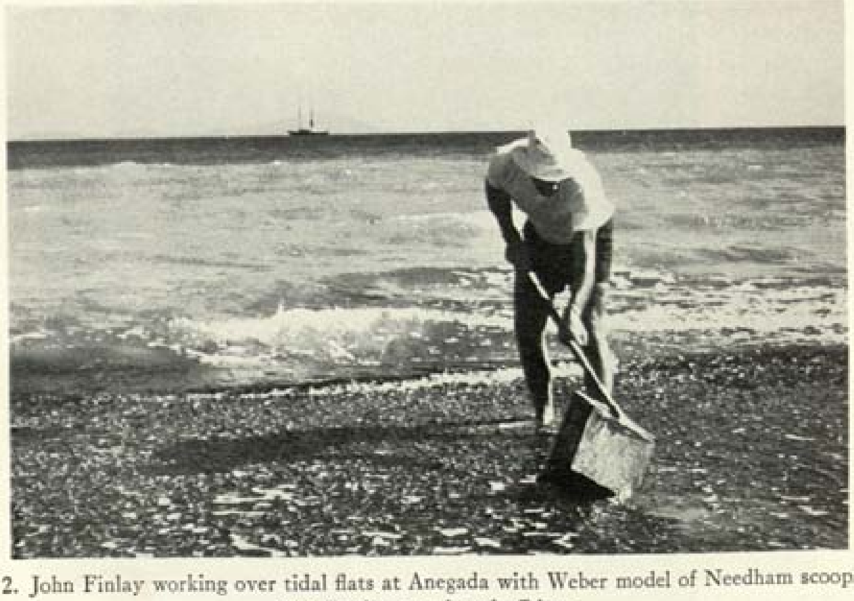
The shrimps, when later critically examined by Dr. Fenner A. Chace, Jr., National Museum's curator of marine invertebrates, proved to be *Typhlatya monae*, a species he had described from four female specimens taken in 1951 from a 30-foot well on Mona Island, between Hispaniola and Puerto Rico, and three others of the same sex discovered on that occasion in an old catchment basin on a high plateau on the island. Only two other Typhlatyas are known, both from America, *T. garciae* from a cave at Banes, Oriente Province, Cuba, and *T. pearsei* from a cave on Yucatán.

Clarence R. Shoemaker, one of the world's foremost authorities on amphipods and a research associate of the Smithsonian Institution, quickly determined that the amphipods from Dark Cave represented two new species belonging to two quite different genera, both subterranean. Neither, scientifically or physiologically, had ever seen the light of day. As dwellers in dark, unilluminated places these amphipods, like our cave shrimp, have only inconspicuous pigment spots where the functional eyes in normal crustaceans of their kind are located. Thirty-five of the specimens belong to the genus *Metaniphargus*, of which two other West Indian species are known, one from St. Kitts, the other from the Dutch island of Curaçao, off the north coast of Venezuela. Barbuda now extends the range of the genus farther north. The unique 36th amphipod in our haul will be the 6th species to be credited to the likewise subterranean genus *Bogidiella*. Of the five already known, three are recorded from Europe—at Strasburg, in the Balkans, and in salt water in the Mediterranean area; and two from Brazil, one at Bahia in underground salt water, the other in fresh water in Amazonas. Zoogeographically, *Bogidiella* in this cavern is an even more unexpected find than the *Metaniphargus* there, as the other Bogidiellas occur in localities very much farther away than either of the *Metaniphargus* species. Furthermore, until now *Bogidiella* has been known only from continental land masses almost half a world apart. The millipedes, of which Dr. Clarke got 138 with just a few "lifts" of a small pair of curved-point forceps, seem to be a new species of the genus *Epinannolene*.

How these subterranean animals get about from island cave to island cave, or from mainland to island, or vice versa, is an intriguing problem. Millipedes can run about and perchance come to the surface, where in daylight or dark they may lay their fertile eggs or place their young in soil that may become attached to the

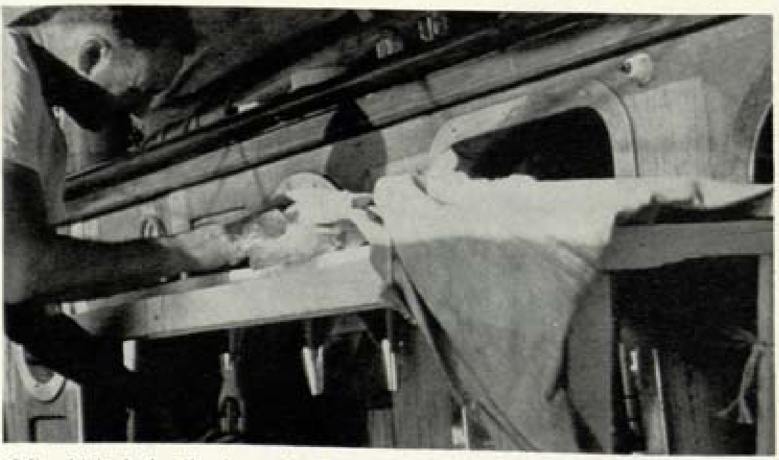


1. At anchor off the harbor entrance, Sopers Hole, Tortola. The *Freelance* is the larger of the two yachts.

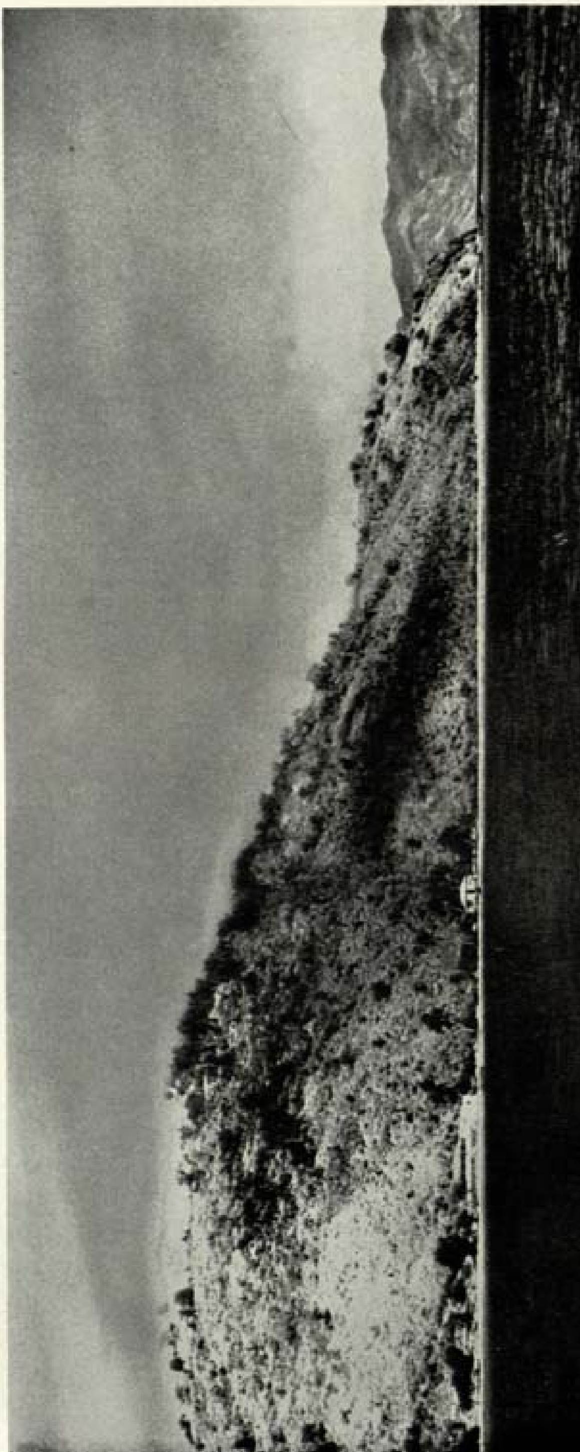


2. John Finlay working over tidal flats at Anegada with Weber model of Needham scoop. The *Freelance* anchored offshore.

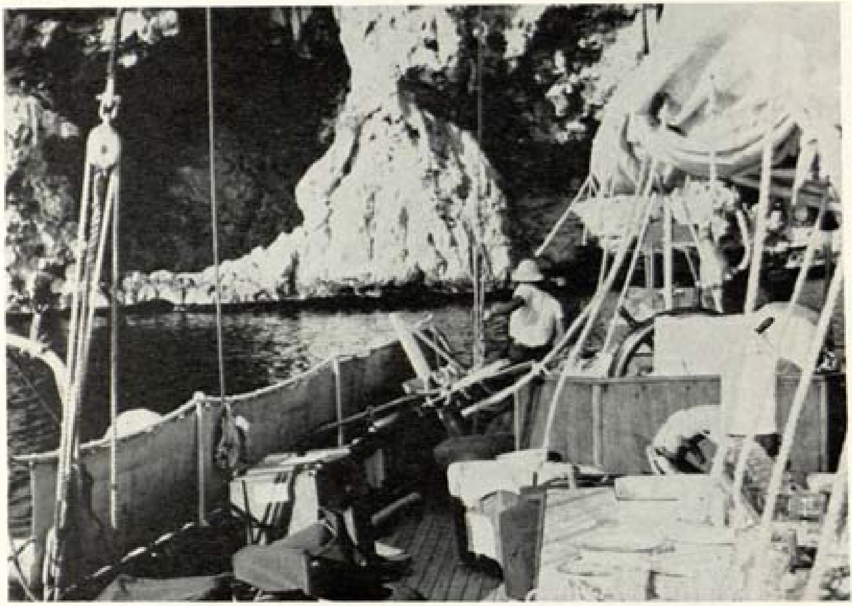
1. One of the larger trees of xerophilous flora of Tortola. The large epiphytes are bromeliads which provide the habitat for diverse and numerous fauna.



2. Microbiological collecting, using Berlese funnel, undertaken at every shore station.

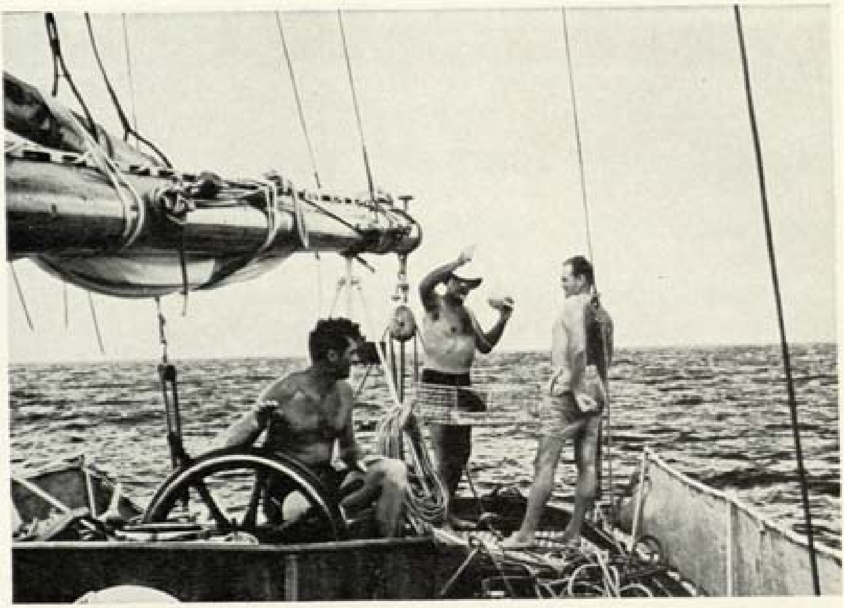


Little Harbor, Jost Van Dyke. On this island William Thornton, architect of the United States Capitol, was born. The hills of Tortola in the distance.



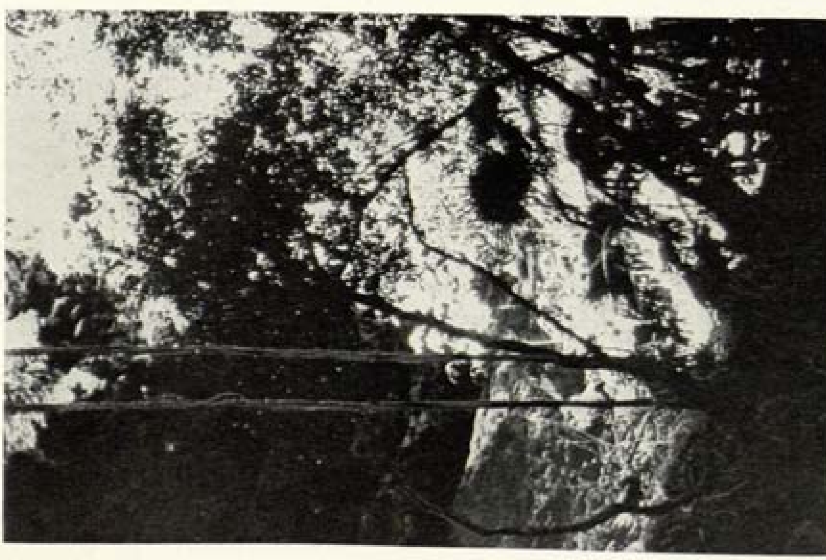
1. Close-up of bat caves, while anchored under Flat Top Rock Point, Crocus Bay, Anguilla.

2. Light trap for Microlepidoptera on hill above village of Road, Anguilla.



1. John Finlay about to lower his rattan mollusk trap in 126 fathoms off Charleston Nevis. In this particular haul he took a unique specimen of *Bursa*.

2. Rest period in an opening in the scrubby thicket on a reconnaissance of the trail to Dark Cave.

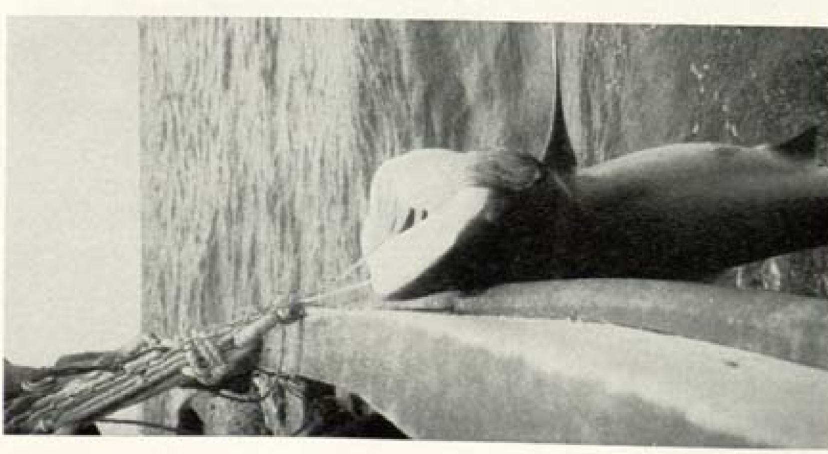


1. Liana roots descending 70 feet from the upper rim of sink hole, Darby Cave, Barbuda.

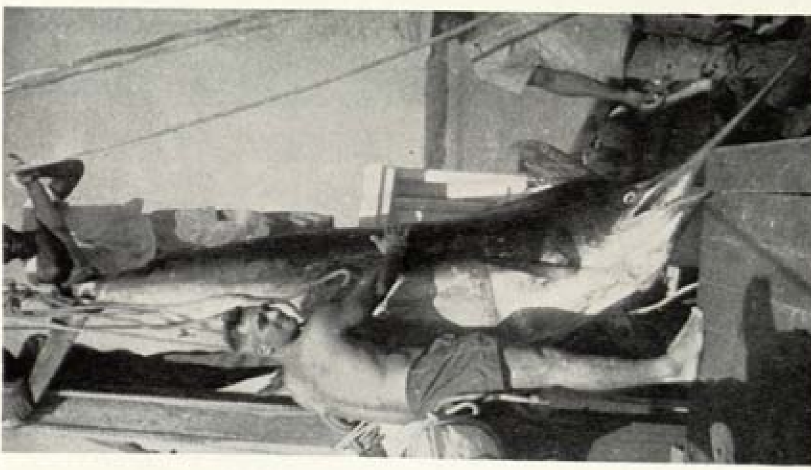
2. Flat-topped columnar stalagmite, Darby Cave, Barbuda.

1. A bit of Egypt in the West Indies. Corral and watering place for stock near Codrington, Barbuda.

2. The *Commando*, Antiguan experimental fishing vessel, steaming into English Harbor.

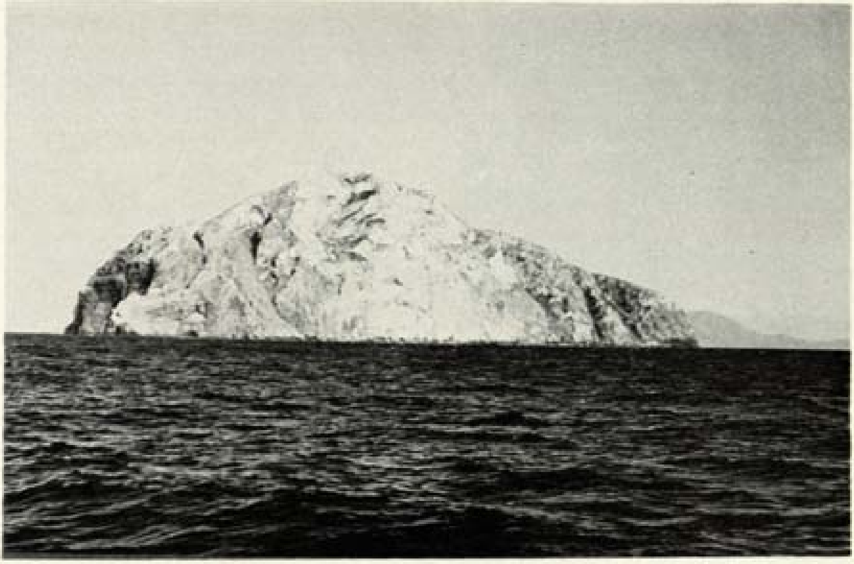


1. One of two dusky sharks taken on long line.



2. Ralph Camacho, fishery officer, Department of Agriculture, Antigua, with 500-pound blue marlin.

3. Six Caribbean red snappers taken on a single, multiple-hooked hand line.



1. Redonda. The island of Montserrat looms faintly in the distance.

2. The very tiptop of Redonda.

1. Booby with nestling.

2. The upper level, Redonda. Former "residence" of phosphate-mining crew at left; rain-water cistern at extreme right.

feet of birds and so be carried far and wide, or else may be blown for considerable distances by strong winds or hurricanes. Could the bats possibly play a part in the transport of cave animals? It does not seem very likely in the case of the animals before us, but studies of flights and migration of banded specimens of bats in New England have brought to light the fact that some individuals have "traveled" as much as 125 to 156 miles from the place where they were banded. But bats are known for their clean feet and claws.

When not in alarmed flight, the squeaking host of bats overhead festooned the irregularities of the higher reaches of the cavern, and had it not been for Dr. Clarke's handiness with his insect net, we might not have captured a single specimen, traveling as we were on this occasion without firearms of any description. A few deft swipes and some scratching with his long-handled net in accessible niches overhead obtained for us at least six of them.

The bats from Dark Cave, *Brachyphylla cavernarum* by name, Dr. Charles O. Handley, Jr., National Museum's associate curator of mammals, tells me are an omnivorous species, eating fruit and insects, and as far as known confined to the West Indian islands. In the Museum's collection we have specimens from six of them: Dominica, Puerto Rico, St. Croix, Barbuda, St. Lucia, and St. Vincent.

On the way home from Dark Cave our guides made a slight detour so that we might take in Bryant Cave. This we found to be an exceedingly wet and slimy sink under a deeply undercut cliff. The thoroughly overshadowed pool at its foot appeared devoid of animal life except for a few aquatic insects and numerous tiny black snails leaving little trails behind them as they crawled over the bottom, which appeared to be largely a muddy, yellowish-greenish bacterial(?) and algal slime. The Museum's associate curator of mollusks, Dr. J. P. E. Morrison, says they are a new species of the genus *Littoridinops*, family Hydrobiidae. Although there was considerable diffused light, no direct sunlight seems ever to reach this sinkhole's dank depths.

Another cave visited the next day was Darby Cave, which turned out to be another great sinkhole. Originally it must have been an exceedingly large cavern, the roof of which had collapsed. The result was an impressive amphitheater, 70 feet in depth and 400 feet across. Its expanse was crowded with the lush green tops of tall trees and magnificent palms, a veritable rain-forest in this otherwise desiccated and arid-looking land. In its dryness at the time of our visit, and in its wealth of cacti and thorny acacias and other xerophytic plants, Barbuda again reminded me of the dry season in the Galápagos. But Barbuda is, underneath it all, well watered. One can dig a well almost anywhere and strike water. The several caves

and sinks are ample evidence of the water resources underlying the whole of this island.

On one side of our amphitheater was a great rock wall rising 70 feet above our heads. Undercut fully 30 feet, there was left just a perilously thin roof, projecting to form what might be described as the top of the proscenium arch of the amphitheater's stage. Not until we were down inside did we appreciate our guides' concern when they pulled us back from the upper rim of this cliff upon which we had dismounted to peer over and to photograph the striking jungle down below.

Opposing the cliffside "stage" were tiers of "seats" of a rubble of broken slabs of rock that once formed the roof of the former cavern. Down this tumbled slope we descended as from a high-up "peanut gallery" to the "pit" below. Because of that 30-foot overhang, the "stage" was so shaded that it was wholly devoid of trees. Here we rested and ate our lunch, which was enjoyed with some qualms, for we could not avoid remarking upon the large blocks of rock that at one time or another had dropped from above. Between us and the "balcony seats" on the far side of the amphitheater, obscuring them from sight, was our dense rain-forest, mostly tall palms stretching upward toward the light. The forest floor was a thick mulch of dead and rotting palm fronds. Before us, from over the cliff's rim, descended hawser-thick roots of mighty lianas, reaching down for moisture and nurture in the humus-rich soil underfoot. In a few places over the rim came the intermittent drip-drip of water, though we saw not the slightest trace of it when we were on top. These little bits of moisture were building up small stalagmites, none larger than a fist. We later found a startlingly large stalagmite 8 feet high and not less than 2 feet in diameter. This greenish-white, almost translucent mass of limestone was so smooth, so solid and well formed, that I have yet to see its counterpart in any of the many caves I have explored along our eastern seaboard. In the lightly misted patches formed about the stalagmites, Dr. Clarke, in his search for insects, discovered tiny frogs hiding among adjacent broken stone and gravel.

We also looked into other and more superficial caves, at sea level and above, in the cliffs under Flat Top Rock Point near Crocus Bay, Anguilla. These are well known locally as popular bat roosts. At night the bats skimmed the surface of the water. While we were hand-lining over the side and dip-netting for plankton under an electric light suspended at the surface of the water, one, indeed, took hold of the captain's line. Before he could jerk the hook upward to impale it, the bat took off. It was to us a new experience. The captain, however, recalled that he had, under similar circumstances, snagged a bat off Dominica one night the year before. He was sure it was fishing at the surface. Try as we might, we never got another

strike at Anguilla that night or the next. Fish-eating bats, I found on my return to Washington, were to our mammalogists an old story, of which the first published record goes back as far as 1860.[2]

The last of the caves visited in the course of this year's investigations was the very appropriately named Bat Cave, on Antigua. This was a favored resort of the species that we had captured earlier in Dark Cave on Barbuda. Of its occurrence in Antigua our mammalogists had long been aware, as our very first specimen of it from this island had been cataloged in 1864.

I never again expect to see as many bats in one place as I did that May 1 in Antigua, unless it should be in the vastly larger Carlsbad Cavern in New Mexico. Although Bat Cave is no small affair, it had been considerably larger not long before our visit. A rock-fall had blocked off an extensive passage, which as local legend has it, went well down under the sea all the way to Martinique. If such connections between these island caves can be conceived, how easily is the distribution of their inhabitants to be explained. As improbable as the story is, I would nevertheless like to investigate any caves on Martinique.

COLLECTING INVERTEBRATES

Before our cave explorations on Barbuda, we cruised for some days among the British Virgin Islands, amplifying our 1956 collections from Tortola (Road Town, March 26) and Virgin Gorda (March 28, 29; April 6, 7). Of the Tortola anchorages, Sopers Hole (March 31; April 1, 5, and 6) was scientifically the most rewarding in fish and invertebrates taken by skin diving, dredging, and shore collecting. Insects were collected from the steep hills encircling this bay by Dr. Clarke, who covered them quite thoroughly with net, by ground and debris searching by day, and by light trapping at night.

Similar activities occupied our time at Guano Island (March 27), Peter Island (March 29), Jost Van Dyke (April 1, 2), Norman Island (April 6), Anegada (April 9), Anguilla and Sandy Island nearby

[2] That and subsequent observations were reviewed in 1945 (Journ. Mammalogy, vol. 26, No. 1, pp. 1–15, 1945) by the late Dr. E. W. Gudger. He acquainted us with the fact that the species hereabouts, *Noctilio leporinum*, is widely distributed through the New World Tropics, ranging from Ecuador and Panama and Surinam through the West Indies. The Museum has specimens of it from Trinidad, Barbados, Grenada, St. Lucia, St. Croix, Mona Island, and Puerto Rico.

But no one was certain just how the bats captured their prey until Dr. Prentice Bloedel, then a member of the University of California's graduate school, looked into the matter and photographically recorded their mode of catching fish (Journ. Mammalogy, vol. 36, No. 3, pp. 390–399, 1955). He watched, and took still flashes and moving pictures of captured individuals on a screened porch, fishing in a shallow pan in which he had small fish swimming. With their sharply clawed feet the bats gaffed fish as they swooped down to the surface of the water, passing the captured fish up to the mouth. That night off Anguilla, with our gangway light hung close to the water, young and larval fish were swarming in countless numbers. A few dips with a net filled a quart jar. Undoubtedly it was this rich plankton "soup" that brought the bats to the side of the ship, more than the hand line the captain put over the side in hopes of snaring one.

(April 13, 14, and 15), and off Bird and Green Islands in Nonsuch Bay on the way to Barbuda (April 23, 24). While at Barbuda, the better part of 2 days (between April 27 and 29) was given over to land and littoral collecting about Spanish Point on the boisterous, spray-drenched, windward shore of that island.

Mr. Bredin, who had planned on participating in our several activities for a full 3 weeks, had to leave after a week. John Finlay, too, left shortly after, but not until he had aroused in Dr. Shuster the desire to make a critical statistical study of a small or dwarf form of the fighting conch, *Strombus pugilis*, that he had dredged up in considerable numbers in the channel between Tortola and Jost Van Dyke.

Dr. Shuster's enthusiasm for detailed analyses of racial differences within mollusk species was carried over to the genus *Vasum*, following John Finlay's visit to a St. Johns curio shop, where he met Mrs. Leslie Allen, of Hartford, Conn., residing at the Mill Reef Club, who told John of the occurrence of *Vasum nuttingi* (strictly speaking, *Vasum globulum nuttingi*) in Carlisle Bay. John tells me that without her explicit directions he would not have come upon this species during his brief stay in Antigua. Thus it was that he obtained the first specimens of the species he had ever seen, with the aid of local children who volunteered their services. Though we were not aware of it at the time, this species had previously been taken in English Harbor and along the rocky shores of Falmouth Bay, from which two areas came the original material described by the late John B. Henderson, noted collector and one-time Regent of the Smithsonian Institution. He found them while taking part in the Barbados-Antigua Expedition of the University of Iowa, in 1918.

This interest in shells and in *Vasum* in particular led to our becoming acquainted with Dr. William T. Bode, of West Sacramento, Calif., who, with his wife, two daughters in their teens, and a younger son, was spending the current scholastic year as a Fulbright fellow conducting a manual-arts workshop for a selected group of Antiguan school teachers. In their spare time, the Bodes became greatly interested in the local molluscan fauna, amassing a very comprehensive collection and a wealth of firsthand information about the environments favored by the various species. Just a few days before our departure they took Dr. Shuster to some of their favorite collecting grounds in others of the many bays indenting the shores of Antigua, where they got considerable numbers of at least two different forms of *Vasum globulum nuttingi*. Dr. Shuster himself quite unexpectedly found other varieties in even greater quantity about Spanish Point, Barbuda, on the surf-beaten windward side of the island on the occasion of our visit there on April 29. Noting the appreciable differences exhibited by this species of *Vasum* from bay to bay around Antigua and from Barbuda, Dr. Bode and Dr. Shuster decided to collab-

orate on an ecologic-systematic study of the Vasums in their respective West Indian collections.

Mr. Finlay's special mollusk traps were also very successful. On one occasion in 126 fathoms off Charlestown, Nevis, and on another in 120 fathoms off Anguilla, they brought up an appreciable number of perfect specimens of *Murex cailleti kugleri*. In that Nevis haul he also got another interesting shell, *Bursa tenuisculpta*, of finer sculpture and of more elongated form than usual. The *Murex* is represented in the National Museum's collections from southeast Florida, off Bahia Honda, Cuba, Yucatán, and north of the Virgin Islands, in depths ranging from 50 to 130 fathoms or more. The Finlay specimens extend the range of the species considerably farther south and east than heretofore known. This *Murex* has also been taken both north and south of Redonda. It has been recorded, almost exclusively by dredging operations, from Sand Key, Fla., in 25 fathoms; Cuba, 180 fathoms; Jamaica; Santo Domingo; St. Croix, 115 and 248 fathoms; Saint Maarten; and Guadeloupe.

FISHING WITH THE LONG-LINE

For the first time on any Smithsonian expedition, the so-called long-line was used for taking specimens at sea. This type of fishing gear was developed by the Japanese for their oceanic fisheries, principally tuna and albacore. Their success with it led our Fish and Wildlife Service to adopt and adapt it for use by American fishermen. We requested from the Fish and Wildlife Service the loan of a long-line for this Bredin expedition, to see what we might catch with it. The Service helpfully complied, being interested in what this gear might catch in the area in which we would be operating. The long-line is an informative tool of the first order in prospecting for commercially important fish.

They advised us to take but half a long-line, 5 tubs ("baskets," or sections) of line, instead of the standard 10. We were new to the game, and our chartered yacht was not specially fitted for this kind of fishing, though our captain and crew soon familiarized themselves with handling it over the side. Each section is 138 fathoms long, so that five tubs alone, end to end, will stretch out more than three-fourths of a mile. Buoy lines are usually adjusted so that the baited Japanese tuna-type hooks hang between 10 and 20 fathoms below the surface, the recommended fishing depth. These hooks, 10 to a tub or section, are each attached to a 4-fathom branch line with a 1-fathom wire leader. A buoy is at the end of each section, and at the beginning and end of the line is attached a signal flag on a bamboo pole, suitably buoyed with cork floats and weighted to stand upright. These markers are essential, as the long-lines are best put over at or just before dawn and allowed to soak for several hours. If a number of

long-lines are out, or other work is undertaken in the interval, the signals facilitate locating expensive gear again, to say nothing of the catch.

We completed four trials with that long-line, not counting a dry run with a couple of sections, to acquaint our crew with the gear. Two of the four actual trials were made from the *Freelance* off Anegada, April 9, and southwest of Redonda, April 18—both unproductive except for an 8-foot white-tipped shark, *Carcharhinus longimanus*, on the first trial off Anegada. Specimenwise, his stomach was empty. His sharp-toothed jaws, dissected out for clinching our field identification, now repose in the National collections. We were unable to get a picture of the shark because in the excitement of landing him we could not see the fish for the men, and a dead, disemboweled shark on deck in a tangle of ropes is not a photogenic subject.

When we got to St. Johns, Antigua, and met Ralph Camacho, fishery officer to the Antiguan Department of Agriculture, the possibilities of long-line fishing appealed so to him that he kindly offered to take us out for further trials on his 41-foot experimental fishing vessel, the *Commando*, a most practical, well-powered craft. With his more expert fishermen and the bait that he was able to obtain, our gear yielded somewhat more promising results. On the first of the two runs he made, the one in the vicinity of French Bank, off the north end of Martinique, we drew another blank. On the second, however, on April 29, well to the eastward of Barbuda, we had our best luck. Here the bottom dropped off suddenly over a "precipice," from 50 to more than 200 and as suddenly again to 1,000 fathoms. Long-lines seem to yield the best results when fishing is done in waters of 500 fathoms and more, and so it was with us this day. The *Commando* got two 8-foot dusky sharks, *Carcharhinus obscurus*, a 10½-foot blue marlin, *Makaira nigricans ampla*, and five 4-foot dolphins, *Coryphaena hippurus*. Attracted perhaps by the baited long-line as it was being taken in, these swift blue-and-gold beauties were schooling about the last flag buoy. Caught on baited hand-lines quickly thrown over to tempt them, they were pulled aboard after many spectacular leaps.

Between making this set in the early morning and hauling it in in the early afternoon, the *Commando* resorted to a fishing ground farther in to fill in the time hand-lining. It was, indeed, a fortunate day all around—corvalos, amberjacks, and black-spotted and Caribbean snappers, these last in several lots of four and five, and in one instance six, on a single hand line. The blue marlin, though, was the prize catch. Since our trip with him, Ralph Camacho landed an even larger one—a 12-footer which weighed 436 pounds dressed, and which he is confident would have tipped the scales at at least 500 pounds in the round. It took 53 minutes to boat that fellow. But the grand-

daddy of all blue marlins must be the one caught off Bimini, June 19, 1949, by Aksel Wichfield, on a 130-pound line. It weighed 742 pounds.

REDONDA REVISITED

Redonda is an isolated, precipitous, and forbidding rock on which Dr. Clarke and I had landed during the Smithsonian-Bredin Caribbean Expedition of 1956. We were ashore but a few hours because the captain did not care to hazard anchoring in those deep and rocky waters, where winds and currents are unpredictable. We landed primarily to get samples of the phosphate deposit formerly mined here and to gather what littoral invertebrates I could in the time available, while Dr. Clarke climbed a steep gully leading to the top, to reconnoiter the rock's insect life. This altogether too brief visit whetted our desire for another opportunity. This Captain Nicholson vouchsafed this year, but regrettably I could not personally avail myself of the offer because of the long-line trial that had to be made. We put Dr. Clarke ashore with his light trap, insect collecting gear, and a bite to eat. We were not to pick him up until the next afternoon, although we could anchor under the lee of the rock for as long as possible after the day's fishing.

As Dr. Clarke recounts his visit:

Landing on Redonda is uncertain, as I learned year before last. This year it was smoother than I had expected. The climb up went better, too, as last time I had unwittingly essayed the more difficult of the two accessible ravines—gullies, if you prefer. By getting ashore in the afternoon, I had ample time for investigating the top of this 1,000-foot-high pinnacle rock, the birds, the bugs, and the buildings before dark. There were also lots of little geckos about. The boobies all had nestlings, but most noteworthy among the feathered residents was the burrowing owl, *Speotyto cunicularia amaura*. Identified by Dr. Alexander Wetmore from my description of its appearance and plaintive call, this is a new record for the species. The cistern on top for collecting water in the phosphate-mining days is still in good condition, and still contains what can be regarded as potable water, though I was not moved to drink any of it. Of the former residence or dormitory, only walls and ceiling of the first floor remain. I spent the night in this shelter, except for frequent visits to my traps and my several bouts with rats. Geckos, which abounded on the walls of my shelter, were easily caught by picking them off the walls with the aid of a flashlight. There were also many large hermit crabs, *Coenobita*, about. They were largest of their kind I had ever seen—perhaps a giant race? Naturally I was chided the next day for not bringing a few down with me, even though this crab is about the most widely distributed crustacean in all the West Indies. My primary objective was to set my light trap on this isolated rock. This I successfully achieved by hanging the light from the island's only tree, an introduction on the island. The catch was meager, but I got a long series of the beetle genus *Hymenorus*, of the family Alleculidae, apparently attracted to the area by the foul-smelling, nitrogenous excrement of the sea birds. There is no previous record for this family for the West Indies. There were few insects attracted to the light, but in addition to the beetles about 20 species of Microlepidoptera have been sorted from that overnight catch.

The inclined plateau forming most of the top of the island is covered by coarse grasses, sedges, a slender narrow-leafed agave, several cacti in great abundance, lantana, and several other scrubby shrubs. The whole island presents an unfavorable aspect, and one must be constantly alert lest he fall in brush-covered holes or fall with a rock slide. On the upper reaches of the island the sea birds share their precarious retreat with goats and a large, swift, black lizard. The latter are curious reptiles. While dismembering a dead agave, in search of beetles or cockroaches, my scratching attracted 20 or 30 of these black fellows, whose curiosity brought them within easy range—but I had no shotgun. Two very recent rockfalls attest to the insecurity of the Redonda sanctuary, rock falls no doubt caused by the several slight earthquakes such as we experienced during our recent visit.

Best of all, I got to the very top of Redonda, something I wanted to do ever since I set foot ashore here 2 years ago, and I sampled the night crawlers and fliers which I did not have the opportunity to do before, and may never have again.

Coming down the gully up which I had climbed was likewise easier than in 1956. I did not have to ride a rock avalanche down this time, but getting off was a wetter performance. After putting my gear safely aboard the dinghy in which Danny and Joe came to get me, in the rise and fall of the surf on the boulder-heaped shore, I stepped unwittingly into the sea instead of the boat, which did not rise in time to meet me, as I thought it would. Either my timing or that of the unaccommodating 5-foot-high surf was poor, but anyway the dip was as refreshing as a shower after a hot and dirty day and a not too comfortable night ashore.

IN CONCLUSION

This year's trip to the Virgin Islands covered less ground—and less water—than the previous Smithsonian-Bredin expedition to the Caribbean—500 miles as compared with 1,000, and 18 islands as compared with 28. This time, however, we got underground, inside the islands, a thing we had never done before in this area, and got to the very top of Redonda. The collecting was good in most places, excellent in some, but this narrative is following too soon upon our return for an evaluation of the size and value of our collections. As a single instance, however, there may be mentioned the nearly 250 cockroaches that Dr. Clarke hewed from a large dead agave's imbricated leaves on the slopes of Peter Island above Little Bay. These roaches are not our usual North American household kind, but one of the wild, outdoor, tropic species, *Hemiblabera brunneri*, of which Dr. Ashley Gurney, of the United States Department of Agriculture, tells me the Museum had but four specimens, while not more than a dozen are known in museums generally. Dr. Gurney is devoting serious study to the distribution of the cockroaches through the West Indies and was very pleased with the material the expedition brought back from 13 different localities, totaling more than 2,000 specimens.

Again the thanks of the Smithsonian Institution go to Mr. and Mrs. Bredin for another memorable, noteworthy, and scientifically profitable expedition.

Tools Makyth Man[1]

By Kenneth Oakley
British Museum (Natural History)

Benjamin Franklin appears to have been the first to call man the "toolmaking animal,"[2] while Thomas Carlyle in Sartor Resartus (1833) declared: "Without tools he is nothing." In pre-Darwinian days the definition of man was no more than a philosophical exercise. That man might have evolved from lower animals was in the minds of very few people in those days. Certainly the question of how to draw a boundary between prehuman and human had not yet become a practical issue. Even the conception that man had a long unrecorded past had barely taken root a hundred years ago, although the seeds of the idea had been sown by a few men far ahead of their time, such as Isaac de la Peyrère, who published a book in Paris in 1655 on *Primi Homines ante Adamum*, and John Frere whose discovery of flint tools in brick earths at Hoxne in Suffolk led him to infer in 1797 that they had been "used by a people who had not the use of metals," and "belonged to a very ancient period indeed, even before that of the present world."

The idea that man had an extensive prehistoric past began to grow during the second quarter of the last century, largely as a result of stone tools being recognized in deposits containing the remains of extinct animals. Flint implements associated with bones of Diluvial (we should now say Glacial) animals were reported from Belgium caves in 1832, and in 1840 from below a thick layer of stalagmite in Kent's Cavern, Torquay. At this time orthodox scientists, following the French naturalist Cuvier, were incredulous of such discoveries. When, in 1846, a French customs official, Boucher de Perthes, repeated his claim (first made in 1838) that he had discovered at Abbeville in the ancient gravels of the river Somme, flints worked by man and associated with remains of Antediluvian animals, the majority of archeologists and geologists were frankly scornful. In 1854 one of his critics, a physician named Rigollot, was converted to the unortho-

[1] Reprinted by permission from Antiquity, vol. 31, 1957.
[2] Quoted in Boswell's Life of Johnson, April 7, 1778.

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dox view when he himself found similar chipped flints (hand axes) in fossil-bearing river gravel at St. Acheul, near Amiens. In November 1858, the English paleontologist Hugh Falconer visited Abbeville, and was favorably impressed by the evidence. In the following April, at Falconer's suggestion, the geologist Joseph Prestwich went to Abbeville and St. Acheul. After examining the collections and visiting the pits in company with the English archeologist John Evans, he returned to London and on May 26, 1859, presented a paper to the Royal Society announcing his acceptance of the claims made by Boucher de Perthes and Rigollot. This pronouncement, coming from a geologist of such high repute, had a great effect on scientific opinion throughout the world. The year 1859 was, as we now see, one of the turning points in human thought; the immense antiquity of man was established almost simultaneously with the publication in book form of Darwin's theory of evolution, "On the Origin of Species by Means of Natural Selection."

Fossilized skeletal remains of man were found during the second half of the last century at a number of localities: Neanderthal (1856), Cro-Magnon (1868), Spy (1886), and Trinil in Java (1891). It was gradually realized that these provided concrete evidence that man had been subject to evolutionary change as deduced by Darwin in his "Descent of Man" (1871). However, none of these discoveries pushed back the antiquity of man, for the unquestionable flint tools from the Abbeville gravels had already indicated his existence in Europe before the arrival of the typically glacial fauna. As Boucher de Perthes expressed it (after translation): "In spite of their imperfection, these rude stones prove the existence of man as surely as a whole Louvre would have done."

How great is the antiquity of man? If he is defined as the toolmaking primate, this problem resolves itself into the question of the geological age of the oldest known artifacts. Although the flint hand axes (*palaeoliths*) dating from the earlier part of the Pleistocene period are crudely flaked, they are nevertheless standardized tools, and this has generally been regarded as indicating that a long tradition of slowly acquired skill lay behind them. This was the idea sustaining the search for traces of the handiwork of Tertiary man, in other words the hunt for *eoliths*.

I must here digress for a moment to recall that the Tertiary era, beginning 75 million years ago and distinguished by the rise of mammals, is divided into the Eocene, Oligocene, Miocene, and Pliocene periods. The Pleistocene period or Ice Age, with its postglacial appendage of Holocene or Recent time, constitutes the Quaternary era. Originally the Pleistocene was defined as coincident with the Quaternary Ice Age, but the International Geological Congress in 1948 recommended its redefinition to include the Villafranchian stage (for-

merly in part Upper Pliocene) distinguished by the spread of elephants of the genus *Elephas*, oxen (*Bos*), and one-toed horses (*Equus*). Owing to these changes in nomenclature, deposits which were formerly "Early" Pleistocene are now counted as Middle Pleistocene (e.g., the Abbeville gravels and the Trinil beds); while other deposits formerly counted as Pliocene, i.e., Tertiary, for example the Red Crag of East Anglia, are now regarded as Lower Pleistocene by the majority of geologists. The "glacial Pleistocene" is estimated to have been about half a million years in duration, but the addition of the Villafranchian stage has nearly doubled the length of the period.

The problem of eoliths, supposed artifacts of Tertiary man, was first raised by the discoveries of Abbé Louis Bourgeois, who found in 1867 a great quantity of chipped flints, in the forms of alleged scrapers, knives, and borers, in a fresh-water deposit of Lower Miocene [3] age near Thenay (Loir-et-Cher). From time to time similar chipped flints were reported in other Tertiary formations: in Lower Eocene strata at Clermont (Oise), in Upper Oligocene gravels at Boncelles, Belgium, in "Upper Miocene" (now Lower Pliocene) deposits at Puy Courny, Cantal, in the so-called Pliocene plateau gravels on the North Downs in Kent, and within and below the Red Crag of East Anglia.

With the growth of knowledge on the evolution of the primates, based on a study of actual fossil remains, it has become clear in the present century that our forerunners had only the size range of bush babies throughout Eocene times. Man-sized apes did not emerge before the Miocene period, while the earliest manlike remains date from early Pleistocene times. Thus, pre-Miocene eoliths at any rate may now be dismissed as geological curiosities, with no bearing on the origins of tool making. The unreliability of the criteria used by the earlier archeologists who recognized "flints shaped by human agency" in the Tertiary formations is evident from the fact that Eocene eoliths are as convincingly artificial in appearance as many of those from later formations!

In some circumstances flint is very readily fractured, and the natural agencies which cause it to be chipped into shapes reminiscent of artifice are legion. The eoliths found in Tertiary river gravels are strikingly similar to flints broken by violent agitation in the water of chalk mills. This is understandable. An accumulation of flints of eolithic form was found in a river gravel in a valley in Würtemberg where the material carried by the main stream had evidently been drawn into whirlpools caused by the inflow of tributaries. Another agency which results in the production of pseudoartifacts is the pressure combined with movement occurring when flint-bearing strata founder through the solution of underlying chalk or other calcareous formation. This was the agency chiefly responsible for the Clermont eoliths. The Kent eoliths

[3] Aquitanian: classified by some authors as Upper Oligocene.

were mainly produced by the powerful friction of one stone against another which occurs in soil creep, particularly under subglacial conditions.

While it is reasonable enough to consider the possibility of tool-using primates having existed during Pliocene times, and even during the Miocene period, there are insuperable difficulties in the way of recognizing the particular pieces of stone or bone that may have been picked up and used. The earliest attempts at making tools from pieces of stone must have been all but indistinguishable from the accidents of nature (and we have already seen how "human" these can appear). Naturally fractured stones probably served as the first tools. Some Australian aborigines at the present day fashion wooden utensils with naturally shaped pieces of stone selected by virtue of their sharp cutting edges. As one French prehistorian expressed the problem of eoliths: "Man made one, God made ten thousand—God help the Man who tries to see the one in the ten thousand."

During the present century large numbers of flaked flints, including some strongly suggestive of intelligent design, have been found in the Stone Bed underlying the Norwich and Weybourne Crags in Norfolk and in the Bone Bed below the Red Crag in Suffolk. These flints show a number of features not found in the general run of Tertiary eoliths; and largely, I believe, because they date from the very interval of time when, according to many lines of evidence, tool making probably began, they have been widely accepted as human artifacts despite the relentless opposition of scientists who have specialized in the study of flint fractures, such as Hazzledine Warren and the late Prof. A. S. Barnes. If one confines attention to the beautiful rostro-carinates, corelike forms, scraperlike flakes, and so on, laid out for exhibition in the Norwich Castle Museum and the Ipswich Museum, it is difficult to disbelieve in their human origin. Yet, collecting for oneself in the Sub-Crag Stone Bed, for example, one is bewildered by the high percentage of the component flints that have been bruised and chipped, the majority obviously in a random fashion. Now and again the flakes have been removed first from one side and then from another side in a way suggestive of design. By keeping only the best of the latter kind one can build a collection that is convincingly like a crude human industry; yet seen as part of a vast series of flakings, with gradation from obviously natural to seemingly artificial, the Sub-Crag "implements" are less convincing than when studied in isolation. Nevertheless, the late Reid Moir and others made a good case for accepting some of the assemblages of flakings in and below the Crag as the work of "pre-Palaeolithic Man," until belief in them was shaken by Barnes's demonstration that on statistical analysis the Crag

flaking was of the high-angled type characteristic of the work of nature.

Out of 1,800 measurements of platform-scar angles in 18 different human industries, Barnes found less than 18 percent over 90°; but in flaked flints from Eocene deposits over 54 percent of the flake scars proved to have angles over 90°, while among flaked flints from the Crag formations over 62 percent of the flake scars are more than 90°. Professor Barnes concluded: "The high proportion of high-angle scars in the Tertiary flints contrasts sharply with the paucity of high angles in the human industries, and suggests that the Tertiary flaking

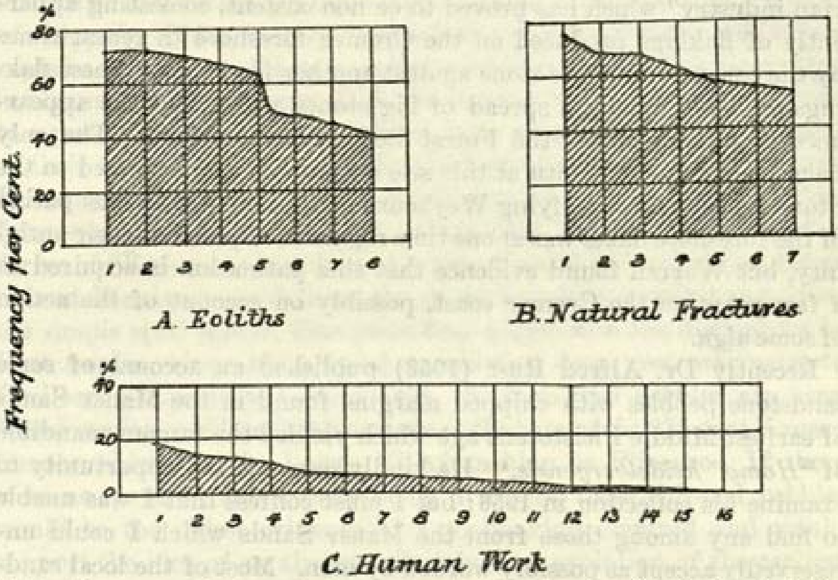

FIG. 1.—Percentages of obtuse platform-scar angles found in: *A*, eoliths in flint, including Sub-Crag (*1* and *3*); *B*, Naturally fractured stones, including flints crushed under cart wheels (*3*) or broken in foundering of deposits (*4*), and chipped hard rocks in moraines (*7*); *C*, human flint industries, mainly early, including Abbevillian (*2*), Acheulian (*5–8*, *12*), Tayacian (*9*, *10*), and Mousterian (*13*). (After A. S. Barnes, by courtesy of the editor of *American Anthropologist*.)

was due to soil movements under pressure arising from solifluxion, foundering, or ice action" (Barnes, 1943).

Warren reached a similar conclusion after prolonged study of the character of the Crag flaking (1948) and, having reviewed the geological evidence, concluded that the Stone Bed and Bone Bed did not accumulate as beach deposits, but on a submarine floor, "which cannot reasonably be supposed to have been available for human habitation." As about 50 percent of stones in some parts of the Stone Bed are flaked, and as the deposit occupies several hundred square miles, a widespread natural cause was most probably responsible for them. The striations and bruisings which many of the Sub-Crag flints show are consistent with Warren's idea that the chief cause of the flaking was the ground-

ing of floating ice (mainly local pack ice) which would have jammed together patches of flints strewn on the floor of the shallow sea (Warren, 1948). Certain flakings strewn on an alleged land surface within the Red Crag at Foxhall have been widely accepted as artifacts, even by those who do not accept the Sub-Crag chippings. To my mind the Foxhall "floor" is an enigma to be further investigated, rather than a proof of the existence of man in Britain during the Villafranchian stage.

If the Tertiary and Sub-Crag eoliths are unacceptable, what then are the oldest undoubted artifacts? Certainly not those of the "Cromerian industry" which has proved to be nonexistent, consisting apparently of flakings produced on the Cromer foreshore in recent times by the concussion of one stone against another in storms. These flakings occurred among a spread of big stones which had the appearance of passing under the Forest Bed (Warren, 1940). The only flaked flints found in situ at this site appear to have belonged to the Stone Bed of the underlying Weybourne Crag. The ochreous patina of the foreshore flakes was at one time regarded as proof of their antiquity, but Warren found evidence that this patination is acquired in a few years on the Cromer coast, possibly on account of the action of some alga.

Recently Dr. Alfred Rust (1956) published an account of some sandstone pebbles with chipped margins found in the Mauer Sands of earliest Middle Pleistocene age which yielded the famous mandible of "*Homo*" *heidelbergensis*.[4] He kindly gave me the opportunity to examine his collection in 1956; but I must confess that I was unable to find any among those from the Mauer Sands which I could unreservedly accept as possibly worked by man. Most of the local sandstone, even before it was weathered, is too coarse and friable to make serviceable tools. Indeed, Heidelberg man could have cut more effectively with flakes of the hard limestone (Muschelkalk) available in the same valley.

In Europe we are left with the so-called Abbevillian hand axes and dactonian flakes in the 40-meter terrace of the Somme as the oldest unquestionable artifacts. The only question here is whether the geological horizon of the "Abbevillian" is First Interglacial or an interstadial within the Second Glaciation, which is by no means impossible. (In fact, the same question applies to the Mauer Sands.)

When we turn to Asia we find that the oldest undoubted artifacts are in the same time bracket, either immediately antedating or contemporary with some phase of the Second Glaciation. The Pre-Soan flakes from the Boulder Conglomerate in the Punjab are not entirely convincing, for they may have been produced by glacial action; but

[4] Now regarded as the European equivalent of *Pithecanthropus*.

there is no doubt about the chert chopping tool of Early Soan type found at Locality 13, Choukoutien (China), in association with fauna indicating a stratigraphic horizon within the period of the Second or Mindel Glaciation. The slightly later flake-and-chopper-tool industry associated with Peking man at Locality 1, Choukoutien, is now generally regarded as dating from the beginning of the Second Interglacial period. Some authors still claim that it is older, either inter-Mindel or even Günz-Mindel, but the associated fauna is clearly Middle Pleistocene in the modern sense.

In Africa, particularly south of the Sahara, high-level river gravels of Lower Pleistocene age have been found to contain large numbers of chipped pebbles, mainly of quartzite, which have been widely accepted as artifacts. These so-called pebble tools were first recognized in Uganda by the geologist E. J. Wayland in 1920, who referred them to a pre-Paleolithic stage of culture, later named Kafuan on the basis of their typical occurrence on the 175-foot terrace of the Kafu River. In a recent monograph on the prehistory of Uganda, the late Professor van Riet Lowe described no less than 27 constantly recurring forms of "Kafuan-type split and trimmed pebbles," and claimed that he and Wayland could trace the evolution of rostrocarinates from the simple split pebble, thus providing a link with the discoveries in East Anglia, where Moir found a gradation from rostrocarinates to Chellean (Abbevillian) hand axes. Kafuan-type pebbles are even found in a layer of lateritic ironstone at the base of the 270-foot Kagera terrace which may be Lower Villafranchian or Pliocene. If there were no question about their being artifacts, these chipped pebbles would be the oldest evidence of a toolmaking hominid and would support the idea of an almost infinitely slow evolution of the earliest culture over some half a million years, from the end of the Pliocene to the first hand axes.

As doubts grew about the artificiality of chipped flints in the Tertiary and Villafranchian formations of Europe, belief waxed strongly in favor of the African pebble tools, because these were not in flint (which breaks so easily under a variety of forces), but in quartzite and the like. Moreover, they were for the most part in situations far removed from Pleistocene glaciers and pounding sea waves which have produced such quantities of pseudoartifacts in Europe.

Some prehistorians are now beginning to feel that the Kafuan pebbles [5] have been accepted as artifacts without sufficient consideration being given to the possibility that these also were fractured by natural forces. Should not quartzite gravels of, say, Triassic age be searched for similar forms, to see if they are produced in circum-

[5] Excluding the "advanced Kafuan" of some authors, which is synonymous with the unquestionably human Early Oldowan.

stances where no question of tool making arises? There is a great need, too, for experimental work on the lines of that by the late Professor Barnes and Mr. Warren, but designed to investigate the forces required to split quartzite pebbles. My own extremely limited observations in Africa suggest that at least some Kafuan-like flakings are produced when gravel is carried over waterfalls.[6] As for secondary chipping, it should not be forgotten that soil creep or solifluxion can occur under tropical conditions as well as under glacial.

One of my reasons for being skeptical about the Kafuan "pebble tools" is their prodigality. In the summer of 1955 I was with a party on safari through the Katanga Province of the Belgian Congo, and we were taken by Prof. G. Mortelmans to an exposure of gravels at Kafila near Elisabethville. Within a few minutes all the members of the party had found more "pebble tools" in this gravel than they could carry away. It is true that artifacts are astonishingly abundant at some African localities on the later hand-ax horizons, but the profusion of chipped pebbles in the Kafilan gravel reminded me of the profusion of eoliths in the Sub-Crag Stone Bed. Miles Burkitt evidently has similar reservations to make about the Kafuan pebbles, for he wrote recently: "From a study of the objects themselves it is not easy to find enough evidence to prove that they *must* be the handiwork of Man and that the fracturing cannot have been produced by natural forces." There has been an undeniable tendency among us all to argue subconsciously like this: "Man *could* have made these; they are of the right age for the beginning of culture; this is where we may expect to find artifacts; these *are* artifacts."

Fortunately there are certain situations in which fractured stones are acceptable as artifacts, even when the flaking appears random or accidental. For example, many of the fragments of quartz in the Choukoutien cave deposits would not be recognized as humanly struck if they were found on the surface away from their human context. The quartz found at Choukoutien is foreign to the site, and can only have been introduced into the cave by human agency. Another situation in which flaked stones are more readily acceptable as artifacts is where they occur isolated in an otherwise stoneless layer of lacustrine mud or sand.

If we discount the Kafuan pebbles, the oldest undoubted artifacts in the world are related to or equivalent to the Oldowan culture, first recognized by Dr. L. S. B. Leakey in the basal bed of the series of lacustrine sediments exposed in the side of the Oldoway (Olduvai)

[6] Perhaps mainly when, under a semiarid climate, large masses of gravel are suddenly moved over falls at the commencement of the rains, with the result that a proportion of the stones collide out of water. Since this paper was published, Dr. J. D. Clark has demonstrated that Kafuan-type flaking does occur through stones falling from the sides of gorges and striking other stones or rock surfaces out of water (Proc. Prehist. Soc., vol. 34, for 1958).

Gorge in northern Tanganyika. The associated fauna indicates that Bed I of Oldoway is of early Middle Pleistocene age. The typical Oldowan industry found in this bed consists of pebbles or other lumps of rock flaked by percussion to form crude chopping tools "varying in size from the dimensions of a ping-pong ball to that of a croquet ball." The chopping edges were made by removing flakes in two directions along one side of the pebble or lump, so that the intersecting flake scars formed a jagged cutting edge. The fact that occasionally these pebble choppers foreshadow bifacial hand axes, and the fact that hand axes appear and begin to replace pebble tools in Bed II, are indications that the Abbevillian-Acheulian sequence of cultures evolved from the Oldowan. The discovery of a few apparently Oldowan-type pebbles in the Laetolil Beds of Tanganyika and in the Kanam Beds of Kenya suggested that the beginnings of Oldowan culture were to be sought in the Lower Pleistocene (Villafranchian) beds of Africa, but until quite recently there has been an element of uncertainty about all pebble tools from Villafranchian deposits.

Unquestionable stone industries closely comparable with the Oldowan have now been found in North Africa and in South Africa in fossil-bearing deposits of Late Villafranchian age. The northern occurrence was discovered by Prof. C. Arambourg in lake-margin deposits at Ain Hanech in Algeria, and consisted of quantities of pebbles or stone lumps flaked in several directions to form subangular stone balls that would have served equally well as missile stones or multiedged pounders. A few hand axes of Abbevillian type are reported as coming from an immediately overlying layer. These Algerian industries are clearly the homotaxial equivalents of those in Beds I and II at Olduvai.

The discovery in March 1953 of pebble tools of "advanced Kafuan" (I would now say "Early Oldowan") type in the calcified surface of the Basal Older Gravels in the 200-foot terrace of the Vaal Valley in South Africa was the first positive indication that toolmakers existed in South Africa as early as the dry phase which terminated the First (or Villafranchian) Pluvial period. The discovery raised a most intriguing problem, because cave deposits that accumulated during this dry Late Villafranchian stage at Taung in Bechuanaland and at Sterkfontein and Makapan in the Transvaal had yielded remains of the subhuman *Australopithecus*. Was it possible that the pebble tools had been made by that creature? Analyzing the evidence available in 1954 I argued that it was possible, but I thought unlikely for two reasons. In the first place, although the Australopithecines walked upright on two legs and qualified structurally to be regarded as Hominidae, rather than as true apes or Pongidae, nevertheless in absolute size their brains were on an average no larger than those of apes.

All the known tool-making hominids had brains considerably larger than those of apes. The earliest known toolmakers, the Chinese representatives of the genus *Pithecanthropus*, had skulls with average capacity about twice as great as that of *Australopithecus*. In the second place, Professor von Koenigswald had reported remains of an early *Pithecanthropus* in the Djetis Beds of Java which he claimed were of Villafranchian age. In other words, *Australopithecus* and *Pithecanthropus* evidently existed in the world contemporaneously, and at Peking at least there was evidence that the latter was capable of tool making. Thus it seemed most probable on the evidence available in 1954 that the pebble tools in the Vaal valley terrace had been made by true men, of the *Pithecanthropus* group, who had penetrated into South Africa before their more backward relatives the Australopithecines had died out. The above hypothesis seemed to be strongly supported by the absence of pebble tools from all the sites where remains of Australopithecines had been discovered, suggesting that although pebble toolmakers existed contemporaneously with the Australopithecines, the two groups frequented different environments.

The whole picture has now been altered by further discoveries. Two years ago, some possible pebble tools, mostly of dolomite, were found in the gravel bed overlying the main Australopithecine deposit in the Limeworks Cave at Makapan in the Transvaal. These were commented on in Antiquity, vol. 30, p. 6, March 1956, and one of the chipped pebbles was illustrated (pl. II). There was considerable doubt as to whether these were artifacts, and the general opinion was that unless more convincing specimens came to light in the same bed they were better discounted as evidence bearing on the cultural status of *Australopithecus*.

In May 1956 Dr. C. K. Brain discovered indubitable pebble tools of Oldowan type in the upper part of the Australopithecine breccias at Sterkfontein in South Transvaal. This is possibly the most important discovery in the field of paleoanthropology since the finding of implements with Peking man. Excavations at Sterkfontein carried out this year by Dr. J. T. Robinson and Revil Mason have confirmed beyond all doubt that the artifacts observed by Brain are part of an industry occurring in situ in a layer of breccia containing teeth of *Australopithecus*.

It is worth reiterating that the hypothetical attribution of the pebble tools, not to Australopithecines themselves, but to some higher type of hominid living contemporaneously with *Australopithecus* in the Transvaal, has rather depended on the assumption that the two types would have occupied different ecological niches. As Bartholomew and Birdsell (1953) pointed out: "By analogy with the ecology

of other animals it would be surprising if man and the Australopithecines[7] had remained contemporaries in the same area over very long periods of time, for closely related forms with similar requirements rarely occupy the same area simultaneously."

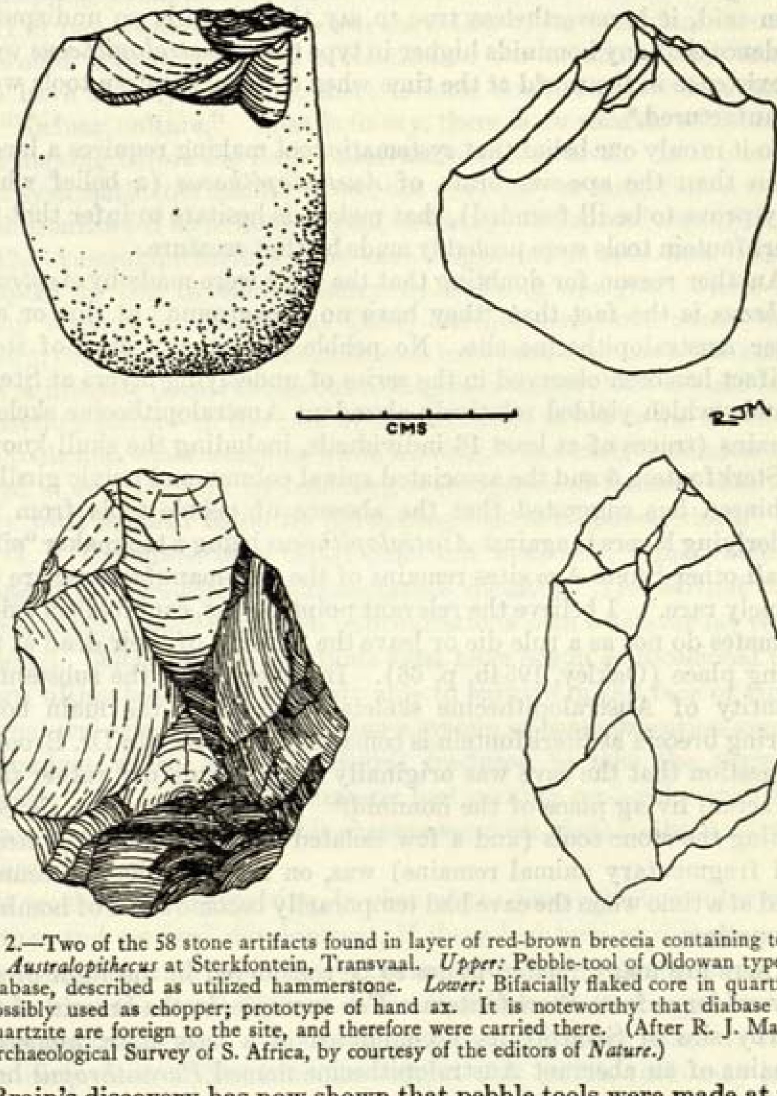

FIG. 2.—Two of the 58 stone artifacts found in layer of red-brown breccia containing teeth of *Australopithecus* at Sterkfontein, Transvaal. *Upper:* Pebble-tool of Oldowan type, in diabase, described as utilized hammerstone. *Lower:* Bifacially flaked core in quartzite, possibly used as chopper; prototype of hand ax. It is noteworthy that diabase and quartzite are foreign to the site, and therefore were carried there. (After R. J. Mason, Archaeological Survey of S. Africa, by courtesy of the editors of *Nature.*)

Brain's discovery has now shown that pebble tools were made at the very site where *Australopithecus* occurred.

At the present time there is general agreement among paleontologists that the Australopithecine breccia at Sterkfontein is of Late Villafranchian (Lower Pleistocene) age. On the other hand Dr.

[7] The authors were assuming that the Australopithecines were nontoolmakers, in contradistinction to man.

D. A. Hooijer's further analysis of the fauna of the Djetis Beds in Java, which contained the remains of the earliest known examples of *Pithecanthropus*, has indicated that they are probably early Middle Pleistocene and not Villafranchian as previously claimed by von Koenigswald. While the last word on this question may not yet have been said, it is nevertheless true to say that there is no undisputed evidence that any hominids higher in type than *Australopithecus* were in existence in the world at the time when the Sterkfontein tools were manufactured.[8]

So it is only our belief that systematic tool making requires a larger brain than the ape-size brain of *Australopithecus* (a belief which may prove to be ill founded), that makes us hesitate to infer that the Sterkfontein tools were probably made by that creature.

Another reason for doubting that the tools were made by *Australopithecus* is the fact that "they have no background" at this or any other Australopithecine site. No pebble tool or any kind of stone artifact has been observed in the series of underlying layers at Sterkfontein which yielded relatively abundant Australopithecine skeletal remains (traces of at least 16 individuals, including the skull known as Sterkfontein 5 and the associated spinal column and pelvic girdle). Robinson has suggested that the absence of pebble tools from the underlying layers is against *Australopithecus* being a toolmaker "since on all other Stone Age sites remains of the tool-manufacturer are extremely rare." I believe the relevant point is that, cannibalism aside, primates do not as a rule die or leave the remains of their dead at the living place (Oakley, 1954b, p. 66). In other words the substantial quantity of Australopithecine skeletal remains in the main bone-bearing breccia at Sterkfontein is consistent with the late Dr. Broom's suggestion that the cave was originally a carnivores' den rather than the actual living place of the hominid.[9] The red-brown breccia containing the stone tools (and a few isolated teeth of *Australopithecus* and fragmentary animal remains) was, on the other hand, accumulated at a time when the cave had temporarily become a site of hominid occupation.

There are many related issues to be considered in the light of the new evidence from Sterkfontein. For example, in the breccia of the nearby site of Swartkrans, accumulated at a later date, numerous remains of an aberrant Australopithecine named *Paranthropus* have

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[8] The antiquity of the fragmentary mandible of *Homo* cf. *sapiens* recorded from the Kanam Beds of Kenya is now considered too doubtful to stand in the way of this generalization.

[9] The evidence collected in South Africa recently indicating that modern hyenas do not carry carcasses or bones into caves (Dart, 1957) has little bearing on the activities of extinct species or varieties of hyena. Behavior of mammals is modified in response to environmental, particularly biotopic, changes. There is evidence that under subglacial conditions in Europe the hyena *Crocuta* took bones into caves, at least as long as competition by man did not preclude it.

been found, also some fragments, including a lower jaw, referred to a related form called "*Telanthropus*," which Robinson believes may have been the toolmaker. However, as the Swartkrans breccia is on a later time horizon than the Sterkfontein tools, one feels hesitant in attempting to explain the latter in terms of the former.[10]

If in fact *Australopithecus* was the maker of the Sterkfontein tools, it would involve almost a revolution in our conception of "man." We have already seen that there is some doubt about the existence of "Kafuan culture." That is to say, there is no reliable evidence of tool making before the Late Villafranchian time level. Is it possible that systematic tool making arose, not gradually as most 19th-century evolutionists led us to imagine, but suddenly, and spread rapidly?

The Australopithecines must have originated as apes that became adapted to life in open country by walking upright. There are many reasons to suppose, as Dart, Bartholemew, and others have shown, that the earliest hominids must have been tool *users*. Bipedalism is initially disadvantageous biologically unless there is some compensating factor—in the case of the hominids this was the ability to use tools and wield weapons while moving. The early hominids survived in open country by becoming scavengers and hunters, and this they were enabled to do by developing "extra-corporeal limbs" (as O. G. S. Crawford once called tools and weapons), which could be changed or discarded as circumstances dictated. The earliest tools and weapons would have been improvizations with whatever lay ready to hand. Although the hominids must have begun as occasional tool users, ultimately they were only able to survive in the face of rigorous natural selection by developing a system of communication among themselves which enabled cultural tradition to take the place of heredity. At this point systematic tool making replaced casual tool using, and it may be that this changeover took place in the Australopithecine stage.

It would not be surprising, in view of the close correlation between culture and cerebral development, if there had been at this stage intense selection in favor of larger brains, with the result that the transition from the small-brained *Australopithecus* to the larger-brained *Pithecanthropus* took place in a comparatively short space of time. The discoveries at Sterkfontein suggest that pebble tools may have been made by *Australopithecus*, while Professor Arambourg's finds at Ternifine ("*Atlanthropus*") indicate that by the time culture in Africa had reached the beginning of the Acheulian stage the toolmakers had attained the grade of *Pithecanthropus*.

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[10] In any case some authorities doubt whether "*Telanthropus*" is separable from *Australopithecus* (Le Gros Clark, 1958, p. 133.)

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An American Indian contemplating the progress of civilization.

From "A Pictorial History of the United States," by S. G. Goodrich. Philadelphia, 1845.

The Backwash of the Frontier: The Impact of the Indian on American Culture[1]

By A. Irving Hallowell
Department of Anthropology, University of Pennsylvania

[With 8 plates]

Although Frederick Jackson Turner and his disciples have made little point of the influence of the American Indian upon our civilization, it is the Indian's continuing presence throughout our whole colonial and national history that has given many aspects of our culture a special coloring. In this respect, our national experience differs from that of any western European nation, though our culture is continuous with that of Europe. Recently, Bernard De Voto has stressed the manifold nature of this unique historical situation and its neglect by historians[2]:

> Most American history has been written as if history were a function solely of white culture—in spite of the fact that till well into the nineteenth century the Indians were one of the principal determinants of historical events. Those of us who work in frontier history—which begins at the tidal beaches and when the sixteenth century begins—are repeatedly nonplused to discover how little has been done for us in regard to the one force bearing on our field that was active everywhere. Disregarding Parkman's great example, American historians have made shockingly little effort to understand the life, the societies, the cultures, the thinking, and the feeling of the Indians, and disastrously little effort to understand how all these affected white men and their societies.

It is discernible Indian influences of this sort that have formed what I have called "the backwash of the frontier," fertile silt carried on the currents and eddies left by the turmoil on the borderlands. Many other factors besides frontier conditions were involved in the further development of these influences—factors too complex to analyze here. And the problem is complicated by the extreme diversity of America's reactions to the Indian and his cultures; by the manner in which Indian influences have been mediated, the varying

[1] Reprinted, by permission of the copyright owners, the Regents of the University of Wisconsin, from The Frontier in Perspective (Walker D. Wyman and Clifton B. Kroeber, editors), 1957, the University of Wisconsin Press.

[2] Joseph K. Howard, "Strange Empire," p. 8. New York. 1952.

forms they have assumed at different periods of our national existence, and their depth. Most often they have been manifested at the vernacular level of American culture, one expression of our cultural provincialism, which is perhaps the reason so little systematic attention has been paid to them. Our contacts with the Indians have affected our speech, our economic life, our clothing, our sports and recreations, certain indigenous religious cults, many of our curative practices, folk and concert music, the novel, poetry, drama, and even some of our basic psychological attitudes, and one of the social sciences, anthropology.

To the outside world there is a closer association of the Indian with the image of America than perhaps we are aware of. For example, Cooper's "The Last of the Mohicans" is not only read by every American schoolchild, but it has been said to be the best-known American novel in the world. So too, "Hiawatha," Longfellow's poetic image of the Indian, is widely read and translated in other countries. Ivan Bunin, the Russian poet and novelist, "is probably as well recognized for his translation of 'Hiawatha' as for any of his original works."[3]

Americans have created a whole succession of images of the Indian, some literary and interpretative, some growing out of direct contact of particular types of white men with him and changing with historical circumstances. Although the Pope declared as far back as 1512 that the natives of America were descended from Adam and Eve, in colonial New England Cotton Mather thought that "probably the *Devil* decoy'd . . . [them] . . . hither, in hopes that the gospel of the Lord Jesus Christ would never come here to destroy or disturb his absolute empire over them." As God's elected agents and under his "wonder-working Providence," the colonists must convert these "tawney serpents" or annihilate them. However, the Indian was never simply The Enemy. On the earliest frontiers, the colonists were befriended by the natives. Who has not heard of Squanto? White men from the beginning profited in many practical ways from the Indians' knowledge of their own country and through intimate contacts learned about their customs, manner of thought, and character, and were influenced by them.

During the 18th century, when in England and on the Continent a literary image of the noble savage, partly derived from ideas about the Indian, was being created, the colonists greatly deepened their firsthand knowledge of the American natives. Trading activities brought tribal groups over a wider range into contact with the colonists. The Indians were not always fought against; on occasion they were comrades-in-arms, and aboriginal methods of fighting influenced

[3] Clarence Gohdes, The reception of some nineteenth-century American authors in Europe, *in* "The American Writer and the European Tradition," ed. Margaret Denny and W. H. Gilman, p. 116. Minneapolis. 1950.

the colonists. The speeches made by Indians in treaty negotiations aroused so much interest in native oratory that a novel literary form, with no prototype in Europe, emerged. Verbatim reports of these conferences were widely circulated and read in printed form. It has even been said that information about the organization and operation of the League of the Iroquois, which Franklin picked up at various Indian councils, suggested to him the pattern for a United States of America. In any case it was Franklin whose appreciation of the attitude of the Indians toward their own culture led him to express the anthropological principle of the relativity of culture norms when, in 1784, he wrote: "Savages we call them, because their manners differ from ours, which we think the Perfection of Civility: they think the same of theirs." [4]

As the eastern frontier receded westward and for most Americans the contemporary Indians could be viewed at a comfortable distance, it was their decline that became a romantic literary theme. As expressed in poetry, drama, and the novel, it was an early backwash of the frontier. But it was by no means always the noble savage that was depicted; a double image was created—the savage as ignoble as well as noble. During this period, the first half of the 19th century, when the Indian was such a popular figure in American literature, it is particularly significant that most of the authors who dealt with Indian themes derived their information from written sources rather than from direct observation. Cooper depended on Heckewelder's writings, and Longfellow on Schoolcraft's "Algic Researches" (1839). It has been said that "Cooper poured the prejudices of John Heckewelder into the Leatherstocking mold, and produced the Indian of nineteenth century convention." [5] The authors who were busy writing about the Indians were far removed from the men who faced them on the new frontiers.

Two and a half centuries after Englishmen on the eastern frontier faced the Indian, American frontiersmen in the Mississippi Valley and the Far West found themselves in a parallel situation and regarded him in much the same hostile light—the Indian blocked the path of America's "manifest destiny." In 1867, the Topeka Weekly Leader spoke for the West when it characterized the Indians as "a set of miserable, dirty, lousy, blanketed, thieving, lying, sneaking, murdering, graceless, faithless, gut-eating skunks as the Lord ever permitted to infect the earth, and whose immediate and final extermination all men, except Indian agents and traders, should pray for." [6]

[4] Alfred O. Aldridge, Franklin's deistical Indians, Proc. Amer. Philos. Soc., vol. 94, p. 398, 1950.

[5] Paul A. W. Wallace, John Heckewelder's Indians and the Fennimore Cooper tradition, ibid., vol. 96, p. 500, 1952.

[6] Robert Taft, "Artists and Illustrators of the Old West, 1850–1900," p. 66. New York. 1953.

A

TREATY of FRIENDSHIP, &c.

September, 1736.

THE Chiefs of the *Six Nations* having been expected at *Philadelphia* theſe four Years paſt, to confirm the Treaty made with ſome of them, who came down in the Year 1732, *Conrad Wyſer* our Interpreter, about the Beginning of this Month, adviſed from *Tulpyhokin*, that he had certain Intelligence from ſome Indians ſent before him, that there was a large Number of thoſe People with their Chiefs, arrived at *Shamokin* on *Saſquehannah*; upon which he was directed to repair thither to attend them, and ſupply them with Neceſſaries in their Journey hither.

On the *Twenty-ſeventh* of this Month, about a Hundred or more of them came with *Conrad* to the Preſident's Houſe, at *Stenton*, being near the Road, where ſuitable Entertainment was provided for them; and the next Day the Honourable the Proprietor, and ſome of the Council, with other Gentlemen coming thither from *Philadelphia*; after Dinner

A Council was held at *Stenton*, *September* 28. 1736.

PRESENT,

The Honourable *THOMAS PENN*, Eſq; Proprietary.

JAMES LOGAN, Eſq; Preſident.

Samuel Preſton, *Ralph Aſheton*,
Clement Plumſted, *Thomas Griffitts*, } Eſqrs;

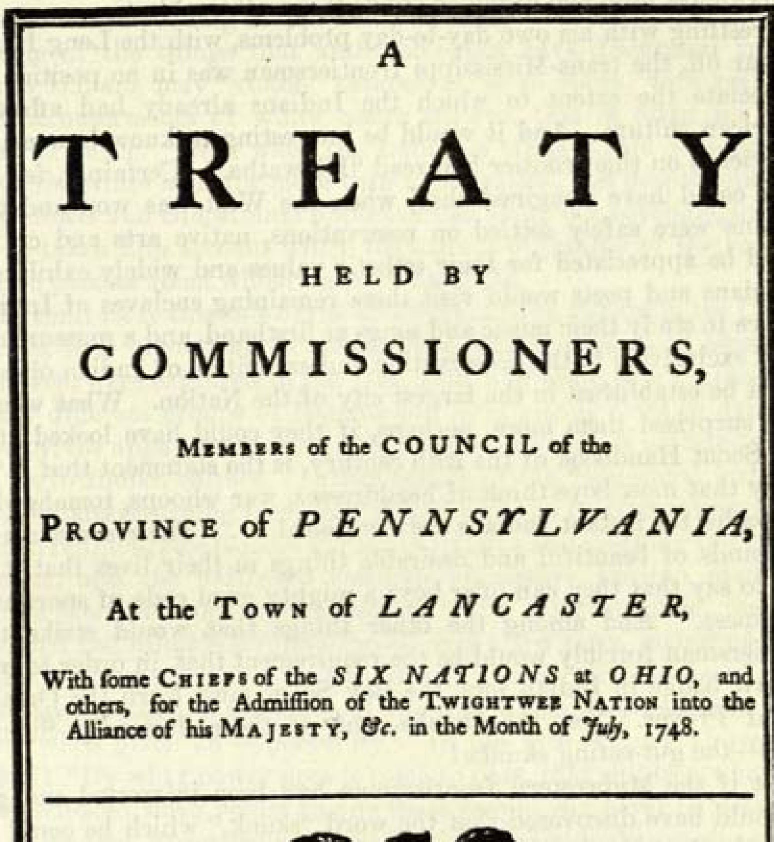
And the following *Indian* Chiefs, to wit.

Of the TSANANDOWANS *or* SINEKAS.
Kanickhungo, Speaker.
Togachſhaholoo,
Sagoyatundachquai,
Askotax,
Hetaquantegechty, Speaker.

ONANDAGOES.
Kahiskerowane (Brother to their former great Chief *Conoſſoorah* at *Albany*)
Tagunhuntee,
Kaxhaayn,
Kuchdachary,
Saweegatee-o.

CAYOOGES.

FIGS. 1 and 2 (on opposite page).—Title pages of the published accounts of two Pennsylvania Indian treaty conferences of the type widely read for their literary value in the 18th century.



A

TREATY

HELD BY

COMMISSIONERS,

MEMBERS of the COUNCIL of the

PROVINCE of *PENNSYLVANIA*,

At the TOWN of *LANCASTER*,

With ſome CHIEFS of the *SIX NATIONS* at *OHIO*, and others, for the Admiſſion of the TWIGHTWEE NATION into the Alliance of his MAJESTY, *&c.* in the Month of *July*, 1748.

PHILADELPHIA:

Printed and Sold by B. FRANKLIN, at the New Printing-Office, near the Market. MDCCXLVIII.

FIG. 2

Cotton Mather's terser characterization of the "tawney serpents" seems almost mild and dignified beside this scathing blast.

Wrestling with his own day-to-day problems, with the Long Hairs not far off, the trans-Mississippi frontiersman was in no position to appreciate the extent to which the Indians already had affected American culture. And it would be interesting to know how many Americans on this frontier had read "Hiawatha." Certainly, few of them could have imagined that, when the West was won and the Indians were safely settled on reservations, native arts and crafts would be appreciated for their esthetic values and widely exhibited, musicians and poets would visit these remaining enclaves of Indian culture to study their music and songs at firsthand, and a museum devoted exclusively to the preservation and exhibition of Indian objects would be established in the largest city of the Nation. What would have surprised them more, perhaps, if they could have looked at a Boy Scout Handbook of the 20th century, is the statement that it "is a pity that most boys think of headdresses, war whoops, tomahawks, and scalps the instant Indians are mentioned. . . . There are so many thousands of beautiful and desirable things in their lives that it is safe to say that they can offer boys a mighty good code of sport and happiness." And among the other things that would strike the frontiersman forcibly would be the requirement that, in order to win a merit badge in Indian lore, the Boy Scout must learn the Omaha Tribal Prayer. Yes, the Omaha, one of those dastardly Siouan tribes—the gut-eating skunks!

But if the Midwestern frontiersman had been interested enough, he would have discovered that the word "skunk," which he could so glibly hurl at the Long Hairs as a derogatory epithet, was derived from an Indian language and had entered American speech in the 17th century. The borrowing of words as well as traits of Indian culture, like the use of corn, had been going on for a long time. Referred to by anthropologists as cultural diffusion, this kind of cultural borrowing is a process that has been occurring throughout the entire history of man. It has been one of the main stimuli of cultural change. When people of different cultures meet and social interaction takes place, this situation inevitably eventuates in some cultural borrowing on the part of either or both peoples.

In the past two decades, cultural anthropologists in this country have devoted increasing attention to detailed studies of the effects of Euro-American culture upon the Indians, that is, acculturation, rather than confining themselves, as was once the case, primarily to the collection of data that would make it possible to reconstruct an ethnographic picture of aboriginal life in its undisturbed form. On the other hand, although recognizing that in principle acculturation is seldom if ever a one-way process, anthropologists have

paid scarcely any attention to the total effects upon American culture of our continuing contacts with Indians.

One of the things that anthropologists have discovered is that while Indians may "clothe" themselves, so to speak, with many of the accouterments of white man's culture, this is often no more than skindeep. Even when the Indian is brought into close contact with the white man for more than a generation, and despite missionary efforts and educational opportunities, there is a psychological lag to be taken into account which indicates a dimension of the acculturation process about which we know too little.

In contrast to this side of the acculturalization picture in the United States, it is interesting to recall, when white adults, and especially children, were captured in the 17th, 18th, and early 19th centuries by many different groups of Indians and lived among them in daily intimacy, the apparent ease with which these individuals adjusted themselves to Indian culture. Turner speaks of the "occasional instances of Puritans returning from captivity to visit the frontier towns, Catholic in religion, painted and garbed as Indians and speaking the Indian tongue, and the halfbreed children of captive Puritan mothers." While there were many hundreds of white captives taken, we have detailed and reliable information on only a few cases, including individuals who were abducted as children. These "white Indians" often refused to return to the mode of life into which they had been born, even when given an opportunity.[7] In the 18th century Crèvecoeur asked: "By what power does it come to pass, that children who have been adopted when young among these people, can never be prevailed on to readopt European manners?" Such individuals sometimes forgot their native speech, like Cynthia Ann Parker, captured by the Comanches in 1836 at the age of 9. When recaptured by the whites as a grown woman, all she could remember was her name. Other captives praised Indian character and morals and some of them adopted an Indian world view and religious beliefs. It was said of Mary Jemison, abducted in 1758 at the age of 15, that "she was as strong a pagan in her feelings as any Indian," that all her religious ideas conformed to those of the Senecas, and that "the doctrine taught in the Christian religion she is a stranger to." Of William Failey, abducted in 1837, his brother-in-law and biographer wrote: "In fact, his long residence among the Indians has made him an Indian." Don Ryan in "The Warriors' Path" (1937) and Conrad Richter in "The Light in the Forest" (1953) have given this theme modern novelistic treatment. The latter book was soon republished in paperback form (1954), and Walt Disney has made a movie of it.

Benjamin Franklin must have been highly impressed by the atti-

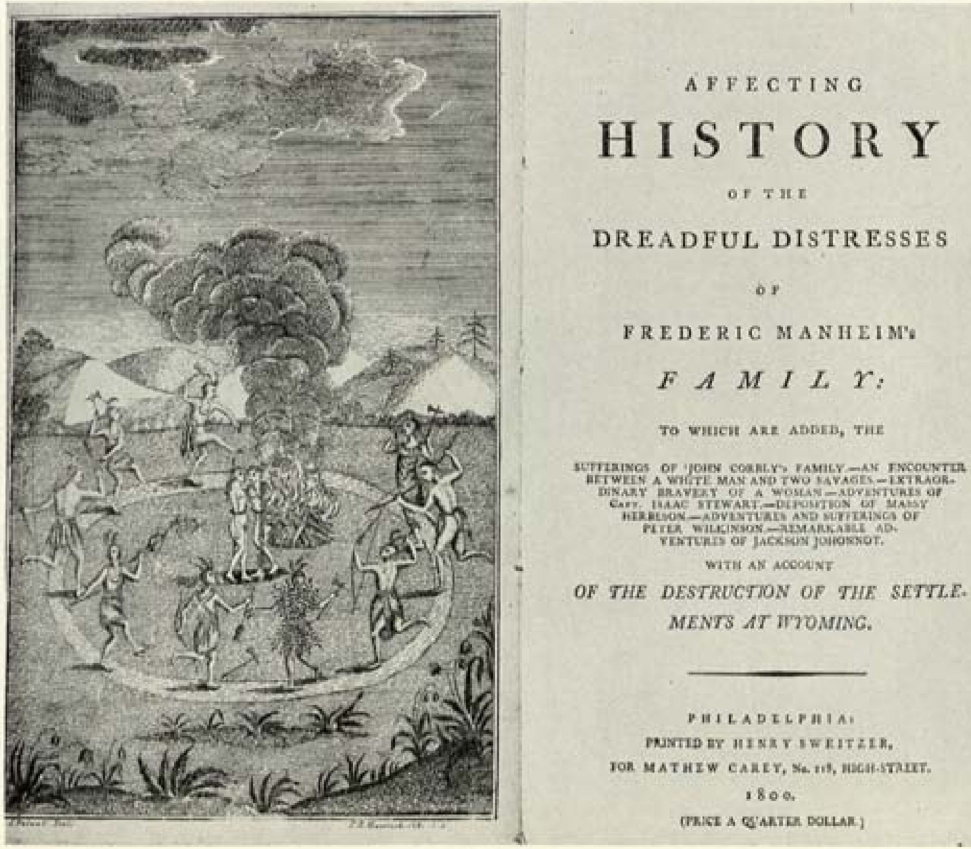
[7] Erwin H. Ackerknecht, White Indians, Bull. Hist. Med., vol. 15, pp. 26, 30, 1944.

tude which the Six Nations assumed toward the values of their own culture as compared with that of the whites. An anecdote, in several forms, appears in his writings which presumably was derived from the considered response these Indians made when, during the Lancaster conference in 1744, it was suggested that if they so desired some of their boys might be sent to Williamsburg for a white education. The Iroquois countered with the proposition that "if the English Gentlemen would send a Dozen or two of their children to Onondago, the great council would take care of their Education, bring them up in really what was the best Manner and make men of them."[8]

These Indians not only felt secure in their own values; they felt free to appraise those of the white man. And the captives who became "white Indians" discovered that the actual manner of life of the natives was something other than the literary images of the noble savage or the fiendish red man. The Indian cultures contained values which the white child could assimilate, live by, and in adulthood refuse to relinquish. Old White Boy and all his sons became Seneca chiefs. Even aside from captives, there were white men on the frontier who became semiacculturated to Indian ways. Sam Houston, in his early days, lived with the Cherokees. It has not been sufficiently stressed that Leatherstocking, the most famous internationally of all characters in American fiction, falls into this category. Although a white man by "natur," he had Indian "gifts." He is said to have "acquired some knowledge of most of the Indian dialects." During his early life, he lived among the Delawares and long before they called him Deerslayer, he had successively borne three other Indian nicknames. On occasion, he identified himself with the Delawares and their aboriginal values. When contemplating torture by the Hurons, he says he will strive "not to disgrace the people among whom I got my training." And the Huron chiefs, uncertain about his return from the brief furlough granted him, entertained "the hope of disgracing the Delawares by casting into their teeth the delinquency of one held in their villages." While they would have preferred to torture his Indian comrade Chingachgook, they thought the "pale face scion of the hated stock was no bad substitute for their purposes." Quite aside from his characterization as the honest, resourceful, intrepid frontiersman and scout, the uniqueness of Leatherstocking as the first white man in fiction represented as acculturated in his youth to Indian languages, customs, and values, should not be overlooked.

From a contemporary vantage point, I believe that our relations with the Indians involve one distinct peculiarity which might have been difficult to predict at an earlier period of our history. Despite our achievement of political dominance, considerable race mixture, and the effects of acculturation on the native peoples, neither the In-

[8] Aldridge, Franklin's deistical Indians, p. 399.



AFFECTING

HISTORY

OF THE

DREADFUL DISTRESSES

OF

FREDERIC MANHEIM's

FAMILY:

TO WHICH ARE ADDED, THE

SUFFERINGS OF JOHN CORBLY's FAMILY.—AN ENCOUNTER BETWEEN A WHITE MAN AND TWO SAVAGES.—EXTRAORDINARY BRAVERY OF A WOMAN.—ADVENTURES OF CAPT. ISAAC STEWART.—DEPOSITION OF MASSY HERBISON.—ADVENTURES AND SUFFERINGS OF PETER WILKINSON.—REMARKABLE ADVENTURES OF JACKSON JOHONNOT.

WITH AN ACCOUNT

OF THE DESTRUCTION OF THE SETTLEMENTS AT WYOMING.

PHILADELPHIA:

PRINTED BY HENRY SWEITZER,

FOR MATHEW CAREY, No. 118, HIGH-STREET.

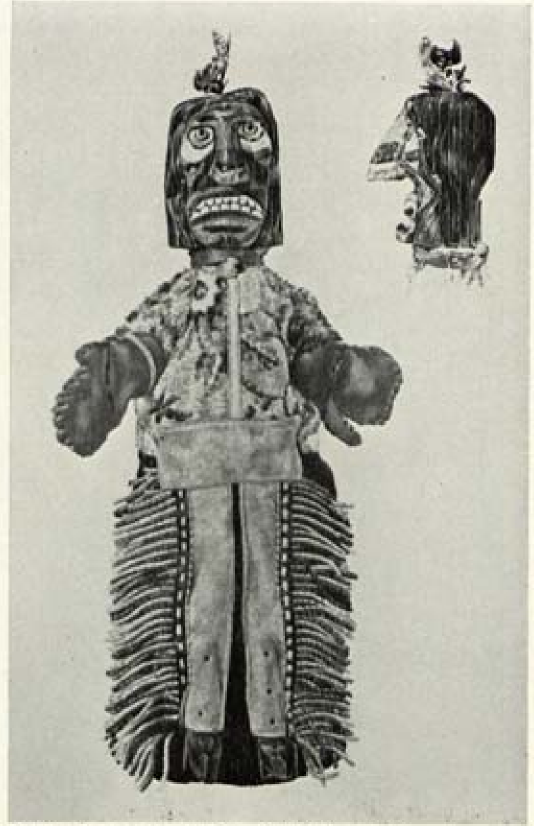
1800.

(PRICE A QUARTER DOLLAR.)

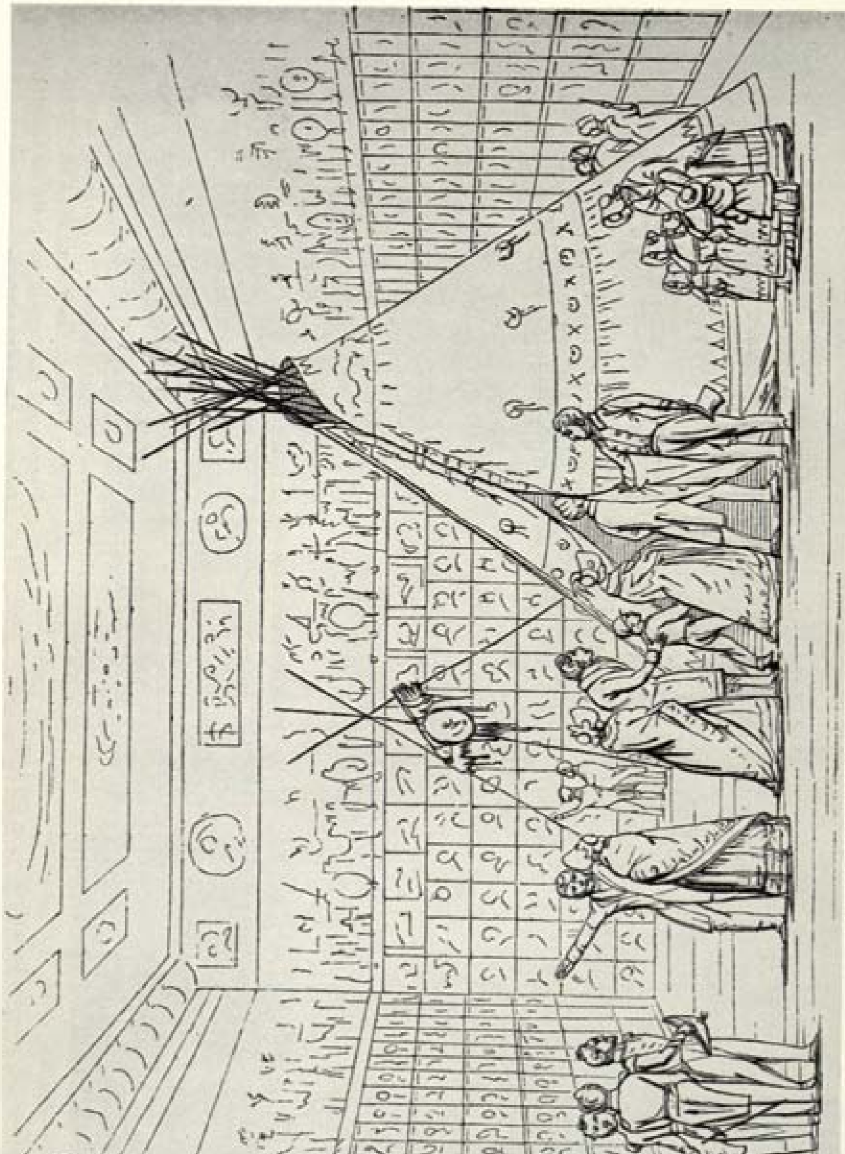
Frontispiece and title page of an anthology of Indian captivity stories, originally published in 1793. The engraving shows Manheim's twin 16-year-old daughters being burned at the stake.

Deh-ge-wa-nus [Mary Jemison], "the golden-haired Seneca," in full Indian costume carrying her baby on a cradleboard. Bronze statue in Letchworth State Park, New York.

1. Cigar-store Indian so familiar to the 19th-century scene. A fine example of portraitlike realism.



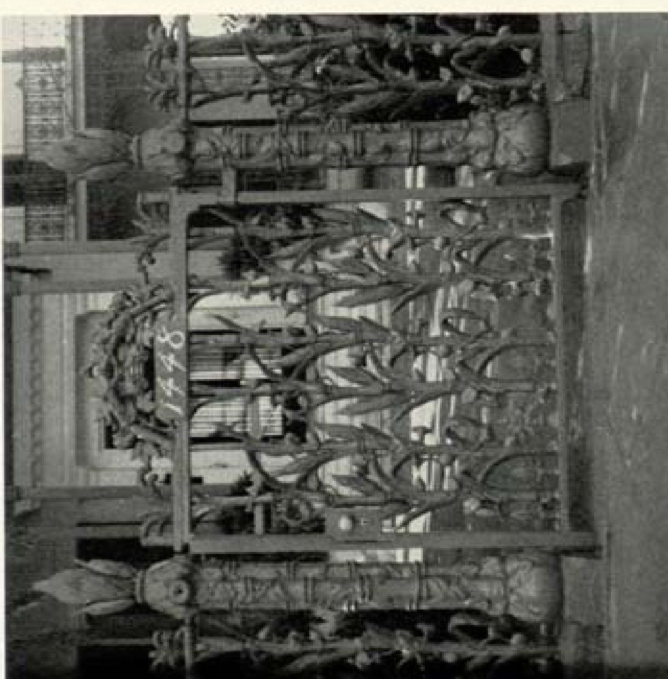
2. Hand-puppet Indian "Rain-in-the-Face," noted North Dakota Sioux Indian Chief (1835–1905). Photograph courtesy of the National Gallery of Art, Index of American Design.



"I met his Majesty again, with a number of illustrious friends, in my collection; and after he had taken them around the room while he described familiar scenes which he had met there on a former visit, I continued to explain other paintings and Indian manufactures in the collection."
(From "Catlin's Notes of Eight Years' Travels and Residence in Europe with His North American Indian Collection," 1848.)

"At the approach of the lady and her Royal party, the Indians all arose, and the chiefs having been introduced, half an hour or more was passed in conversation with them . . . and an examination of their costumes, weapons, etc., when they seated themselves in a circle, and passing the pipe around, were preparing for a dance. The first they selected was their favourite, the eagle-dance, which they gave with great spirit, and my explanation of the meaning of it seemed to add much to its interest." (From "Catlin's Notes of Eight Years' Travels and Residence in Europe with his North American Indian Collection," 1848.)

American Indian motif, created by Tom Two Arrows, talented young Indian artist, interpreted on fine china. (Courtesy of H. E. Lauffer Co., Inc., New York City.)



1. Front gate of corn fence, 1448 Prytania St., New Orleans. Wreath over gate is cotton.

2. Detail of corn fence shown in figure 1.

Photographs by J. H. Kempton.

dian nor his culture has completely vanished from our midst. The question arises, have the Indian cultures of the postfrontier period completely ceased to influence us? The answer is no. One effect of the reservation system has been the conservation of those aspects of the native cultures that had survived all the vicissitudes of previous contacts with the white race. A new potential source of influence on our 20th-century culture was created. Before we can turn to the nature of this influence, however, it is necessary to obtain the wider historic perspective that a more systematic consideration of the older lines of influence will provide us.

In the first place, it could have been predicted that, as a result of the colonization of the New World, loan words would appear in various Indo-European languages that could be traced to aboriginal American languages. Besides the nouns borrowed to designate objects unknown in England, there are many expressions in American English that reflect Indian influence—*burying the hatchet*, *Indian summer*, *Indian giver*, *happy hunting ground*, and *war paint*, used by the American woman. *Buck* as a slang expression for *dollar* harks back to the Indian fur trade when prices had reference to beavers or buckskins. Place names of Indian origin are, of course, legion—the names of 26 States, 18 of our largest cities, thousands of small towns, most of the long rivers and large lakes, and a few of the highest mountains are of Indian derivation.

Having come to a country new to them, it was inevitable that the colonists, whose traditional culture had not prepared them to live as they had to live here, should be influenced by those aspects of Indian culture that had immediate practical advantages in daily life. In any case, the determinative importance of the fact that this was not in any sense a virgin land must not be forgotten. The countless generations of Indians had left their imprints upon the landscape. Without the plow, the soil had been cultivated, and the raising of native crops was as typical over wide areas as was hunting and fishing. It is still debatable how far the actual virgin terrain had been radically modified by burning, girdling, and tilling. There were narrow forest trails, trodden by moccasined feet, that were already old, and the whites made use of them in their own system of overland communication, developing some of them into highways eventually connecting great centers of American civilization. Then there were the earthworks of an older Indian population in the Old Northwest Territory which influenced the patterning of some early white settlements. The "pilgrims" who founded Marietta, Ohio, found it convenient to moor their flatboats "at the foot of a raised terrace the Mound Builders had once used as an avenue between their temple and the river." Circleville takes its name from the fact that in the laying out of the original

town, concentric circles of aboriginal earthworks were closely followed by the outlying streets. An octagonal courthouse, surrounded by a circular green, became the hub of the town. And it is said that "in the Wabash River bottoms, in the early spring, many farmhouses stand high and dry on a wooded burial mound while all the fields are under water."[9]

Among the early settlers, communication by water was everywhere the most important. While they were familiar with certain types of watercraft in their own culture, they and their descendants have been influenced by at least two types used by the Indians, the Chesapeake Bay log canoe and the bark canoe of the north.

From a European point of view, the Indians wearing moccasins, leggings, and breechclouts were considered to be relatively naked compared to themselves. However, considered in a very broad culture-historical perspective, their own style and that of the aborigines shared a generic trait in common: throughout the boreal regions of the Northern Hemisphere, clothing of the fitted or tailored type prevails, standing in marked contrast to the untailored style once found in the ancient Mediterranean region, Africa, and Central and South America. In all these latter regions, for example, nothing like the fitted footgear represented by the boot, shoe, or moccasin is found. While the practice never spread beyond the frontier itself, nevertheless there were white men who adopted the wearing of not only Indian moccasins, but leggings and a breechclout as well. The moccasin, of course, is the most noted item of Indian clothing that was used by white men very early. It was a fitted type of footgear, and if the colonists had been Romans, this item of clothing might not have been borrowed so quickly, or its use continued. Turner has noted that the General Court of Massachusetts once ordered 500 pairs each of snowshoes and moccasins for use in the frontier counties. Much later, footgear of this type was used by lumbermen. In the backwoods of Manitoba in the 1930's, a clergyman of my acquaintance always wore a pair of his best beaded moccasins in the pulpit on Sundays. It would be interesting to know more about the commercialization of the moccasin type of shoe which we see increasingly on the feet of Americans today.

It was, however, the discovery of the plants cultivated by the New World aborigines that from the very first produced the most profound impact on both European and American culture, revolutionizing the food economy and diet of Old World peoples and at the same time laying one of the foundations on which was to rise the distinctive structure of American agriculture. Of the several plants—maize, beans, pumpkins, squash, and others—maize in partic-

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[9] Walter Havighurst, "Land of Promise, the story of the Northwest Territory," pp. 24–25, 158. New York. 1946.

ular was important from the start, taking precedence over the grain which the settlers had brought from Europe. It became a primary factor in the acculturation of the Englishmen to an American way of life. We need think only of corn on the cob, cornbread, Indian pudding, hominy, mush, grits, succotash, and corn sirup; of breakfast cereals, cornstarch, and popcorn; or of corncob pipes and bourbon, to understand the extent of this Indian contribution to our civilization today.

Tobacco is an equally significant "gift" of the American Indians, symbolized by the once-familiar figure of the "wooden Indian" inextricably linked with the tobacco shop in the 19th century. The history and use of it in our culture present a number of features in cultural borrowing at large. Readaptation to the values of the borrowing people is well illustrated. The consumption of tobacco was completely divorced from the ceremonial context in which it appeared among the Indians and became purely secular.

Peruvian bark, now known as quinine, proved highly sensational since it was a specific for malaria. It reached Spain before the middle of the 17th century and was soon introduced into the English colonies. In Virginia, Governor Berkeley said in 1671 that whereas formerly one person in five had died of fever in his first year, now almost no one succumbed. When one considers that in this same century Governor Winthrop's famous remedy for ulcers consisted of "one ounce of crabbe's eyes and four ounces of strong wine vinegar," the general state of colonial medicine can be well appreciated, and the reason why Peruvian bark, an Indian herbal, achieved such high fame can be easily understood. Indian medicine was likewise given a boost when, in 1738, Dr. John Tennent was awarded 100 pounds by the Virginia House of Burgesses for curing pleurisy with Seneca rattlesnake root. As William Fenton well says, when Western medicine met Indian herbalism, the former "was still carrying a heavy burden of medieval practices so that the first few physicians in the colonies were but several centuries advanced from the Indian shaman who selected his herbs thinking of the effect that their appearance might contribute to the disease, and guaranteed their efficiency with incantations and feats of magic. Moreover, the average settler had brought from the Old World a knowledge of herbs that in kind was not unlike that of the Indian, but as newcomers they were unfamiliar with New World plants, and although the level of their own popular medicine did not set them above adopting Indian remedies, the Indian herbalist whose knowledge was power was not always a ready teacher." [10] In "The Pioneers," Cooper pictures for us how "Doctor" Elnathan Todd managed to steal one of John Mohegan's remedies.

[10] W. N. Fenton, Contacts between Iroquois herbalism and colonial medicine. Ann. Rep. Smithsonian Inst. for 1941, pp. 505–506.

Popular confidence in Indian medicine remained strong during the early 19th century, when the population was flowing over the Appalachians. The "yarb and root" doctor, red or white, played a prominent role in many communities. In 1813 in Cincinnati there was published "The Indian Doctor's Dispensatory." Other books followed, including Selman's "The Indian Guide to Health" (1836) and Foster's "The North American Indian Doctor, or Nature's Method of Curing and Preventing Disease According to the Indians" (1838). In a lecture given at the New York Academy of Medicine in 1936, Dr. Harlow Brooks (emeritus professor of clinical medicine, New York University) said:

> The universal testimony of those qualified to judge has been that even within the memory of my generation we have incorporated into our pharmacopoeia and practice a good many practices and drugs of our Indian predecessors. . . . The leading doctor in my boyhood memory, in the district in which my parents settled, was an old Sioux medicine man, whose services were considered by the territorial government so valuable that when his tribe was removed to a reservation he was asked to remain with his white patients, among whom were my own parents. I am sure that much of the medicine I received as an infant and child was derived directly from the lore of this fine, learned, and much respected old man. In those days it was on the service of these men that our pioneers relied for medical help; otherwise, little or none at all was available to the early settler.[11]

What is particularly interesting is not merely the incorporation in our pharmacopoeia of some aboriginal drugs, but the positive attitude toward Indian medicine and charms that has persisted into the 20th century. For instance, old Seneca families still sell wild flowers and sassafras on certain street corners in Buffalo, and the Pamunkey Indians of Virginia until a decade ago went to Washington every spring to sell sassafras and other herbs. In "Triple Western" (fall, 1954) there is a short item on "Medicine Man's Wisdom."

The potencies attributed to Indian herbal remedies have had still other manifestations in our culture, an important one being the medicine show. While not all these shows made use of the Indian, most of them did. It has been said that "as a symbol" the native "was as important to the med-show platform as the wooden Indian was to the tobacco shop." It exploited the image that had already been created of him as a "healer." When Chief Chauncey Kills-in-the-Bush Yellow Robe died, eulogies appeared in the theatrical press. Rolling Thunder, the owner of the Kiowa Indian Medicine and Vaudeville Company, commented on these as follows:

> It is fine to see this intelligent recognition of the life work of an Indian. Too many people have always thought of the American Indian as next to a beast. There are some who are now learning the truth: that the Indian's drug-

[11] Harlow Brooks, The contribution of the primitive American to medicine, *in* I. Goldston (ed.), "Medicine and Mankind," p. 87. New York. 1936.

store was always the field and the forest, where the herbs he uses in his medicines are gathered as God placed them for him to use, and God gave the Indian the knowledge to gather and compound them. That is why the Indian as a healer has been a success.[12]

The authors of "Show Biz" say that "when the Kickapoo Indian Medicine Company went on the block in 1911, after 30 years roaming the American plains and hamlets, it still brought $250,000. At one time, there were 150 medicine shows on the road, all of them featuring one or more Kickapoo Indians."[13] It may be pointed out in passing that at the same time that the image of the Indian as a healer was being exploited in the medicine show, the old image of him as a bloodthirsty enemy was being dramatized by the Wild West show that William F. Cody took on the road in 1883 and which in various incarnations and imitations continued until 1931, when the 101 Ranch closed down.

The red man also became involved in another characteristic area of American cultural development in the years before the Civil War—religion. In Spiritualism, the United Society of Believers (Shakers), and the Church of Latter-day Saints (Mormons), the American Indians had special significance for the founders or adherents. According to Shaker tradition, "it was a native of the forest who first recognized the saintliness of Mother Ann. One poor Indian saw a bright light around her, and prophesied that the Great Spirit had sent her to do much good. In another story it is related that when Ann was returning from her eastern mission, she was met at the Albany ferry by a number of Indians, who joyfully cried: 'The good woman is come! The good woman is come!'"[14] What other religious sect in the world has turned to an aboriginal people for validation of the saintliness of the founder? Besides this, some of the Shaker "gift songs" received in trance came from Indian spirits. Once the spirits of a whole tribe of Indians, who had died before Columbus discovered America and had been wandering homeless ever since, turned up at a Shaker meetinghouse, where they were made welcome. As described by an eyewitness, more than a dozen of the Shakers present became possessed by these Indian guests. A pow-wow ensued. There were yells, whoops, and strange antics. The Indian spirits asked for succotash, which they ate, and after some instruction were sent off under guidance "to the Shakers' heavenly world."

Although "speaking in tongues" had a long history in Europe as well as in America, one of the striking facts in the early developmental phases of American Spiritualism is the frequency of refer-

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[12] Winnifred Johnston, Medicine Show, Southwest Rev., vol. 21, p. 393. 1936.

[13] Abel Green and Joe Laurie, Jr., "Show Biz, from Vaude to Video," p. 83. New York. 1953.

[14] E. D. Andrews, "The People Called Shakers," p. 169. New York. 1953.

ences to mediums speaking Indian languages and to those who had an Indian "control" or "guide." The names of more than a dozen mediums, men and women and their Indian controls, appear in the "Encyclopaedia of Psychic Science." Such historic figures as Red Jacket, Black Hawk, and Tecumseh are on the list, as well as spirits with such names as White Feather, Bright Eyes, and Moonstone. What is particularly significant is that these Indian spirits were thought to be beneficent in their influence, especially because of their healing powers, although they often manifested themselves at seances in a somewhat rambunctious manner. As time went on and spirit photography was introduced, some of these spirits appeared in native costume in the photographs.

It would seem that no other American religious sect, with the possible exception of the Shakers, felt such a genuine affinity with the aborigines. While there was no question of borrowing Indian beliefs as such, nevertheless the Spiritualists saw analogies to their own views and practices. One of these was the "shaking tent" rite of the Algonkians of the eastern woodlands (which has been described elsewhere).[15] Into a framework of poles covered with birchbark or canvas a conjurer goes; the tent sways and voices are heard which, however, are usually believed to be nonhuman. An early historian of American Spiritualism, writing in 1870, after referring to some of these rites, says:

> Such are some of the phases in which communication exhibits itself amongst a people whom we call "savage" and whom, in comparison to our more advanced civilization, we may justly call so; and yet, does our knowledge of the occult and invisible forces in nature furnish us with any clue to the mystery of these astounding manifestations or the power by which the unlettered "savage" can avail himself of a knowledge which all our control over the elements fails to compete with? In a word, the red Indian can do what we can neither explain nor imitate.[16]

This interest of the Spiritualists in the Indian and his ways has continued down to the present. At Lily Dale, N.Y., the summer mecca of Spiritualists, which commemorated its 50th anniversary in 1929, it has been customary to celebrate Indian Day with parades and dances given by natives from nearby reservations.

To turn now to the Church of Jesus Christ of Latter-day Saints, the attitude of the adherents of this indigenous American sect toward the Indians is in sharp contrast with that of the Spiritualists. According to "The Book of Mormon," the red men are essentially the degenerate posterity of a rebellious segment of a small group of Jews who, migrating to the New World before the beginning of the Christian era, brought with them an advanced culture. Consequently, it is said

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[15] A. Irving Hallowell, "The Role of Conjuring in Saulteaux Society." Philadelphia. 1942.

[16] Emma Hardinge [Emma Hardinge Britten], "History of Modern American Spiritualism," Independence, Mo., 1945, p. 144. (New York, 1870, p. 487.)

that "The Book of Mormon" supplements the Bible, since it is a history of God's dealings with remnants of Israel and the Saviour's ministrations among them in the Western Hemisphere.[17] For in America, the great Nephrite prophecy has been fulfilled—the second coming of Christ. After the Resurrection He appeared to a multitude of nearly 3,000 people in Mexico, before a greater assembly the next day, and after this "he did show himself unto them oft." The occurrence of the legendary figure of a so-called "white god" with certain associated attributes among the Incas, Mayas, Aztecs, and Toltecs, the Mormons interpret as supporting evidence for the historic appearance of Christ in America.

In the Mormon view, the aborigines of the United States were the descendants of the Lamanites, the "bad" people of the Mormon epic. Unlike the Spiritualists, the Mormons had nothing they could look to them for; still, a strange affinity connected them with the Indians. In Mormon hymnals there are songs about the red man. In the days before the rise of archeology or anthropology in the contemporary sense, "The Book of Mormon" was representative of the speculations that had been going on in Europe for several centuries about the peopling of the New World. These earlier theories had to be reconciled first of all with the account given in the Bible of man's creation and dispersal. What is peculiar in the Mormon case, however, is the fact that a particular theory of the peopling of the New World was incorporated as a dogma of a religious sect. This could hardly have occurred anywhere but in early 19th-century America. The early Mormons easily reconciled their theory with the Bible, but since the sect has survived into a period of American culture when an enormous increase in our knowledge of New World prehistory from archeological investigations has taken place, a further reconciliation of the inspired history found in "The Book of Mormon" with this new knowledge is now being sought.

Outside the Mormon church, the consensus is that in its nondoctrinal aspects "The Book of Mormon" is derived from a romance written but not published by Solomon Spaulding, a clergyman who left the church and was in business in Ohio by 1812. There he dug into some mounds and became interested in the origin of the extinct people who had erected them. The theory that they were of Jewish origin was not original with him, since it was maintained by many prominent men in this country. If Spaulding's manuscript had been printed in its original form as fiction, he would have anticipated those writers in America who were soon to exploit the Indian in the historical novel. Even when "The Book of Mormon" was published in 1830, it fell precisely in the period when the Indian was assuming great prom-

[17] Paul M. Hansen, "Jesus Christ Among the Ancient Americans," p. 144. Independence, Mo. 1945.

inence in American literature. Three of Cooper's "Leatherstocking Tales" had met with acclaim by this date, and at least 39 novels published between 1824 and 1834 included Indian episodes.

There was a parallel development in the drama. Barker's "Indian Princess" (Pocahontas), staged in 1808, had a long line of successors. There were at least 30 so-called Indian plays staged between 1820 and 1840 and 20 or more between the latter date and the Civil War. Some of these were dramatizations of the novels of Cooper, Bird, and Simms. The peak in the popularity of these Indian dramas also falls within the period (1830–70) that has been called "the golden days of the American actor." Perhaps the most outstanding example is "Metamora, or The Last of the Wampanoags," which was in the repertoire of Edwin Forrest for almost 40 years. It was played in Philadelphia every year—except two—for a quarter of a century. Forrest had specifically advertised in 1828 for a play in which "the hero, or principal character, shall be an aboriginal of this country." William Cullen Bryant was the chairman of the committee which selected "Metamora" from the 14 plays submitted. It proved to be one of the most popular plays of the 19th-century American theater. "Metamora" was played even after Forrest's death, and a radio version was broadcast in 1939. During its theatrical lifetime, more Americans are said to have seen "Metamora" than "Abie's Irish Rose" or "Tobacco Road" in the 20th century.

In poetry, the Indian had appeared as a subject ever since the time of Freneau, but there was nothing that could compare with the initial impact and continuing popularity of "Hiawatha." It became *the* poem of the American Indian. Before publication in 1855, there was an advance sale of 4,000 copies; in 5 months the sale had risen to 50,000 copies. It has been said that what was unique about Longfellow's poem was the fact that "'Hiawatha' was the first poem of its kind in America based on Indian legend rather than on Indian history."[18] While true enough, it is clarifying to note that until 1839, when Schoolcraft published his "Algic Researches," there were no reliable collections of Indian myths or tales on which a poet could draw. It was, therefore, a historical accident that Longfellow came to exploit Ojibwa material; he had no other choice. Paradoxically, Schoolcraft himself published a poem dealing with the Creek Indian wars 12 years before "Hiawatha" appeared. He did not know the Creeks at first hand, while he knew the Ojibwas intimately, his wife being of that tribe. Evidently it never occurred to him to use his Ojibwa myths as the basis of a narrative poem. Thus Schoolcraft epitomizes the force of the traditional literary approach to the use of Indian themes.

[18] W. L. Schramm, Hiawatha and its predecessors, Philol. Quart., vol. 11, p. 341, 1932.

Longfellow bore the same sort of relation to Schoolcraft as Cooper did to Heckewelder. Generally speaking, there was no inclination on the part of eastern novelists, dramatists, or poets who selected Indian themes to become acquainted with living Indians of the contemporary frontiers as a background for their productions. Indeed, a volume of short stories, "Tales of the Northwest," about Indians in the Upper Mississippi region, written by one who knew them intimately, was ignored after its publication in 1839. William Joseph Snelling, the author, had insisted that "a man must live, emphatically, live with Indians; share with them their lodges, their food, and their blankets, for years, before he can comprehend their ideas, or enter their feelings." American writers were not yet ready for this early call to realism. But for American readers, a novel entitled "Altowan; or Incidents of Life and Adventure in the Rocky Mountains," by Sir William Drummond Stewart, an eccentric Scot, who during the 1830's had spent 6 years in the West, was published in New York in 1846. Although the novel was undistinguished in writing and had some romantic trappings, in this case the author *had* seen a great deal of Indian life. What makes the book unique is that one of the leading characters, as pointed out by De Voto, is an Indian transvestite—a berdache—and this individual is depicted in highly realistic terms. The author pictures his behavior and dress in detail, and no doubt is left about what he was. "I know of no English or American novel of that time or for many years later that is half so frank about homosexuality," writes De Voto.[19]

In painting and popular music there was a parallel romantic tradition. Gleanings from historical documents or tradition were tinctured by an extremely free use of imagination. It is obvious, for instance, that the artist who provided the frontispiece for Mrs. Morton's "Ouabi, or The Virtue of Nature" (1790) knew as little about Indians at first hand as did the author of this poem in the noble savage tradition. And Benjamin West's painting of one of Penn's treaties with the Indians, dating from about 1771, offers a direct parallel to the literary artist who drew on historical documents for his source material.

Part of Mrs. Morton's poem was set to music by Hans Gram the year after its publication. This composition, the first orchestral score published in the United States, was entitled "The Death Song of an Indian Chief," although there is no evidence that the composer knew anything about aboriginal music. In 1799, a musical arrangement of "Alk'amoonok, the Death Song of the Cherokee Indians," reputedly based on a genuine Indian melody, was published and soon became very popular. It had been sung in "Tammany" (1794), the first American opera. An eccentric musician, Anton Philip Heinrich,

[19] Bernard De Voto, "Across the Wide Missouri," p. 426. Boston. 1947.

who died in 1861, was the composer of the "Pocahontas Waltz" for piano and is said to have been the first to use Indian themes in larger orchestral works. The heroine of the big song hit of 1844, "The Blue Juniata," was an Indian girl, "Bright Alforata."

Actually, it is at this vernacular level that the backwash of the frontier is most clearly discernible in American music of the 19th century. This was due to the role the Indian played in the subject matter of folk songs. In one group of songs, the Indian appears "merely as an incidental personality" and the attitudes toward him are vague. In a second group, however, negative attitudes are sharply defined since many songs in this class are long narrative ballads which depict actual frontier conflicts. Folksongs about historic events, "including songs about dramatic episodes in the relationships of Indians and White, have been sung regularly since the earliest days of colonization and have faithfully reflected changing relationships between the two culture groups at least down to the present century when modern techniques for the commercialization of popular songs may have beclouded the issue." A third category of songs reflects a positive attitude toward the Indian varying "from vague references to good Indians or Indians with heroic qualities, to songs and ballads exclusively about romanticized Indians, who are admired for their stamina and other heroic qualities."[20] An anonymous, undated example of America's folk painting, depicting the rescue of John Smith, belongs to this earlier period.[21] The same motif was subsequently as popular in prints as it was in fiction, drama, poetry, and music.

However, in the midst of all this romanticizing of the Indian, a trend toward greater realism developed, particularly in painting. Here and there in colonial times there had been some realistic paintings of the Indians; for example, the masterly portraits of Lenape chiefs painted in 1735 by Gustavus Hesselius (1682–1755). But about 1821, many of the western chiefs who came to Washington on business with the Government sat for their portraits. A collection of these became the nucleus of the famous "Indian Gallery." The magnificent reproduction of 120 of these portraits in a folio edition of 3 volumes (McKenny and Hall, "History of the Indian Tribes of North America, 1836–44") gave the eastern public an opportunity to see what contemporary Indians looked like. On the other hand, artists themselves began to go west (Seymour, Rindisbacher, Lewis, Catlin, Miller, Eastman, Stanley, Kane, Bodmer, Kurz), so that greatly enriched images of the natives, the kind of life they led, and the grandeur of the country they inhabited soon became more widely known to those living far removed from the contemporary frontier. It was the author

[20] Austin E. Fife and Francesca Redden, The pseudo-Indian folksongs of the Anglo-American and French-Canadian, Journ. Amer. Folklore, vol. 57, pp. 241, 394, 1954.

[21] "American Folk Art. The Art of the Common Man in America, 1750–1900." Mus. Mod. Art Publ. No. 19, 1932.

of "Altowan" who induced Alfred Jacob Miller—now one of the most famous of these artists, whose true accomplishments have only become known to the public in recent years—to accompany him west in 1837. Catlin is particularly important, however, not only because he was a pioneer, but because he was a showman. He toured eastern cities in the late 1830's exhibiting his "Indian Gallery," which has been called the first Wild West show. It included Indian "curios," featuring pipes, and in exhibition halls he erected a real Crow tepee. Catlin appeared in person and, taking selected pictures as a point of departure, lectured to his audiences about Indian life. He would dress lay figures in Indian clothing and frequently had some Indians on hand to pantomime native activities. Although Catlin was not an anthropologist, his Indian Gallery did mediate to Americans a more realistic type of knowledge about the Plains tribes than had been available. After touring American cities, he took his show to England and the Continent. In 1954, an exhibition of Catlin's work, sponsored by the United States Information Agency, was again on tour in Europe, while in this country Bodmer's watercolors were being exhibited.

Even though Catlin "had been there," he had detractors, like Audubon, who challenged the accuracy of his paintings. The same thing had happened to Cooper and Longfellow. The romantic tradition in America was strong, and the application of a purely realistic standard of judgment was, in effect, an attack upon the tradition. Cooper may have idealized the Indian in some respects and erred in many details, but he idealized the pioneer and backwoodsman too. The Indian was enveloped in the romantic tradition and what is interesting is how long he has remained a part of it.

When the dime novel sprang into popularity in the 1860's, the Indians of the Cooper tradition became an integral part of this literature. In one way or another, Indians play a role in at least 45 percent of the 321 stories in the original dime-novel series. "Maleska, the Indian Wife of the White Hunter" (1860), the first one published by Beadle and Adams, actually was a reprinting of a story that had been serialized in 1839. "The death of the dime novel, if it ever really occurred, was accompanied by the birth of the nickelodeon, the motion picture, and the radio, which simply transferred the old stories of cowboys, desperadoes, and Indians to more dynamic forms." [22] In fact, as soon as the silent cinema began to flicker, the Indian of the old romantic tradition was in. There was a screen version of "Hiawatha" as early as 1909, the "Deerslayer" was shown in 1911, the "Last of the Mohicans" in 1920. And, until very recently, what Stanley Vestal called the "Hollywooden Indian" has persisted in that typically American movie genre—the western.

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[22] James D. Hart, "The Popular Book. A History of America's Literary Taste," p. 156, New York. 1950.

On the other hand, there was an increasing awareness that authentic knowledge of the aboriginal cultures was relevant and desirable in the arts. Perhaps this attitude developed along with the emergence of a more realistic tradition in American writing. However this may be, I think that the publication of Edna Dean Proctor's "Song of the Ancient People" in 1893 represents a transitional case. While it is in the high romantic tradition, there is an appended commentary to this poem by F. H. Cushing (1857–1900), a pioneer anthropologist who went to the Southwest in 1879 and lived among the Zuñi for 5 years. He says he can bear witness to the poet's "strict fidelity of statement, and attempt to show, as one of the Ancient People themselves would be glad to show, how well she has divined their spirit." The volume was illustrated with realistic aquatints made by Julian Scott in the Hopi country. No other Indian poem had ever been offered to the public with such an aura of authenticity about it—it was bound in buckskin with a design taken from Southwestern pottery on the cover.

The inauguration of genuine Indian themes in American concert music is ordinarily attributed to Edward MacDowell, whose "Indian Suite" was first performed in 1896. But where did he find such themes? He was not a frontier boy. He entered the Paris Conservatory at the age of 14 and did not take up residence here until he was 27. The fact is that MacDowell exemplifies a repetition of the same kind of relationship to the source of his thematic material as was noted in the case of Cooper and Longfellow. He got them from Theodore Baker, the first trained musician to go into the field and study Indian music at first hand. Baker, a German, visited the Seneca Reservation and the Carlisle Indian School in the summer of 1880, offering the results of his analysis to Leipzig University as a doctoral dissertation. But he was not a composer, nor was Alice C. Fletcher, whose monograph on Omaha songs (1893) initiated the study of Indian music in American anthropology. However, two of the songs she collected, "Shupida" and the "Omaha Tribal Prayer," undoubtedly have been among the most widely circulated examples of authentic Indian music in American culture. Together with three other Indian songs, they appear in "Indian Lore," a pamphlet in the Merit Badge Series of the Boy Scouts of America. In the past 6 years, approximately 47,000 copies of this booklet have been printed. Scouts who aspire to the merit badge in Indian lore must be able to "sing three Indian songs including the Omaha Tribal Prayer and tell something of their meaning." Since 1911, there have been more than 18,700 American boys who have won this distinction.

Following the lead of MacDowell, other composers began to make increasing use of Indian themes, though only a few made direct contact with the reservation Indians. Among them were Burton, Cad-

man, Farwell, Jacobi, Lieurance, Arthur Nevin, Skilton, and Troyer, who found native music interesting to them, because as Skilton has said, "many devices of the ultra modern composers of the present day have long been employed by Indians—unusual intervals, arbitrary scales, changing tune, conflicting rhythm, polychoral effects, hypnotic monotony." [23] Indian songs were harmonized and arranged for performance by white musicians; Indian themes were handled freely in the composition of original works, much in the same way that Longfellow handled Ojibwa myths.

In the field of operatic composition, despite the popularity of other compositions of Herbert and Cadman, neither the former's "Natoma" (1911) nor the latter's "Shanewis" (1918) became established in operatic repertoire. Some compositions based on Indian themes have received high acclaim in the repertoire of orchestral music, others as popular songs. Skilton's "Indian Dances," along with MacDowell's "Indian Suite," were among the 27 compositions of 12 American composers which had the greatest number of performances in the United States during the 7 years following World War I. Jacobi's "String Quartet on Indian Themes" was selected to represent American music at the International Festival of Contemporary Music at Zurich in 1926. Elliott Carter's ballet "Pocahontas," presented in New York in 1939 (and later developed into a suite for orchestra) received the Juilliard Publication Award the following year. Cadman, who went to the Omaha Reservation in 1909 with Francis LaFlesche, an Indian anthropologist, wrote one of his most famous songs that year, "From the Land of the Sky Blue Water." It vied with "The Rosary" in popularity. He likewise wrote two operas on Indian themes. "By the Waters of Minnetonka" (1921), composed by Thurlow Lieurance, who had visited the western reservations as early as 1905, has had a phenomenal success. At midcentury it appears in the Victor Album "Twelve Beloved American Songs" along with "The Rosary" and "A Perfect Day." Nor should commercialized popular songs of a lower order—some Indian in name only—be forgotten. Among those composed early in this century were "Navajo" (1903), "Tammany" (1905), "Red Wing" (1907), and "Hiawatha's Melody of Love" (1920), to say nothing of "The Indian Love Call" (1924), and "Ramona," a hit of 1927.

In the early years of this century, some American poets, like the musicians, sought out the Indians, and those of the Southwest became a focal point of interest. These were the same people that Edna Procter had written about. They had been the subject, too, of a novel, "The Delight Makers" (1890), by A. F. Bandelier, said by Alfred L. Kroe-

[23] Charles S. Skilton, American Indian music, Int. Cycl. Music and Musicians, p. 48. New York. 1939.

ber to be "a more comprehensive and coherent view of native Pueblo life than any scientific volume on the southwest."

A few American painters (Sharp, Phillips, Blumenschein) had also discovered the Southwest before the opening of the 20th century. Blumenschein's graphic commentary on the acculturation process, which shows two Indians mounted on merry-go-round horses, had appeared in Harper's Weekly in 1899.

Among the poets who became interested, Mary Austin soon took the lead. She became the key figure in the use of Indian material for literary purposes, and her extremely positive attitude toward the cultures of the Indians influenced many others to seek inspiration in their art. She characterized her "Amerindian Songs" as being "Reexpressed from the Originals." Some of these first appeared in "Poetry" (1917), along with comparable interpretations by Frank S. Gordon, Alice Corbin Henderson, and Constance Lindsay Skinner. Mary Austin wrote plays and stories, too. She seems to have moved from a romantic primitivism to a more and more realistic handling of Indian themes, as exemplified by her play "The Arrow Maker," produced on Broadway in 1911, and her "One-Smoke Stories" (1934), one of her last books. Nor should the fact be overlooked that four anthologies containing translations of American Indian songs and poetry have appeared in this century (George W. Cronyn, "The Path of the Rainbow," 1918 and 1934; Nellie Barnes, "American Indian Love Lyrics and Other Verse," 1925; Margot Astrov, "The Winged Serpent," 1946; and A. Grove Day, "The Sky Clears," 1951).

In the 20th century, the Indian has also reappeared in American plays, particularly in the work of the regional dramatists. While the setting is frequently the historic past, the problems the native faces in the acculturation process are sometimes dramatized. Both "Strongheart" (1905) and "Cherokee Night" (1936) are examples of this theme. In prose fiction, we also find that anthropologists, inspired by Bandelier and the stories collected in Elsie Clews Parsons' "American Indian Life" (1922), entered the field. "Laughing Boy," a Literary Guild book of 1929, by Oliver LaFarge, and "Hawk Over Whirlpools" by Ruth Underhill (1940) are outstanding illustrations. In "America in Fiction," the authors call attention to the fact that "now that he is on reservations, not a military foe, and generally not an economic competitor, the Indian is a subject of great interest, so much so that more fiction has been written about him in recent years than about any other ethnic group except the Negro. In many works of fiction, he has been given central prominence, his cultural complex has been detailed, and much attention has been paid to his problems of adjusting himself to the dominating civilization that surrounds him."[24]

[24] Otis W. Coan and Richard G. Lillard, America in Fiction. "An Annotated List of Novels that Interpret Aspects of Life in the United States," 3d ed., pp. 161–162. Stanford. 1949.

Their bibliography lists 37 novels or collections of stories published between 1902 and 1947. "Where once we had melodrama about the Indian with his bloody tomahawk," they say, "now we have clear-cut realism." Whatever the art form may be, what is striking is the more intimate acquaintance with contemporary Indians that informs the work of the painter, musician, poet, dramatist, or novelist who has drawn upon aboriginal cultural forms or used the problems of the Indian for his thematic material.

Finally, it seems to me that among these more recent influences, the impact of the Indian on modern anthropology should not be omitted. The social sciences as they have developed in the United States during the past half-century have attained an unusual prominence in American culture. Among these, anthropology in its modern form was just getting under way about the time the frontier closed. It was in the 1890's that Franz Boas began to teach at Columbia University and to train students in fieldwork. Boas was a specialist in studies of the American Indian and a majority of his early students followed in his footsteps. Indeed, practically all the chief authorities on North American Indian ethnology, archeology, and linguistics have been American. A historical accident? Of course. But that is the point. It is only recently among the younger generation that more attention is being devoted to peoples in the South Seas, Africa, and Asia. But it was the study of the Indians, and the problems that emerged from the investigation of the Indian as a subject, that gave American anthropology a distinctive coloring as compared with British, French, and German anthropology. Recently an American psychologist has remarked that "if the word 'anthropology' were presented to a sample of psychologists in a word-association test I would venture 'culture' would probably be the most popular response, with 'Indians' a runner-up." [25] The presumption, no doubt, is that these hypothetical responses would be those of American psychologists.

The more detailed and reliable accounts of native Indian cultures that have emerged from the fieldwork of American anthropologists have made possible a more objective appraisal of the values inherent in the aboriginal modes of life. To those who look at the record, the Indian no longer appears as either a noble or ignoble savage. He has moved into a clearer focus as a human being. Like our own, his traditional cultural background and historical situation have determined the nature of his experience and made him what he is.

Viewing the panorama of our colonial and national history as a whole, I have referred to many diverse aspects of our culture—speech, economic life, food habits, clothing, transportation, medicine, religion,

[25] M. Brewster Smith, Anthropology and psychology, *in* John Gillin (ed.), "For a Science of Social Man. Convergences in Anthropology, Psychology and Sociology," p. 39. New York. 1954.

the arts, and even a social science—which have been influenced by our relations with the Indians at different times and in differing ways. Some of these influences have been mediated directly, others indirectly. Contacts with the Indian on the frontier have by no means been the source of all of them.

In summing up, we may ask: how deeply have such influences penetrated our culture? To what extent are our relations with the Indians one key to our differentiation as Americans, not only culturally but psychologically? Constance Rourke once wrote, "The Backswoodsman conquered the Indian, but the Indian also conquered him. He ravaged the land and was ravaged in turn." Phillips D. Carleton, concluding his comments on the captivity literature, writes: "It emphasizes the fact that it was the line of fluid frontiers receding into the West that changed the colonists into a new people; they conquered the Indian but he was the hammer that beat out a new race on the anvil of the continent." [26] Carl Jung, who has probably analyzed more persons of various nationalities than anyone else, thought he could discern an Indian component in the character structure of his American patients, and D. H. Lawrence asked whether a dead Indian is nought. "Not that the Red Indian will ever possess the broadlands of America," he said and then added, "But his ghost will."

In America we faced the Indian on receding frontiers for a long period; but outside the frontier there was the shadow of the Indian. This shadow is still upon us. We still mouth words and idioms that reflect intimate contacts with the aborigines of our land. We still make use of plants originally cultivated by them. We wear derivative forms of the footgear they wore. We have collected objects made by them in our homes and in our museums. Our artists have found inspiration in their artistic modes of expression. We constantly see the Indian sweep past our eyes on the movie screen. He persists in our historical novels and westerns. In 1954, "The Leatherstocking Saga" reappeared, compressed into one handsome volume. We Americans have seen the Indian come and go on the commonest national coins we have fingered. The first Bible to be printed in colonial America was in the Indian language, John Eliot's translation of the Old and New Testament into an Algonkian tongue. Over the generations thousands of American men have belonged to the more-than-a-century-old Improved Order of Red Men. American anthropologists have labored most industriously to provide more and more authentic information about aboriginal modes of life and the influence of American culture on the Indian. The Indian has never been rejected from the American consciousness. Perhaps his shadow upon us is even disappearing—he has become a part of us: in the "Dictionary of American Biography"

[26] Phillips D. Carleton, The Indian captivity, Amer. Lit., No. 15, p. 180, 1943.

will be found side by side with other famous Americans, Pontiac and Tecumseh, Blackhawk and Osceola. In 1931 a brief popular biography of Osceola—only a few pages in length—was printed at Palm Beach; it was entitled "Osceola the Seminole. Florida's Most Distinguished Historical Character!" And it is said that more statues have been erected of Sacajawea than of any other American woman.

Now that the frontier has passed, our children discover the Indian in the comic books, as well as in the library. They are familiar with Cooper's tales in "Classics Illustrated." Indeed, there appears to have been a marked increase in number, variety, and quality of children's books about Indians published in the last two or more decades. There are biographies of Indians famous in our history as well as historical romances. The stories of famous white captives have been retold; there are excellent books on Indian crafts and simplified but accurate accounts of tribal life, besides well-written stories which center around Indian children as major characters. Nevertheless, the average American is by no means aware of all the ramifications of Indian influence upon our culture. Perhaps the Red Indian ghost D. H. Lawrence saw here and what Jung discerned in the character of his patients provide clues to an aspect of the American ethos that invites deeper scrutiny in the future.

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The Restored Shanidar I Skull [1]

By T. D. Stewart
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[With 13 plates]

The discovery of the first adult skeleton in the Mousterian layer of Shanidar cave, northern Iraq, was reported in the press in the spring of 1957.[2] Since then Dr. Ralph Solecki, leader of the expedition excavating the cave, has published more details of the find in Sumer (1957b) and in the Scientific American (1957a). Now it is possible to follow up these reports in a remarkably short time with illustrations and a brief description of the restored skull. A fuller report on the skull and on certain postcranial parts is in course of preparation.

The work of reconstruction, which the writer carried out in the Iraq Museum during the months of October through December 1957, was made possible by the farsighted cooperation and generosity of the American Philosophical Society in Philadelphia, the Directorate General of Antiquities in Baghdad, and the Smithsonian Institution in Washington.

This account has had to be prepared at the termination of the laboratory work and before comparative studies could be undertaken. For this reason only very tentative statements regarding the biological significance of the specimen will be made. Mainly I will tell what has been accomplished in the way of skull reconstruction and point out certain features thereof which affect interpretations. I am indebted to Antran Evan, photographer of the Iraq Museum, for the excellent photographs here reproduced. In making the drawings of the skull I did not strive for extreme accuracy. My intention was merely to supply an interpretation of the photographs. In viewing

[1] Reprinted, with the addition of footnotes and references, by permission from Sumer, vol. 14, Nos. 1 and 2, pp. 90–95, 1958.

[2] To avoid confusion in the future it should be noted that although an infant was found in 1953, only the three adults found in 1957 as yet bear distinguishing numbers. I have now decided that Shanidar I is a male around 40 years of age (see Stewart, 1959).

them thus the reader should remember that the camera and stereograph record the object from slightly different viewpoints.

To students of human paleontology the traditional aspects of the skull here shown will speak for themselves. Such significant details as the heavy brow ridges, the large flat face, the receding chin, the low forehead, the small mastoids (but large digastric fossae), etc., recall the forms of ancient man which are usually designated "Neanderthal." This is a term that no longer has an exact morphological meaning. In an effort at more exactitude anthropologists are now using qualifying words, such as "progressive" and "conservative" or "classical," meaning closer to modern man and farther from modern man, respectively. Even this device is not wholly satisfactory. For this reason I am going to risk being specific and state that at the moment I am inclined to rank the Shanidar skull with the somewhat earlier Mousterian population of Mount Carmel in Palestine, as described by McCown and Keith in 1939. Within this highly variable population I would rank Shanidar closer to Tabūn than to Skhūl.[3] Be this as it may, the really significant thing is that an individual with such primitive features persisted in the mountains of Iraq to the end of the Mousterian cultural period; that is, to a time which Solecki estimates to be only about 45,000 years ago.[4]

In a symposium on population genetics held in Cold Spring Harbor, N.Y., in 1950 I (1951) expressed skepticism that the variety of types encountered at Mount Carmel was due to hybridization between modern and Neanderthaloid types, an idea then widely held. The primitiveness of Shanidar I and the late occurrence of this type strengthen my skepticism. I still feel that all these specimens could be variants of a local and durable population. In this connection it is interesting to recall Senyürek's conclusion, recently (1957) published in Anatolia, that the infant recovered earlier in the Mousterian layer at Shanidar is a distinct subspecies deserving the name *Homo sapiens shanidarensis*.

Such generalizations are interesting and are certain to be debated in anthropological circles for some time, but ultimately their validity depends upon the quality of the evidence. It is of primary importance, therefore, to raise immediately the question: How accurately has the Shanidar skull been reconstructed? In general, my answer must be: Not perfectly, but probably close enough for all practical purposes. Actually, the skull is far less complete than a first glance at the pictures reveals; also, it shows signs of injuries in life and has undergone

[3] In making this statement I was influenced by the appearance of the posterior part of the skull. The face (including the supraorbital ridges) is every bit as primitive as in the "classical" Neanderthals. Yet, when attention is directed to the back of the skull, one is inclined to qualify the designation "classical."

[4] This figure takes into account Coon's report (1957, pp. 306–307) of a C_{14} date of 43,000 years for the upper part of the Mousterian layer in the Jerf Ajla cave in Syria. Analyses of the Shanidar carbon samples are in process.

some postmortem warping. The extent to which the latter factor has influenced the shape is best seen as an enlargement of the left side in the views of the top and base. This asymmetry results from certain parts on the left side failing to meet and leaving gaps. Except in the left zygomatic arch, the gaps are no longer apparent, because they have been filled in to give more rigidity to the specimen.

Not only are there gaps on the left side but there are large areas on this side where the bone has been lost entirely or, if present, cannot be accurately placed. One such area in the posterior left parietal has been left open intentionally so that the inside of the skull can be inspected. Anyone looking through this hole in the actual specimen sees that even more of the inside surface has had to be restored. The explanation is that ancient cranial bone tends to split through the diplöe, or porous middle layer, and thereupon the inner table crumbles. Thus I found some sections of the vault to consist only of outer table, 1 to 2 mm. thick. Such sections had to be reinforced on the endocranial side.

In reinforcing weakened bone and in filling in areas where the bone was missing I used a commercial "crack filler" (trade name: Savogran). This substance comes in the form of a powder and is mixed with water to the desired consistency. It has the advantage of being readily moulded into the prescribed shape, of setting fairly rapidly, of not shrinking, of becoming quite hard, and of turning a light brown color to give a nice contrast with the stained bone. Also, it is not affected by the ordinary laboratory chemicals and therefore can be varnished for protection against moisture. Where deemed desirable, reinforcing wires have been embedded in the filler. I mention all this just in case it should be necessary in the future to remove or restore the filled-in areas of this specimen.

In contrast to the very incomplete left side, the right side is essentially complete, except superiorly. Therefore, it was natural at the outset of reconstruction to assemble the right side from the many pieces into which it had been broken. By making the joints between these pieces fit tight, the original form of the skull, or what was assumed to be the original form, emerged. Necessarily, the restored areas, especially of the left side, largely depend on the right side. If there are inaccuracies in the joining of the component parts of the right side, or if warping has affected the right side, the gaps on the left side are probably the result. Owing to the fragility of the bone, the refitting of joints had to be kept to a minimum.

The top of the skull presented a special problem. The whole of this area from the middle of the frontal bone to the lambdoid suture (between the occipital and parietal bones) depends for its shape and elevation on one large fragment hinged at a narrow joint on the right side anteriorly. The word "hinge" graphically describes this type of

joint. Since there is contact only through the outer table of bone, all of the piece which includes most of the sagittal suture, and hence the vertex of the vault, could be raised or lowered without revealing the correct position. The only solution to this problem was to position this piece of bone arbitrarily so as to get a symmetrical appearance relative to the median plane. I believe that I may have placed this piece a little higher than it was originally. If this is true, it is due to the warping of the whole neurocranium already referred to. In justification of the position adopted I can only say that all other arrangements yielded outlines more asymmetrical than the present one. Nevertheless, cranial height cannot be seriously affected.

I realize, of course, that intact skulls are never wholly symmetrical. This is one reason for letting the joined fragments determine the over-all form. However, in assembling a fragmentary skull, as in the present instance, one has to assume original symmetry. When, in spite of this assumption, gaps develop, it is reasonable to attribute them to postmortem warping. Considering the fact that a rock rested on this skull and the skull was recovered from a depth of 4.34 meters in the cave deposits, some warping should be expected. Advanced suture closure may have helped the skull sustain the pressures until the warping was fixed in the bone.

Besides being warped and thus rendered asymmetrical postmortem, the Shanidar skull shows signs of having been asymmetrical antemortem. The signs are in the form of scars and indicate that this individual suffered injuries about the face and forehead. The frontal scars are simply roughenings and depressions of the surface of the bone, mainly on the right side; they did not alter appreciably the outlines of the vault. On the other hand, the old healed injury to the left side of the face altered the shape of the orbit, the supraorbital ridge and the malar bone. The left orbit is compressed from the side and its outer border is sharper than the corresponding one on the right. The left supraorbital ridge, unlike the right, is divided into two parts by an unnatural depression (scar). The left malar bone, in addition to involvement of the part forming the lateral wall of the orbit, is flattened so that the zygomatic arch presents a decided contrast in shape to its counterpart of the right. The location of the scars on the forepart of the head suggests injuries received in combat.

Interesting as these scars are, inasmuch as they seem to reflect occupational hazards, they were a nuisance in reconstructing the incomplete left side of the face. It is easy, of course, in normal specimens to make one side of the face the mirror image of the other. But in abnormal specimens the eye alone is the judge of correctness of restoration. In the present instance three unconnected facial fragments (one abnormal) had to be oriented largely by eye. At the same time

the abnormal malar portion had to be related to the left temporal bone, which in turn had very meager connections with the base and occipital bone. As each fragment was placed in position, it was anchored by wires cemented to it. When the relationships appeared to be correct, the missing parts were filled in with modeling clay. If at this stage the eye detected malpositioning, changes were made. Ultimately the clay was replaced with "crack filler" and all supporting wires hidden from view.

This brief account of the procedures used in reconstructing this ancient skull has not followed the true sequence of events. Actually, the lower jaw was assembled first, then the right side of the neurocranium (plus the anterior part of the frontal bone) and the right side of the face separately. Thereupon the lower jaw was mounted in its natural position on a piece of plate glass so that it could be turned about easily. The right side of the face was then placed so that the teeth of the right side were in natural occlusion. The teeth were cemented together (temporarily) in this position. Next the right side of the neurocranium (with attached frontal bone) was brought into position. In this process attention was given to the frontomalar suture, the zygomaticotemporal suture and the temporomandibular joint. Unfortunately, there was no contact in the nasofrontal region, so I had to judge the relationships of the supraorbital ridges to the jaws, etc., by eye. After various trials, the frontomalar suture appeared to be the connection of prime importance. From here on the midplane of the face and neurocranium was clearly established and could be maintained in the vertical position. Subsequently, the left side of the face, the left side of the neurocranium, the base, vertex, and occiput were adjusted and added in that order.

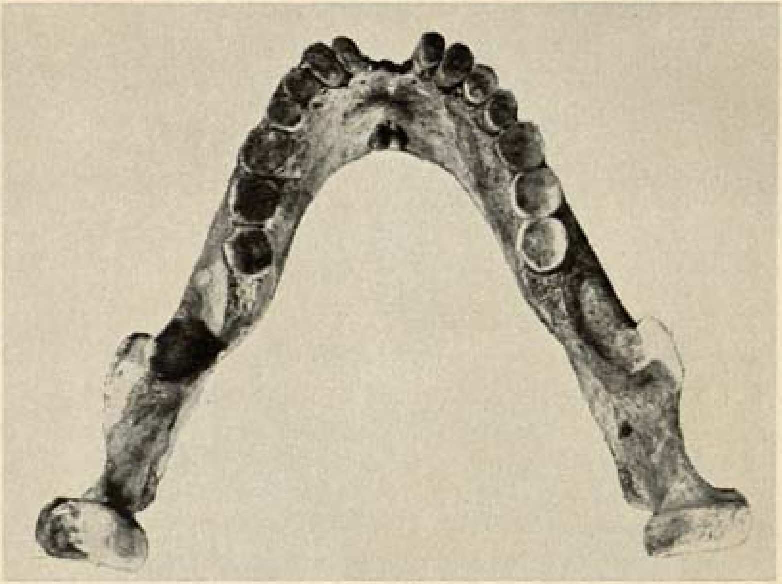
Since by far the most difficult part of the whole operation centered about the placement of the left temporal bone, it is desirable to include a few words about how this was done. The first step was to bring the temporal bone and the left side of the base into position. This was a delicate procedure, because this part of the base was displaced downward. Also, the temporal had lost most of the petrous portion, but was nearly complete externally. Thus the mandibular condyle had to be relied on to orient the glenoid fossa and make it correspond in position with the one on the right. However, in addition at least three other parts had to be considered: (1) A piece of occipital squama (including the left side of the foramen magnum) with a tenuous connection to the temporal; (2) the left side of the basiccipital with attached left occipital condyle; and (3) a small section of base connecting the temporal and basioccipital anteriorly. In fitting all these together the objective was to maintain the position of the left temporomandibular joint and to obtain a symmetrical foramen magnum. The maneuvering of these fragments would have

been greatly simplified if there had been a top to the vault so that the whole skull could have been inverted. Under the circumstances it seemed best to hold to the original positioning of the total assemblage, and only when the pieces were firmly fixed by wires to turn the skull over (supported by the hands) for inspection. Needless to say, the stated objective was not reached on the first trial. Indeed, it took a couple of days to get everything here satisfactorily arranged; that is, satisfactory only if the gaps already mentioned are disregarded.

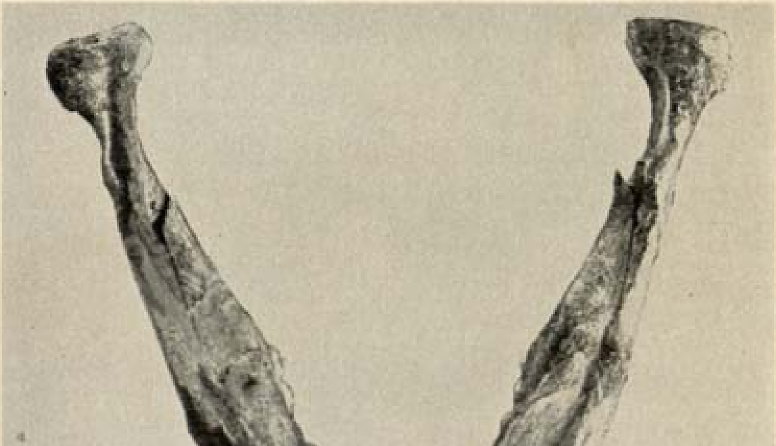
One more point should be mentioned in connection with the last phase of reconstruction, namely, the placement of the occiput. Early in the work I discovered that a large central piece of occipital bone had what seemed to be definite, if slight, connections on both sides, but no other connections. Then, in the course of trying out various arrangements the connection on the right was damaged. Also, a gap developed in this region and it was no longer possible to connect the central occipital fragment on both sides. I decided finally to use the connection with the right side, because this side is more complete, but I remain unhappy that I could not confirm the connection. Possibly this part of the occiput should be shifted more to the left.

From this description of the problems encountered during the course of reconstructing the skull the reader will understand why the original form has not been entirely recovered. Yet I am fairly certain that the skull, as restored, looks very much like it did before it was damaged. The parts could not be assembled very differently without yielding a bizarre appearance. I am inclined to believe that I achieved a compromise between the original form and the distorted form caused by earth pressure.

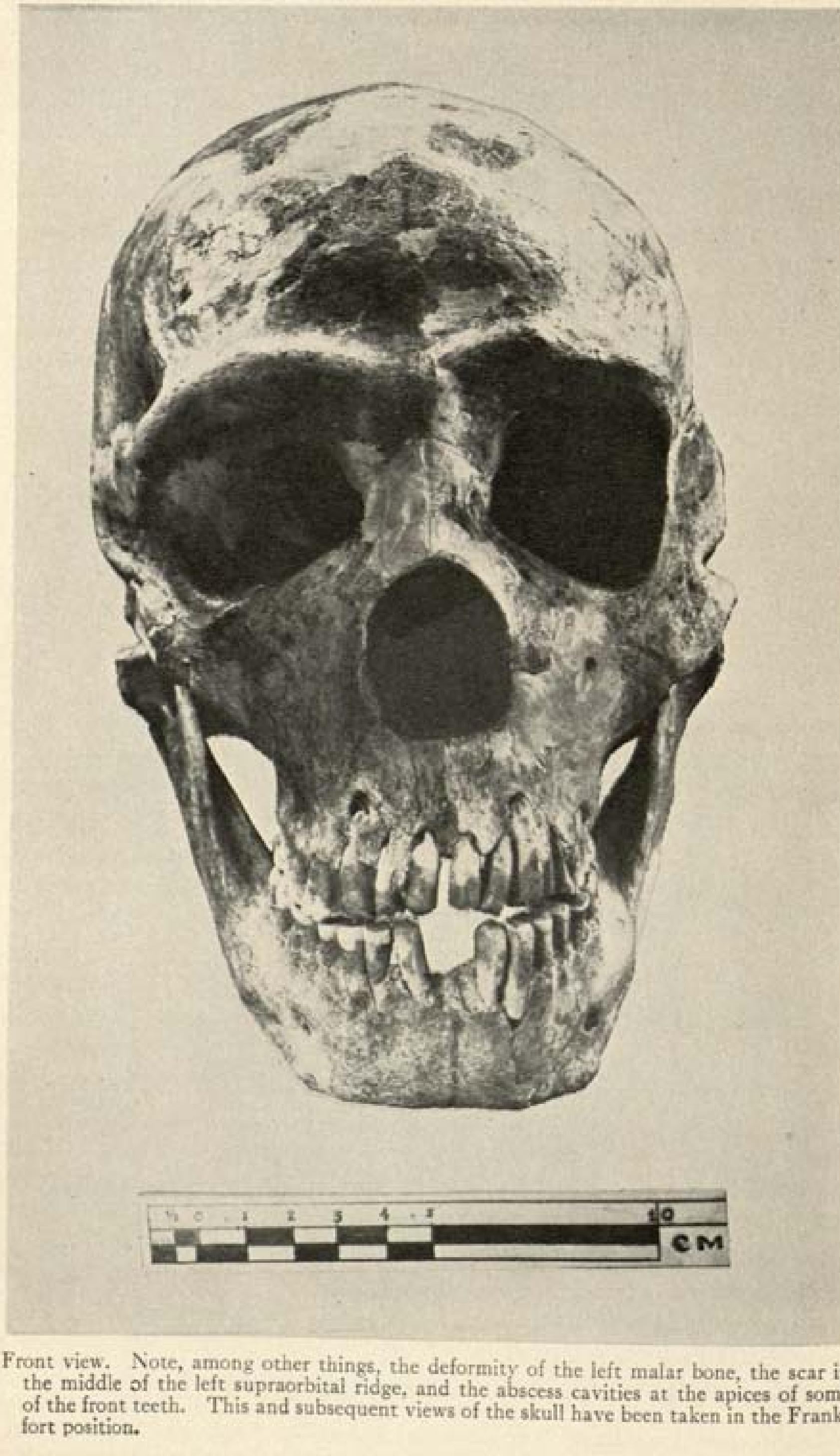
Necessarily the deficiencies of the skull have been emphasized in the foregoing account. To offset this I will now review some of the assets. In spite of what has been said, the skull can be considered essentially complete, since the parts recovered are so distributed that they permit the missing parts to be interpolated from them. Moreover, all important landmarks, with the possible exception of lambda, are present. The location of lambda is rendered uncertain because of suture closure, the possible presence of a small "Inca" bone, and the loss of critical bone. Very important is the evidently correct placement of the foramen magnum and its useful landmark basion at the anterior margin. Indeed, the whole base, delicate though the parts are, is almost complete. The same can be said with considerable confidence of the face; the details of the face could not have been very different from those of the face as restored. It is noteworthy that even the zygomatic arches are complete. And finally, all the teeth were present in life and are now in place, except only the lower central incisors, the absence of which was noted at excavation. Such assets (and more could be



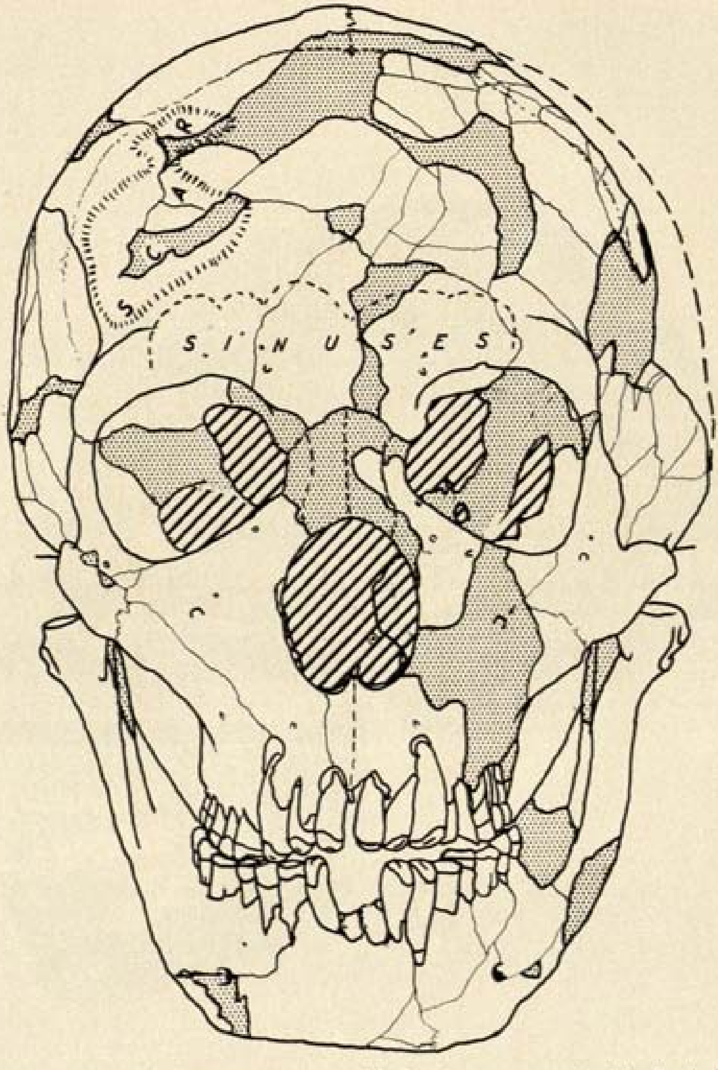
1. Superior view of mandible. Note flattening of left glenoid process and wear of lower teeth.



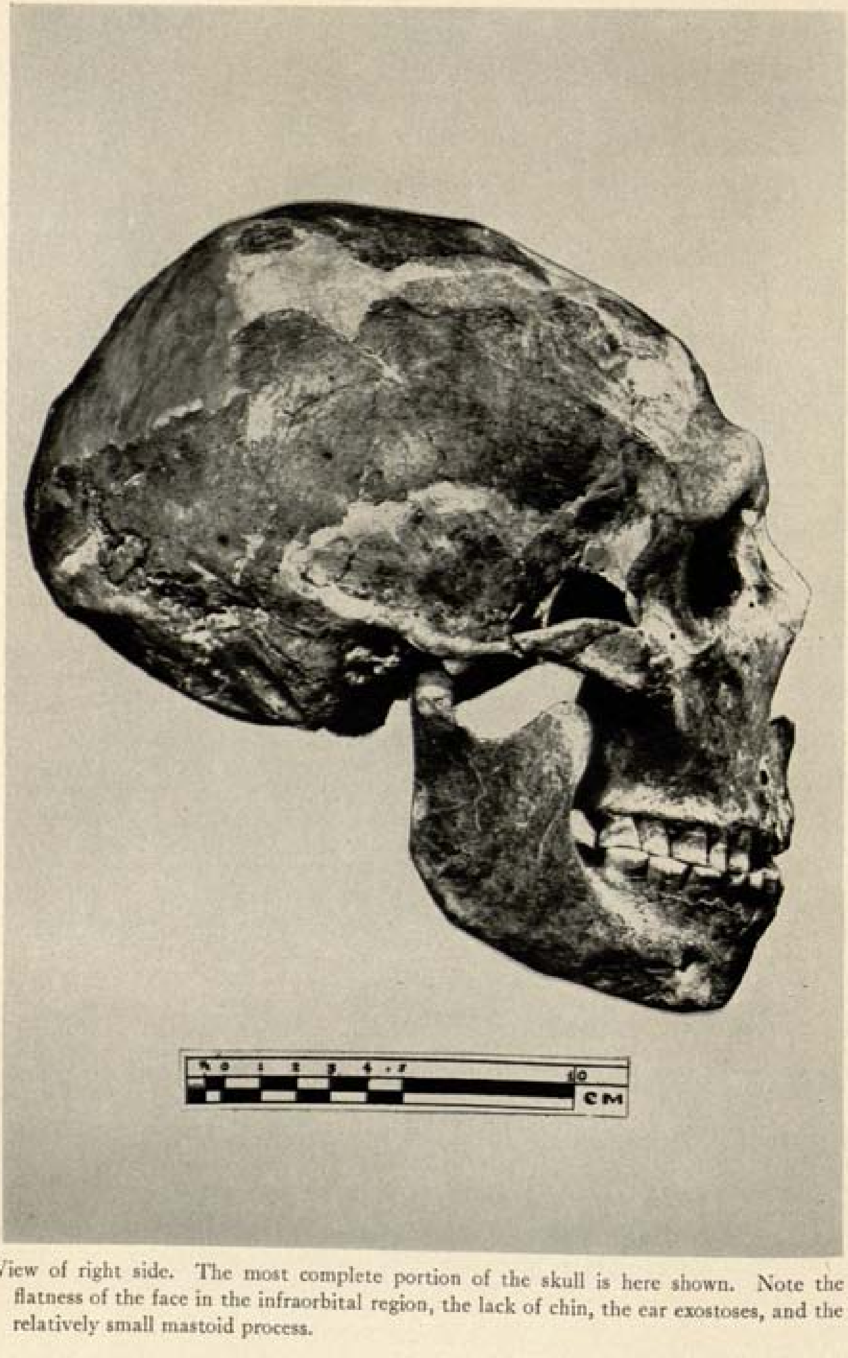
2. Inferior view of mandible. Note tubercle on lateral side of right glenoid process (the one on the left does not show as clearly), and the sculpturing in the region of the symphysis.



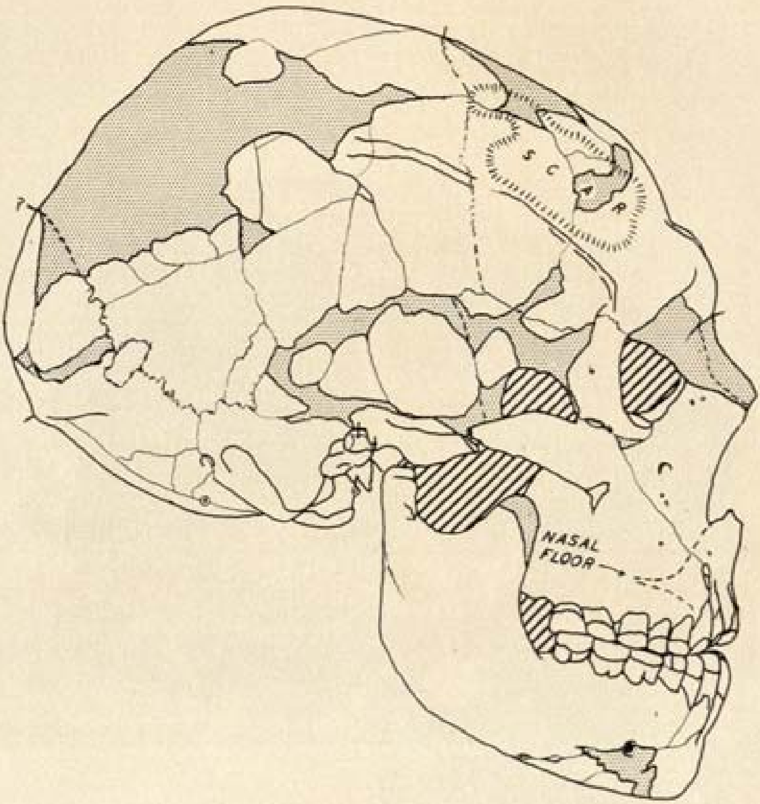
Front view. Note, among other things, the deformity of the left malar bone, the scar in the middle of the left supraorbital ridge, and the abscess cavities at the apices of some of the front teeth. This and subsequent views of the skull have been taken in the Frankfort position.



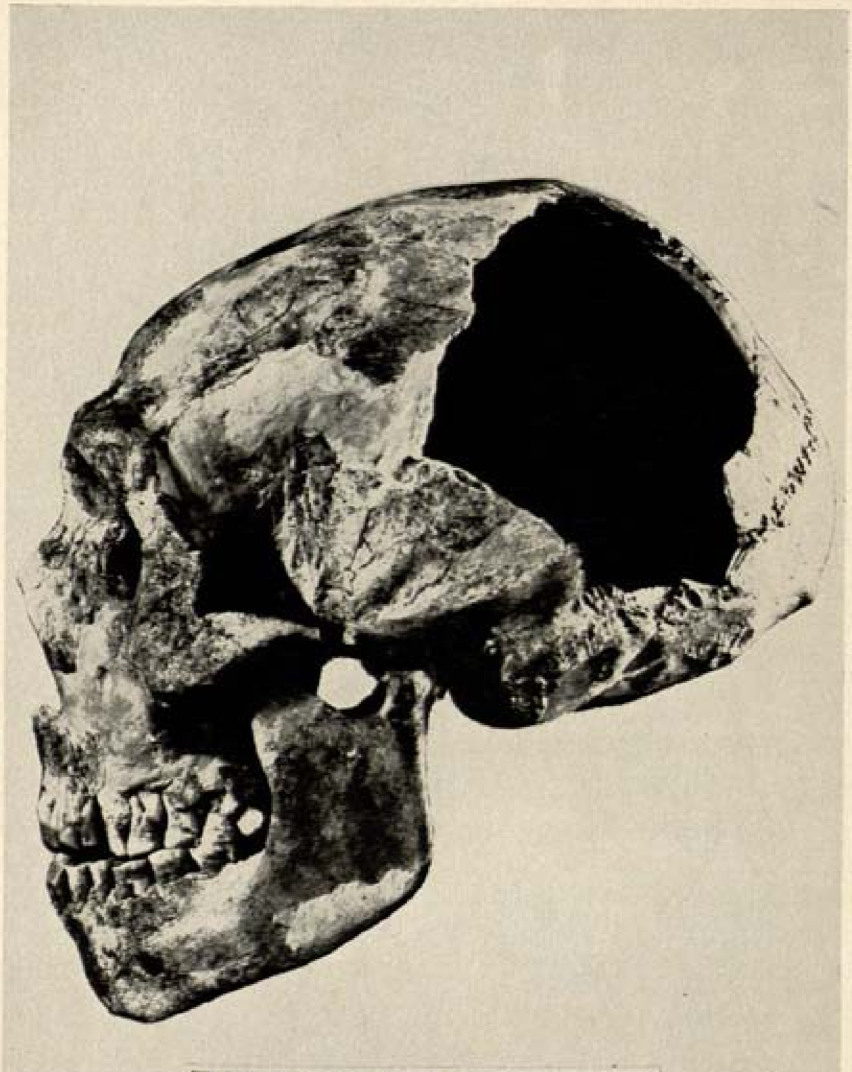
Front view. This and subsequent stereographic drawings were made with the skull in the Frankfort position. Stippling indicates areas of missing bone replaced with filler (except as noted in plate 11); heavy parallel lines, areas of unreplaced missing bone or natural openings into the interior of the skull; fine parallel lines, broken edges of bone.



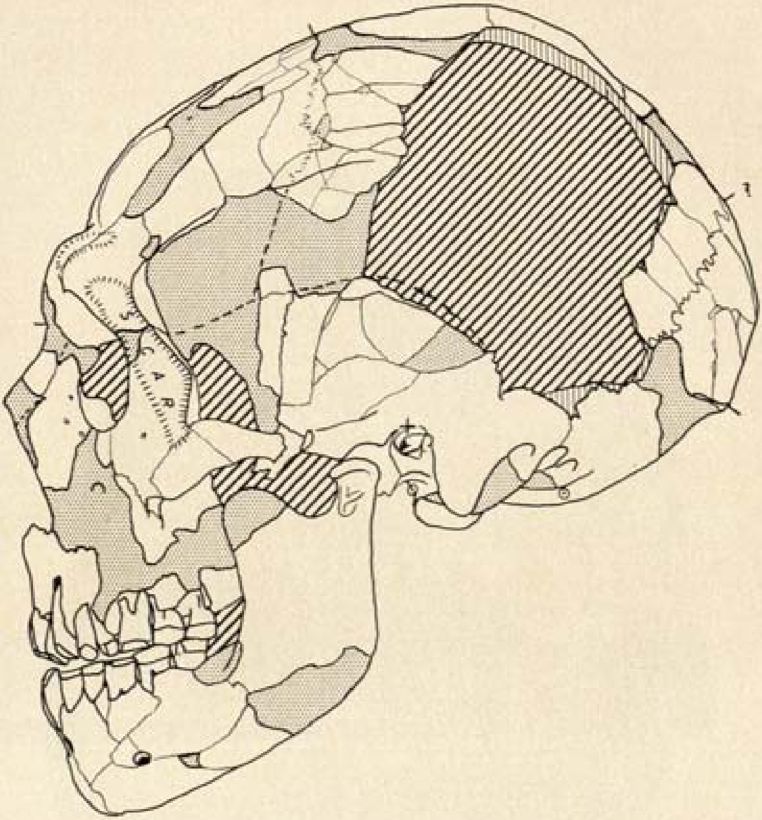
View of right side. The most complete portion of the skull is here shown. Note the flatness of the face in the infraorbital region, the lack of chin, the ear exostoses, and the relatively small mastoid process.



View of right side. (The position of the nasal floor has been added to this drawing since the original publication.)

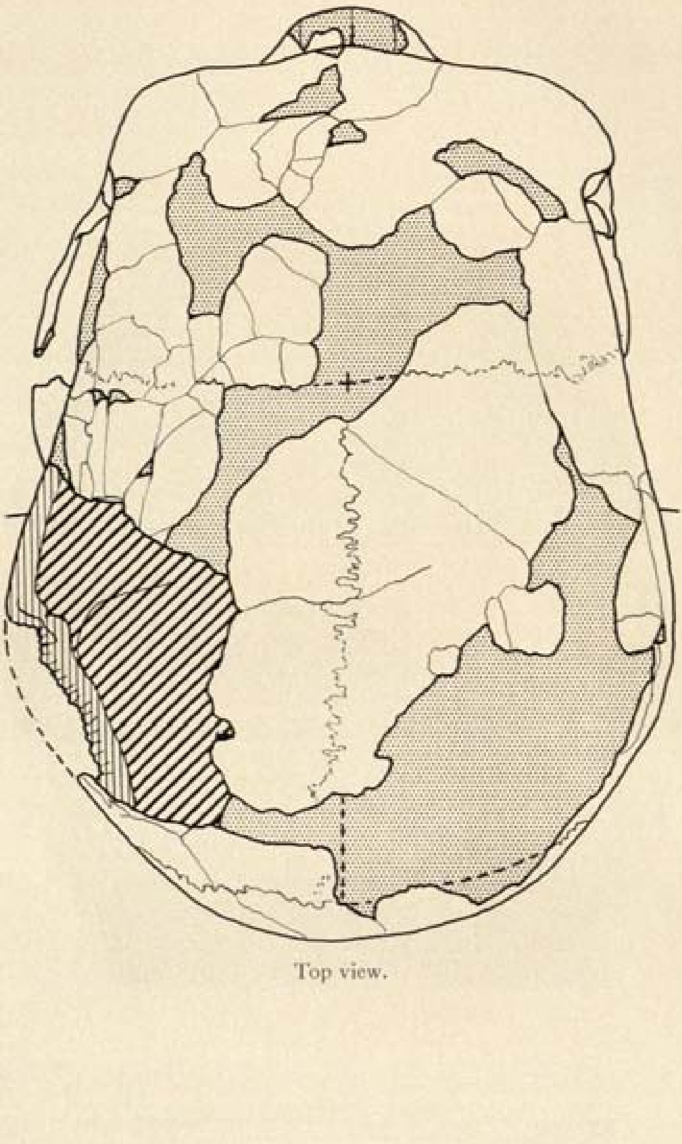


View of the left side. The many missing parts on this side are apparent. The opening was left for inspection of the interior. The gap in the zygomatic arch is probably one of the results of postmortem warping.

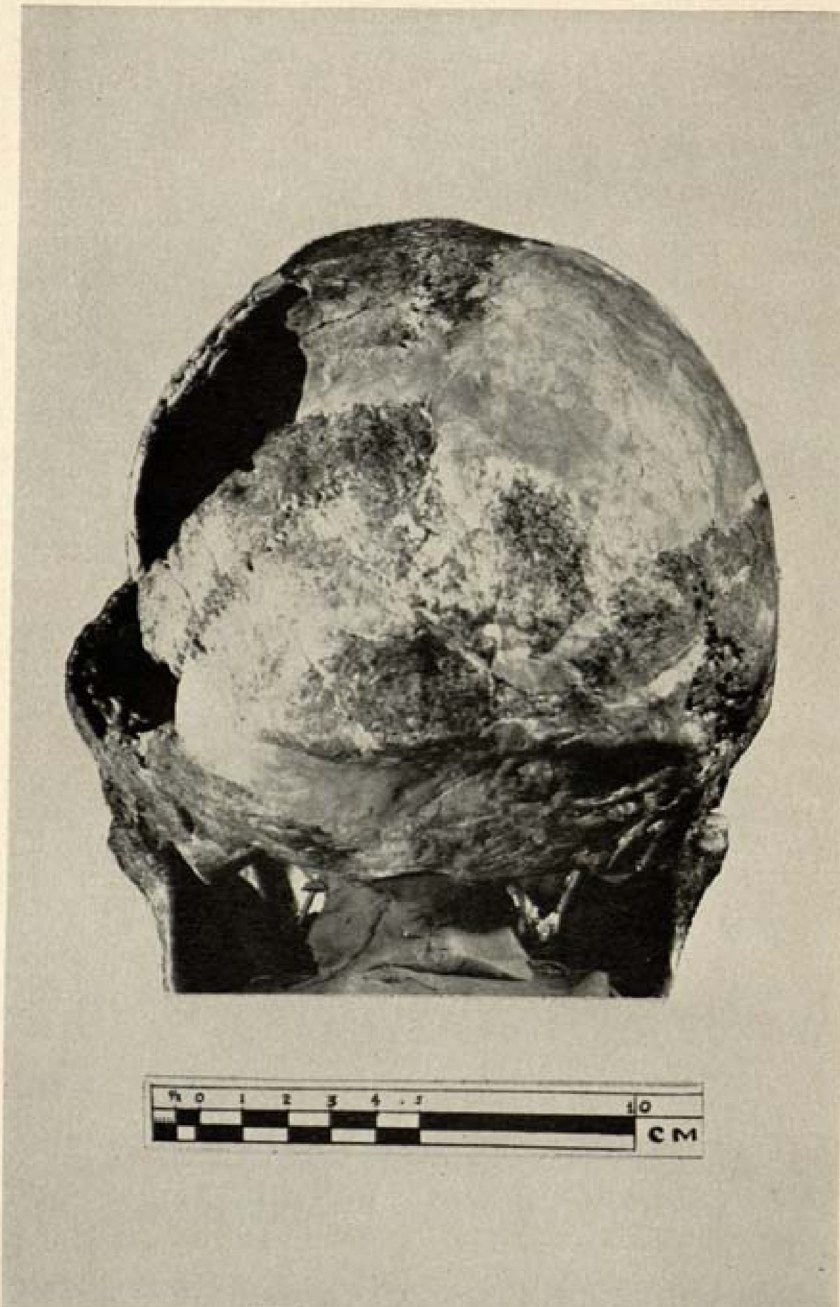


View of left side.

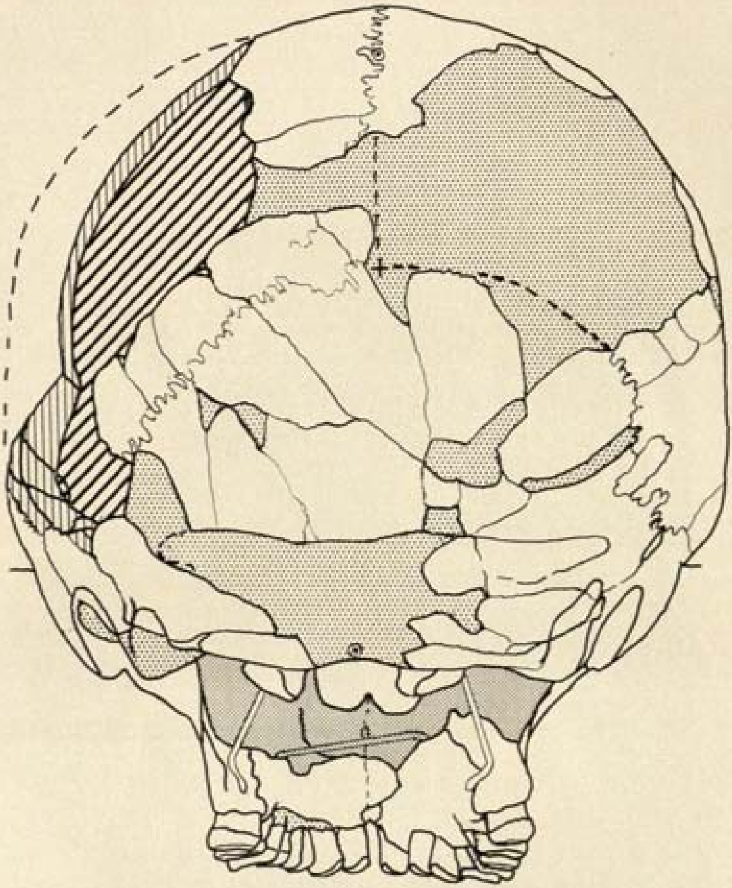
Top view. The large piece of bone forming the center of the vault has only a short hinge type of connection with the right side. Note the deformity of the left supraorbital ridge. The cross marks the position of bregma, where the sagittal suture meets the coronal suture.



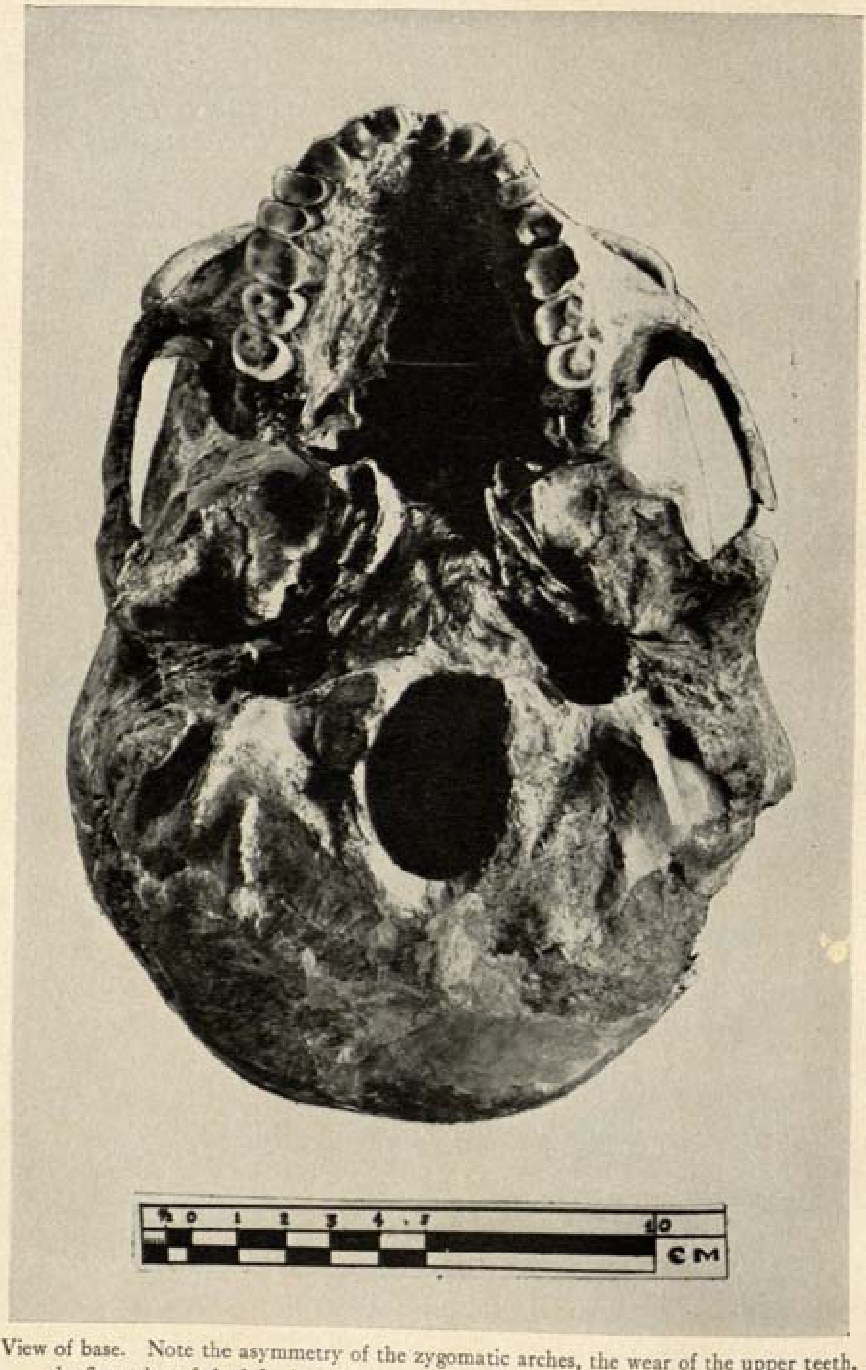
Top view.



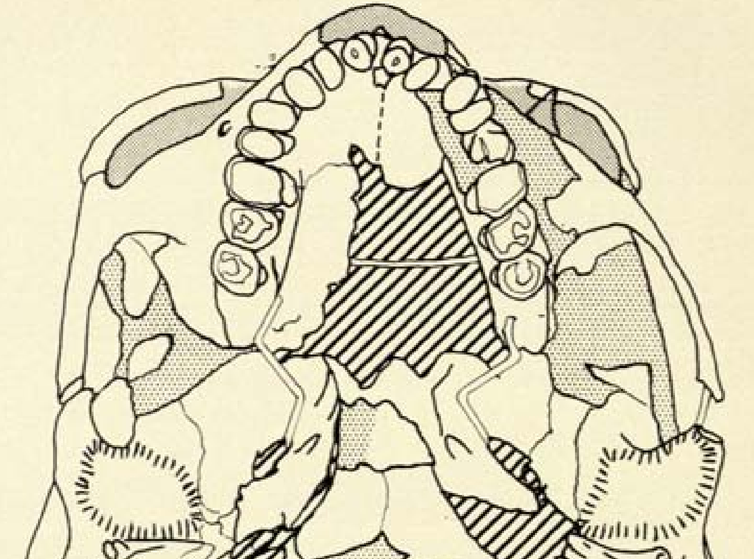
Back view. The upper part of the occiput has a small and somewhat uncertain connection with the right side. On the left of the occiput is a gap attributed to postmortem warping. Note the large digastric fossa behind each mastoid.



Back view. Very fine stippling represents interior of nasal cavity and adjacent antra.



View of base. Note the asymmetry of the zygomatic arches, the wear of the upper teeth, the flattening of the left glenoid fossa, and the relatively large foramen magnum.



View of base.

enumerated) make the Shanidar I skull a most valuable addition to the list of examples of ancient man.

There remains to point out a few morphological details which the eye does not detect immediately, or which are not visible, in the pictures. I direct attention first to the flatness of the face in the infra-orbital region. The lack of a fossa in this place—so common in modern man—together with the elongation of this portion of the face, gives an impression of unusual massiveness. A correspondingly large antrum fills the inside of this part of the face from the orbit to the roots of the teeth. Also, curiously, the floor of the nasal aperture does not go straight back as in modern man, but slopes down rapidly and levels off more than 1 cm. below the bottom of the aperture (see pl. 5). Note, too, that there are numerous little foramina in the facial bones, especially about the orbits.

Next, I would point out the wear of the teeth. In the molar areas this wear has eliminated much of the enamel and has created a flat occlusal surface. More peculiar is the wear of the anterior teeth, the incisors and canines particularly, which consists not only in the loss of all the enamel, but in more extreme wear anteriorly and posteriorly than in the center and on the sides. Thus the acclusal surface of each of these teeth is smoothly curved in the anterior-posterior axis with the convexity of the curve meeting that of the opposed tooth. Wear of this type likely was associated with the habitual holding of objects between the front teeth rather than with ordinary chewing of food.[5] I was much impressed also by the robustness of the lower lateral incisors, which in modern man often are quite diminutive. The missing central incisors may have been even larger.

In this connection it is noteworthy that the lower jaw has been well sculptured by attaching muscles. This is particularly true of the underside of the symphysis where there are well-defined depressions for the origins of the genioglossus, geniohyoid, and digastric muscles. The large and asymmetrical ascending rami are also interesting. In reconstructing the tips of the coronoid processes I may not have extended them enough. Both glenoid processes have lateral tubercles and the articular surface of the left process is abnormally flattened. It is not clear to me whether this alteration is associated with tooth wear or with the facial injuries described above. On the lingual side of the ascending rami the mylohyoid canals have remained open.

Finally, I would direct attention to the auditory meatus, which have their circular outlines altered by exostoses. On each side the lumen is almost occluded by these bony growths. So far as I am aware

[5] This can be further explained now by the fact that Shanidar I had no right hand and therefore used the front teeth for holding objects (see Stewart, 1959).

now, ear exostoses have not been found before in ancient man.[6] In modern man the incidence of this abnormality is quite variable. It is not yet clear what causes them.

Many other details remain to be described, but for the most part they need to be evaluated in terms of comparative data. At least these initial comments will serve to make the pictures more intelligible and thus give a broad idea of the importance of the specimen. It should be remembered, however, that physical type is incompletely revealed by even the best description of the skull alone. When I am able to add more to the description of the skull and to present the evidence from the rest of the skeleton, the evolutionary position of the first Mousterian adult from Shanidar will become clearer.

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[6] I have learned since that Shanidar I is not unique in this regard. In describing the ear openings of La Chapelle-aux-Saints, Boule (1913, p. 44) says, "Ces orifices présentent quelques exostoses. L'orifice gauche est rétréci vers son milieu par des productions osseuses qui lui donnent une forme en sablier." Apparently Hrdlička failed to observe this for he says (1935, p. 79): "It is not known, and will probably never be determined, when in the existence of man the abnormality of ear exostoses made its first appearance. No case of the growths has as yet been reported in early (geologically ancient) man, and none even from the Neolithic period, though that does not necessarily mean that they were absent."

Acculturation in the Guajira[1]

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[With 8 plates]

IN A PREVIOUS PAPER ("The Land and People of the Guajira Peninsula," Ann. Rep. Smithsonian Institution, 1957, pp. 339–355) the author discussed the physical setting and some significant features of the cultural geography of the Guajira Peninsula. It is the purpose of this paper to present the results of a study of the process whereby those of Guajiro culture accept or reject the cultural values of modern Venezuela. For this study, intensive, on-the-spot investigations were made in La Gloria, a tiny Guajiro settlement 100 kilometers north of Maracaibo.

CULTURAL AND HISTORICAL HIGHLIGHTS

It is a matter of historical record that the rich and extensive Indian cultures of Mexico and of Peru collapsed like the proverbial house of cards under the impact of a mere handful of Spanish Conquistadores. In striking contrast, the Indians of the desertic, isolated, and inhospitable Guajira Peninsula—a kind of dead end of Nature—who were a much less numerous and more primitive group, living by hunting and fishing, with perhaps occasional raids on the weaker or less warlike neighbors within their range, were able not only to survive but to enrich their culture and by those tokens increase their numbers. They adopted into their scheme the domestic animals introduced by the Spaniards and created a pastoral society that has persisted over the centuries, despite unfavorable conditions, down to the present day.

The Guajiro social organization of the present time includes an assortment of elements. Polygamy flourishes along with matriliny,

[1] The field and library work on which this paper is based was made possible by a grant of the Creole Petroleum Corp. Various departments of the organization cooperated in every way to further the undertaking. Thanks are due the ministries of the Venezuelan and Colombian Governments that helped to facilitate fieldwork involving movement back and forth across the frontier; also Prof. Lorenzo Monroy and E. J. Lamb, who were of assistance at every step throughout the author's stay in Venezuela. To Drs. Woodfin L. Butte and Guillermo Zuloaga, directors of the Creole Petroleum Corp., the writer is especially grateful.

for the bride price is a part of the property of the clan of the mother, and by the same token a kind of economic security for the children to be born of the union. Perhaps greater male authority was first superimposed upon the original matrilineal structure with the adoption of a pastoral economy, in order to achieve more efficient handling of herds of livestock; at the same time membership in the maternal clan was preserved as security against protracted droughts when part or all of the stock could be accommodated at the waterhole of some distant clansman.

Once the pastoral way of life was established it was powerfully reinforced by the cultural factors of bride purchase and polygamy, for the payment of a groom for his bride is traditionally made in cattle. Although cash—preferably in bolivars—is becoming more and more important in many transactions of life, cattle are still the basis of wealth for most Guajiros, and the families of both bride and groom are happier if the bride price is paid in cattle. Until this concept has changed it will be difficult to do much about overgrazing in vast sectors of the Peninsula. Overgrazing sets in motion a chain reaction, for it spells an ultimate decrease in the carrying capacity of the land for livestock, and consequently for those whose livelihood depends on their herds, and thus the end result often is migration from the Peninsula of both human beings and their animals. Such migrants often find it more to their liking to enter gradually the area of Latin culture, and are therefore happy to settle in a place like La Gloria where the process of acculturation is operative at degrees of speed that can be somewhat controlled by the principals. Observations made in the settlement of La Gloria show that not only in its matrilineal structure, but in many other important aspects as well, the Guajiro social organization continues to be receptive to cultural influences from outside. Conclusions reached in the study of acculturation of the Guajiros might be valid for investigators of cultures and subcultures elsewhere.

La Gloria is the last—or the first—outpost of the Guajira, a tiny settlement on the fringe of the great desert. It is here in La Gloria that the process of acculturation can be most clearly observed, for those who live here look one way to the Guajira desert and the other to the asphalt highway that leads to "civilization." Geographically and culturally they front both cultures. La Gloria lies 100 kilometers north of Maracaibo, only 3 kilometers beyond the end of the macadam road that goes from Maracaibo to Paraguaipoa, which is a regional center and the site of the big Monday Guajiro market. It is a mere *caserío*, a diminutive group of houses set among the white dunes that have been formed by sand blown inland by the ever-active trade winds from the beach of the Gulf of Maracaibo as much as 4 or 5 kilometers.

Beyond the paved road that stops at Paraguaipoa one enters a desert plain that stretches as far as the eye can see. It has no established roads, and travel is accomplished on foot, on horse or donkey back, or by jeep or truck. Scattered over its remote reaches are the Guajiro Indians, living in widely isolated houses, or in *caseríos*, groups of a few houses, perhaps only two or three, or moving from place to place, in temporary camps; ceaselessly leading their animals in search of pasture over the cactus-studded plains, or to far, infrequent waterholes, or taking them to market; trekking long miles and many days' journey to small exchange posts or to the larger, more distant market towns; traveling often with their women and children, their flocks, and all their meager possessions.

The Guajiro, it should always be kept in mind, has for centuries been a nomad or seminomad. Before the coming of the Spaniards, in the words of Juan de Castellanos:

> Es solo su sustento y su cosecha lo que les puede dar el arco y flecha. (Their only food supply and harvest is what their bows and arrows win.)

Naturally Indians living in a hunting and gathering stage of economy were not sedentary; they were forced to range for food over a wide area. By 1551—within a half century after the arrival of the Spaniards—they had begun to raise cattle, and especially sheep and goats, and had entered on the seminomadic way of life that characterizes a large part of the population to the present day.

The Guajira Peninsula was never actually subdued by the Conquistadores. Although the Spaniards made many halfhearted attempts to conquer the Guajira by force, the fact is that the Peninsula was simply not rich enough in gold or precious stones to make its conquest worth an all-out effort. But another reason—perhaps the most important one—why the Guajira Peninsula was not conquered by the Spaniards was the incessant guerrilla warfare waged by the Guajiros against any outsiders, with all the ferocity of the old Irish clans against the English. The cohesive strength of the various clans, or *castas*, was amazing. The motto of the Guajiros was:

> Suwarajen arijuna, sainjara arijuna. (White man did it, white man will pay for it.)

It is a matter of course that for these people one of the first steps in the process of acculturation is to become adjusted to living together, perhaps first in a *caserío*, such as La Gloria, later on in a village or urban agglomeration. For a basic cultural fact of Latin American life is the village, with its own patron saint who is the protector—a kind of godfather—of the village and of its individual members. The "village" has somewhat the meaning of the New England township, and it may include a number of small settlements, *caseríos*, *rancherías*, *placitas*, etc., the name depending on the country. The nomadic

Guajiro finds it more congenial first to settle in a *caserío* such as La Gloria, which forms an intermediate step between life in the country and life in a village such as Paraguaipoa or in a city such as Maracaibo.

La Gloria is neither an organized village nor just a group of houses dispersed at random. Except for the store of the Carvajals, the only urban function performed by the settlement is that its members visit back and forth to exchange gossip and to perform household tasks together. The houses generally are from a hundred yards to a half mile apart; occasionally two are set close together. In only a single instance is there a large cluster of houses (pl. 3, fig. 1) in which lives the extended family of the Carvajals (who will be discussed in detail later), together with their servants. In their compound the family also operates a store in which basic food staples may be purchased and in which produce from the interior may be sold or bartered. Here the transient Guajiro, after his long trek from the interior, is sympathetically received by people who understand his problems as well as his language. It might be weeks or months before he would have the moral strength to enter any of the (to him) imposing edifices in Paraguaipoa, full of impersonal strangers speaking only Spanish.

MYTHS, MATRILINY, AND MIXED MARRIAGES

The matrilineal character of Guajiro culture meets us at once in the myths of the Guajiros about the origin of man and of the social order. In a remote epoch, goes the legend, the goddess of the Guajira married Mensh, Time, and had several daughters, one of whom married Para, god of the sea. Of this marriage were born a son and a daughter, Juyap, or Winter (i.e., the rainy season), and Igua, or Spring. Igua married the god of the winds, Jepirech, and from this union sprang all the Guajiros.[2] In this myth are represented the natural elements that are of importance to the Guajira: the actual rain, without which life is impossible, and the northeast trade winds that bring or deny the rain. And the rainy season, Juyap, is the maternal uncle of all; the one who, in the prevailing order, is the member of the family with the greatest power and the highest social rank. Thus the legend is molded to fit the existent social realities of the culture, at the same time that the transcendental role of the natural elements in Guajiro economy is recognized.

The gradual, present-day conquest of the Guajira is being effected in part by the process of mixed marriages, i.e., between Indian women and men from outside who are carriers of modern culture, be they white, Negro, or mestizos. Temporary marriages are entered into with Indian women by civil and military authorities or by tradesmen, who buy their wives in accordance with Guajiro law and adapt them-

[2] Chaves, M., La Guajira, una region y una cultura de Colombia, Rev. Colombiana Antrop., vol. 1, No. 1, p. 182, June 1953.

selves to local customs, and whose children, according to Guajiro tradition, do not belong to them but to their wives. Permanent marriages are made by outsiders who have come to settle in the Peninsula, some of whom buy a wife or wives in the Guajiro manner, while others marry one wife according to Catholic rites. Whatever the character of these mixed marriages, the children are brought up in two cultures. During their early, most impressionable years they are imbued with the Guajiro language and with other cultural traits of their mother.

Many of these mestizo children are educated, at least for a time, outside the Peninsula, with the result that a layer of "modern" culture is superimposed or grafted onto the maternal Guajira culture. But the grafting is not universally successful—in the words of the horticulturist, it does not always take. Many who have gone to school or lived for several years in Caracas or Maracaibo, in Bogotá or Baranquilla, upon their return to the Guajira appear very happy to settle down and live in the manner of their Guajiro ancestors. They may build a permanent, cement-floored house in the nearby settlement of La Gloria, one that is a far cry from the thatch-roofed, dirt-floored huts of their unaccultured fellows in the vast desert beyond, but the idea, for example, of constructing a privy has evidently never occurred to them, and if the visitor asks where such facilities are, a baffled look comes over the face of his host, who makes a sweeping gesture with the hands to indicate that the whole wide desert is available for such use.

The Indians of the Guajira are divided into various clans or blood groups, *castas*, each with its distinguishing totem representing the animal with whose traits, according to legend, the clan was originally imbued. For centuries every clan was theoretically—and often actually—on a war footing with all other clans. Blood feuds for real or imagined causes were common and sometimes resulted in the annihilation or enslavement of the vanquished clan. Marriage was practiced within the clan. Only recently have marriages between members of different clans tended to decrease interclan tensions and blood feuds. Formerly each member of a clan was considered a blood relative of every other member. In the course of time the blood relationship of any member came to be restricted to his mother and her ancestors, her brothers and sisters and their descendants.

In La Gloria, where some marriages are being performed in the Catholic Church instead of by purchase and with Guajiro ritual, still more marked changes in the system of relationship have been introduced. In the case of marriages within the church—which first of all substitutes the concept of monogamy for the traditional polygamous unions—children are no longer considered to pertain exclusively to their mother's clan, nor do they carry her name. Instead the

children carry their father's name, and the father's side of the house thus becomes more important than the mother's. At the same time the avunculate, the authority and the dominant role of the maternal uncle in the life of the family and clan, is destroyed by the predominance of the father, whose responsibilities to his children are also increased. Since the church forbids plural marriages, and the father has a feeling of greater responsibility toward his children, the tendency to be limited to one wife likewise increases—this in spite of the fact that Guajiro law can be invoked and a number of wives purchased outside the church.

The Carvajal family in La Gloria (pl. 1, fig. 1) has been affected by these various cultural cross currents. The parents themselves were formally married in the church only a few years ago after 25 years of common-law marriage and when the eldest of their 11 children was already grown. The eldest daughter (pl. 1, fig. 2), married in the church, lives in Maracaibo with her Latin husband and five children, who speak only Spanish and who will have only vague memories of the part-Guajiro household of their grandparents. The eldest boy, Jesús, was also married in the church, but, in spite of several years at school in Maracaibo, to a pure-blooded Guajira (pl. 2, fig. 1), whose whole background is Guajiro, who speaks no Spanish, and by whom he now has a daughter and a son. They will be brought up to school age speaking only the Guajiro language, after which they will also learn Spanish and thus in time will sit astride the two cultures.

According to Guajiro law, a man acquires a wife through purchase from her family, by paying a certain sum in cattle, horses, goats, sheep, and perhaps in some costly jewelry. A girl child accordingly represents a certain amount of wealth that will come to her family with the bride price, whereas the boy child will be an economic drain upon his family when he marries, since they must get together the bride price, which will leave the family. For this reason the Guajiro takes better care of his female children and watches over them with greater solicitude than he does over his male children. This situation is reflected in the few statistics that are available, which show a much higher death rate for male than for female children.[3] When the Guajiro begins to appreciate certain values of the culture of the *civilizados*, the attitude toward male children undergoes a change: the boy can help his father at an early age, and particularly if his father is engaged in trade with the Guajiros, he can be an economic asset rather than a liability.

M. E. S. Hartland, in "Primitive Society,"[4] observes that "Patriarchal rule and patrilineal kinship have made perpetual inroads upon mother-right all over the world; consequently matrilineal institutions

[3] Roberto Pineda Giraldo, Informe preliminar sobre aspectos sociales y económicos de la Guajira, Bol. Arqueol., December 1947, p. 565.

[4] 1921, p. 34.

1. Mr. and Mrs. Carvajal, with seven of their children and one of their grandchildren, in the inner patio of their home.

2. The eldest daughter, married to a businessman in Maracaibo, with her five children, all of whom speak only Spanish. Her younger sister is dressed up to take first communion, on St. Joseph's Day.

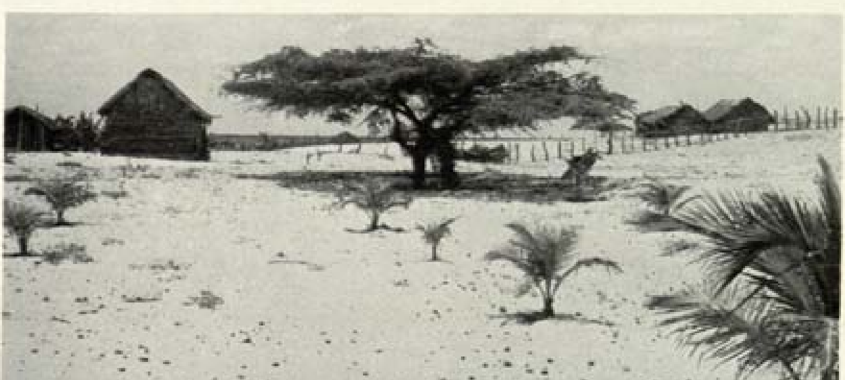
1. The pure-blooded Guajiro wife of the eldest son speaks no Spanish—only her native Guajiro language. She has put on her best *manta*, lace-trimmed, and proudly holds up her 2-weeks-old son to be photographed.

2. A large hammock of complicated design is being woven by a young lady whose face is painted black as a protection from the strong rays of the sun.

3. Two young Guajiro belles, both of whom have been to school in Paraguaipoa where they learned Spanish. They act as interpreters for their families in all contacts with the outside world.

1. The stockadelike home of the Carvajals, which is store, house, and stockade for sheep and goats.

2. This swale, full of water when it rains, supports a thick stand of grass which is cropped during the season of drought. Plantains thrive here where the water table is usually near the surface.



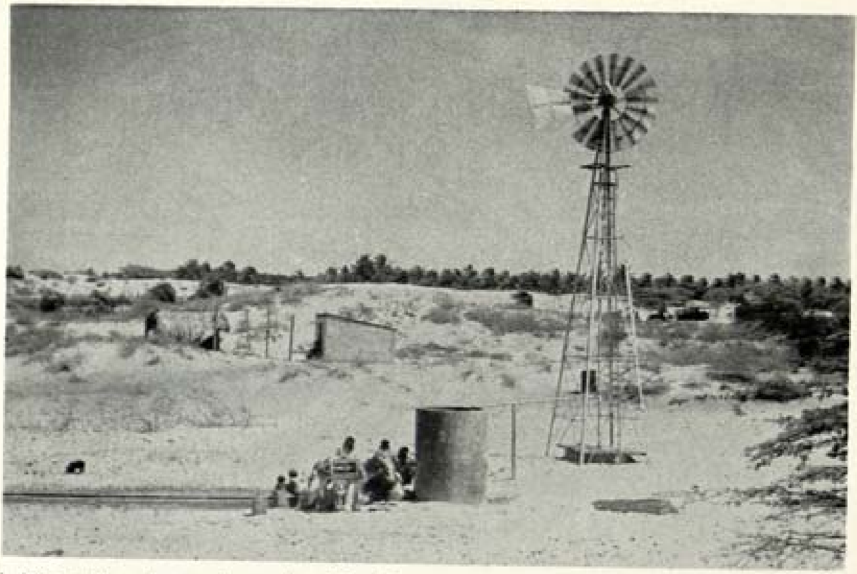
3. Young coconut trees, set out on the dunes, in a few years become a source of regular income to the owner.

1. New arrivals from the bush construct the simplest sort of shelter in which to hang their hammocks.

2. Cooking is done with the barest essentials.

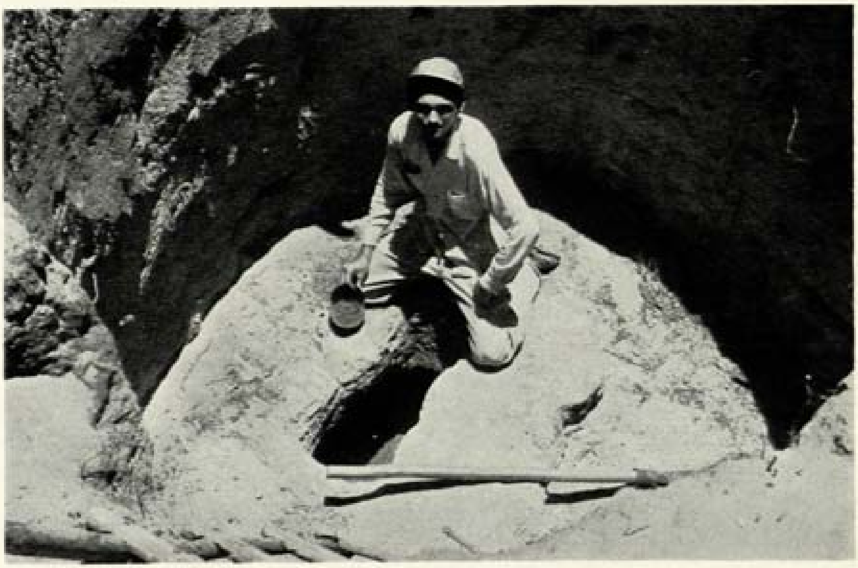
1. Cotton thread is spun by hand for the making of hammocks.

2. Women whose husbands are working on the ranches south of Maracaibo. Not one of them speaks Spanish.



1. The well on the southern edge of La Gloria. Coconut palms are seen in the distance, beyond the wind-swept sand dunes.

2. The scene around the water tank is animated all day long, as animals drink, gourds are filled, children are bathed, and clothes, washed in big wooden *bateas*, or basins.



1. A shallow dug well reaches the water table below the dunes and supplies drinking water for a household during the long drought.

2. At the edge of a coconut grove onions and peppers are grown in the raised frame to the right. The owner spoke almost no Spanish.

1. The women folk especially are always ready to dress up and paint up to dance the *chichamaya.*

2. One family has a thriving business of cutting up old tires and making them into sandals.

are found in almost all stages of transition to a state of society in which the father is the center of kinship and government." These observations hold true of the Guajira. Changes are continuously taking place in the matrilineal structure, but at the present time maternal kinship still continues to exist side by side with institutions of paternal authority.

LAND TENURE

The land in the Guajira is almost completely *baldío*, or state owned, so far as the nation is concerned. The various clans, or *castas*, however, occupy lands that, according to oral tradition, have always been grazed by the flocks of their ancestors; thus they claim the "immemorial rights" of the desert Bedouins. Problems begin to arise as soon as grazing is no longer the principal activity. When sedentary agriculture is carried on, the farmer must know who owns the land or, at least, who owns the crop. The practice followed at present is that whoever plants a crop anywhere has the right to the usufruct of the land planted, as long as he continues to work it. Heirs can inherit the right of usufruct. The burden of keeping the crop fenced off against the depredations of migratory flocks rests upon the owner of the crop.

Since there has been no tradition of landholding by individuals in fee simple, it is difficult to get people interested in rights to land. Many persons even build relatively substantial homes, with cement floors and walls and with aluminum or galvanized-iron roofs, without having made any effort to get what we think of as a clear title—or any kind of title—to the land. To be sure, in Latin America generally, rights to real property are vague, and squatters are prevalent. Those humble folk who do hold papers often find to their sorrow that they are notoriously subject to invalidation. Nevertheless the Guajiro, by his whole background, is conditioned to an acceptance of vague concepts with reference to landholding, which carries over into the zone of acculturation as well.

AGRICULTURAL ACTIVITIES AND HOUSEHOLD INDUSTRIES

Over the past generation a new note has been added to the cultural landscape from Sinamaica northward to well past Paraguaipoa—the coconut grove. Each year new groves are being established (pl. 3, fig. 3) and old groves are being increased in extent. The completion of the asphalt highway to Paraguaipoa made it possible to extend groves even farther north because of the ease of transporting the products to market. While a small number of the coconuts are used to supply the local demand for the refreshing coconut water, *agua de coco*, by far the larger part of the crops is used for the production of coconut oil, which is extracted from the meat of the ripe coconut

in crude presses, bottled, and shipped to the Maracaibo market. The residue remaining after the oil has been extracted is used for the fattening of hogs, which are kept in pens provided with a floor to keep them off the ground. This measure prevents disease, and in the small pens the pigs cannot run off their fat.

Although the basic economy of the Guajira is grazing, and has been for centuries, the Guajiros are not afraid of strenuous physical toil. They have been inured to the hard work of clearing plots for growing their yuca or millets, digging wells, and dipping water. The reply of a *cocal* owner in La Gloria, who had just planted 400 new trees, to the statement that he could surely live well, being the owner of such a fine coconut grove, was that "by dint of hard work one can live well here, as elsewhere." Those who own *cocales* have a more or less steady income; they can sell green coconuts occasionally in the local market; they also have the meats of the ripe fruit to eat themselves or to grind and feed to hogs and chickens for use in the home. The relatively steady income also makes it possible for them to buy and consume more of the protective foods than can those who have only the meager wages of menfolk working on the distant ranches in the foothills of the Perijá Mountains.

One might hazard the guess that at the present rate of planting coconut trees, within another 20 years most of the available sand-dune area between Paraguaipoa and Cojoro may be planted in that crop. The Guajiro or mestizo who establishes a coconut grove is himself the active agent of change of his own physical environment—and he so sees himself. He is already well along in the process of acculturation, for it is then an easy step to acceptance of certain of the nonmaterial elements of Latin culture, in which he has already achieved economic security, or anchorage. In La Gloria, too, on the strip of sand dunes inland from the Gulf, groves are being established by forward-looking settlers.

Although long months of drought had completely dried up the fresh-water lagoon that lies in the midst of the dunes east of the main area of La Gloria, the water table beneath the dunes was still only a few yards deep and could be easily reached by digging a shallow well (pl. 7, fig. 1). In time of drought water from shallow wells is dipped up by hand to water the young coconut trees whose roots have not yet reached the ground-water table. (Trees are planted in August and September, before the annual rains are scheduled to arrive in October, November, and December.) This water is also used for irrigating by hand the small kitchen gardens, called *barbacoas*, a kind of cold-frame structure on legs 3 feet high (pl. 7, fig. 2), in which is put a mixture of loam, sand, and animal manure 8 or 10 inches in depth to form a bed of good soil, and in which a few onions and peppers are grown for home use. It might be mentioned

that south of Maracaibo, *barbacoa* agriculture is carried on on a large commercial scale.

At the edge of the La Gloria lagoon grows a row of banana trees that supply plantains, or cooking bananas, an important item in the local diet. As the lagoon gradually dries up, grass grows in its moist bed (pl. 3, fig. 2). This is eagerly harvested and doled out parsimoniously to the livestock that is most valuable and at the same time most in need.

The Guajira is a land of hammocks. Girls brought up in the Guajiro tradition learn to weave at an early age while helping their mothers (pl. 2, fig. 2). When a girl arrives at adolescence and undergoes the ritual of purification, the *blanqueo* or "blanching," she is secluded in a room or special hut for a period of many months. During this time of enforced seclusion she learns the domestic virtues of cooking, weaving in intricate patterns and designs, and how to please her husband. She may weave belts and moneybags for her future husband, and she usually weaves an enormous hammock which is put away for her own use at marriage. The weaving of hammocks has been carried to a high degree of perfection. In a majority of the houses in La Gloria women are engaged in this activity. It is an operation that can be carried on alone or together with one or two companions, and that can be performed at odd moments between other more pressing chores. A good hammock requires several months to complete, but since hammocks sell for from a hundred to two hundred bolivars or more apiece, a tidy sum may be realized. The opportunity of working together makes the occupation of hammock making particularly attractive to many of the women of La Gloria, whose menfolk are absent for long periods of time working in Maracaibo or in Perijá.

The centuries-old pattern of polygamy has conditioned Guajiro women to adjusting themselves to long absences of their menfolk; they have become used, in accordance with immemorial custom, to carrying on for months or even years at a time their daily routine of living and working without the man of the house. Matrilineal ties are still so strongly structured that the wife can continue to build a satisfying family life which takes such long absences without disruption; she has her weaving to keep her busy and her thoughts occupied, and she can turn for help or advice to her brothers or to a maternal uncle or some other man of her blood who is available in an emergency. Furthermore, where one of the features of the cultural background has been a nomadic or seminomadic way of life, migration of itself is not a disruptive or even a disturbing factor, for the individual capacity of readjustment to change is hardly strained at all. To be sure, many of those living in La Gloria experience periods of food scarcity, if not actual want. To the question.

Why were the men in Ziruma?—the Guajiro slum sector of Maracaibo—a lone woman in her one-room hut, deftly weaving a beautiful hammock, made the shattering and unanswerable reply, "Ziruma is better than the Guajira when you are starving."

One Guajiro who has worked at times as a chauffeur in the oilfields, and who now does odd jobs in the way of trucking and hauling produce to market, operates a little repair shop out in the open air at the side of his house. Between periods of traveling around the Guajira he spends his time in La Gloria reconditioning a beat-up truck or a jeep of ancient vintage, either bought as a bargain in Maracaibo or retired after many years' service over the bumpy trails of the Guajira; he sets up his own work schedule and works when he has the time and feels like it; one is amazed at the ingenuity he shows in tackling difficult jobs. He is considered a master mechanic, and he has as helper or apprentice an intelligent industrious Guajiro youth who is learning the trade.

Incipient industries have also been started by enterprising individuals. One householder has started up a thriving business making sandals with soles cut from castoff rubber tires (pl. 8, fig. 2). His womenfolk make on small hand looms the bands of coarse cotton fiber with which the sandals are held firmly in place on the foot. These products are sold in the local market at Paraguaipoa and are also bought up in job lots by merchants for distribution in Maracaibo. The maker has the advantages of living in a low-rent zone, of having the help of his womenfolk, and of having no transportation or distribution problems.

There is also a jeweler who lives in one of the tiny huts, and whose personal history and background are shrouded and vague. He was the only person who spoke no Guajiro, who was not hospitable, who wanted no pictures taken at all. Although he claimed to be from Maracaibo, he was reportedly from Colombia. It is possible that he may be in Venezuela for his health, that behind the front of gold and silver smelting he is engaged in activities of a secretive or clandestine order.

That La Gloria is a zone of cultural transition is shown by the various house types, a reflection of the cultural background and the degree of acculturation of the builder and owner. There is no fixed pattern; everyone builds what his purse, his fancy, and his degree of acculturation indicate as feasible. New arrivals from the interior may construct a simple framework set on four posts and covered with palm leaves for shade (pl. 4, fig. 1). There are no walls, hammocks are slung from the uprights, and cooking is done in the open (pl. 4, fig. 2). Such a primitive home may be lived in for weeks or even months, after which the owners may build a somewhat more pretentious home, or they may leave for the bush again. They are

comparable to the Bedouins who come in off the desert of North Africa or Arabia and camp near the villages or cities while they decide whether to cast in their lot with the city dwellers or return to the desert to live under the black tents again. The houses of the man with two wives, located about 100 yards apart, are typical of the area around the lagoon of Sinamaica where the houses have walls made of rush mats and roofs of palm-leaf thatch. Those who are well accultured and have enough money will build a house with a cement floor, adobe walls, and thatch roof. The more sophisticated will plaster the adobe walls with a layer of cement, and many even have a roof of eternit or of galvanized iron.

THE CARVAJAL FAMILY: ACCULTURATIONAL LEAVEN

A kind of nucleus for this loosely knit settlement is formed by the stockadelike home of Manuel Carvajal (pl. 3, fig. 1) who first settled in La Gloria 27 years ago. This is rather an agglomeration of one-room units, built with the passage of the years to take care of the family as it gradually increased in size. The central cement-floored structure is used as a dining room, and a living-reception room. At night it accommodates a number of hammocks for guests or for family. Around this are other one-room houses, in which the family lives its private life, and in which the cooking is done and servants and hangers-on sleep. Mr. Carvajal has long been in the business of buying, transporting, and selling livestock. To one side of the cluster of rooms it is possible to drive trucks and jeeps into the fenced-in enclosure. Here animals can be unloaded from the trucks, sorted out and reloaded. Animals not to be reshipped immediately or those arriving on foot can be driven through the corridor between the dining-living room and the structure in which the cooking is done to the large, sturdily built corral on the other side of the agglomeration. Mr. Carvajal is also the only one in this locality who keeps a store, where produce from the interior may be sold or exchanged and where such necessities as yuca, corn, beer, yard goods, and now gasoline and oil may be bought. Thus the increased number of functions made expansion of the original dwelling imperative. The entire compound, surrounded by a high, well-built fence, is a self-contained unit which looks like a frontier stockade.

Mr. Carvajal is ideally equipped to act as an agent of what might be called cultural penetration; born and brought up in Sinamaica, he is a typical product of Latin American culture; energetic and adventurous, he began trading with the Guajiros as a young man, and went all over the Peninsula selling yard goods, tobacco, and other necessities, buying or taking in exchange produce of the countryside, such as goatskins, divi divi pods, and so on. During the early years

he traveled alone, with a train of burros to carry his wares; after he married he was often accompanied on his journeys by his wife and children. His business prospered greatly when he was accompanied by his wife who, being a mestiza, daughter of a Venezuelan father and a Guajiro mother, knew the language and customs well and was thus an invaluable aid in all business transactions. The business increased in volume; the family increased in numbers; the time finally came when it was necessary to have a kind of permanent headquarters. What would be more natural than that this couple settle on the Guajiro side of the economic capital of the district, to work out their destiny in the zone of active acculturation north of Paraguaipoa, where the two cultures interpenetrate? Here they are educating a family of children that includes six sons and five daughters to feel at home in both cultures. The boys have traveled with their parents over much of the Guajira, have pleasant, outgoing personalities, and are serious and cooperative; several daughters have attended school in Maracaibo, where the eldest has married and is the mother of five handsome, Spanish-speaking children.

DIET, ALCOHOLISM, AND MEDICAL CARE

Except for those who own and operate coconut groves, most of the inhabitants of La Gloria buy their foodstuffs from the store on a day-to-day basis with the money received from the menfolk who work in Maracaibo or on the ranches in the foothills of the Perijá Mountains. As acculturation proceeds in La Gloria, Guajiros tend to buy from the store cheap starchy foods such as cooking bananas, polished rice, canned oatmeal, and packaged macaroni and spaghetti. There is an orientation, in cooking, toward what tastes good or sweet; the theory of balanced meals has made little headway. As new foods are incorporated into the diet, there is decreased consumption of one of the traditional dishes, the healthful and filling thick soup, *mazamora*, made of bitter yuca and goat's milk; bottled soft drinks of many hues and weird flavors are substituted for the vitamin-rich *chicha*, a refreshing fermented native beer, made of corn, of millets, or of cactus fruits. The factor of prestige enters into dietary habits. There is more status, for instance, in eating white bread than the *arepa de maís*, with the result that more and more white bread and rolls are substituted for the old-fashioned corn patty, especially on festive occasions. This change in dietary and drinking habits has brought on a marked increase in tooth decay among those who live in La Gloria. The Guajiros living out on the Peninsula almost invariably have fine teeth.

Alcoholism is rampant throughout the Peninsula among the male Indian population. Malnutrition and a monotonous diet may be among the reasons for this excessive fondness for firewater, but it

is significant that heavy drinking is done exclusively by the men. In the face of the niggardly, inhospitable Guajiro physical environment, it is not surprising that some, a prey to frustrations, would hope to drown their worries in alcohol. Perhaps Guajiro men feel, like men in many other societies, that the ability to imbibe large quantities of alcohol is a mark of manly strength and valor. Whatever the reasons, in many of the small *caseríos* or individual houses the menfolk will stay drunk for days or even weeks. However, to the observer it seems that there is less addiction to alcohol in La Gloria than among the unacculturad Guajiros, in spite of certain inevitable tensions brought about by the disturbances in the customary patterns of living implied by the assumption of a sedentary way of life by a seminomadic people.

It is possible that in the process of being incorporated in the national economy, Guajiros become keenly aware of the importance of clear-headedness in commercial transactions. To be sure, fiestas are still popular and the men still enjoy a good drunk, but there seems to be a tendency to cut down the amount of time spent in ritual drinking.

In La Gloria, as elsewhere in the Guajira, the diseases that cause the high rate of infant mortality are intestinal infections of all kinds, due largely to the complete lack of what is known as infant care. In a house with sand or dirt floors, small children, living as they do in close proximity to pigs and chickens and putting in their mouths what they can find, are naturally subject to such ills as stomach aches, vomiting, diarrhea, and intestinal fevers.

Faith in the old-time magic of the *piache*, or witch doctor—usually an old woman—appears to be one of the first items to be lost in the process of acculturation; the "medicine" of the witch doctor, however strong, is often such as to make for the rapid aggravation of the disease rather than for its cure. However, cases are not rare of Guajiros who, accultured to the extent of using trained doctors and modern medicines and techniques when ill, would be found at the same time to be consulting a witch doctor—just to be on the safe side. Indeed, the results of the introduction of modern medicine are not always as felicitous as might be expected or as happy as could be desired. For one thing, modern preventive measures are neglected in favor of modern curative medicines—and the more powerful the better. Injections are all the rage in La Gloria as elsewhere. Itinerant peddlers of injections carry on their "ministrations" openly even in the streets of the large metropolitan center of Maracaibo; hence it is not to be wondered at that those who are groping toward the light, away from the darkness of cures by magic of the Guajiro culture, should seize on this new magic of modern medicine. Thus persons with no knowledge of asepsis—much less of curative medicine—give

injections of powerful drugs that can in some cases be dangerous even when administered by a trained doctor or technician.

In many parts of the world, being sick confers prestige, because only those in a privileged position can afford the time to be sick, the time to think of their symptoms, and especially the money to buy medicines. This aspect of "conspicuous waste" is seized upon avidly by people in process of acculturation in La Gloria as elsewhere, who therein find an easy way to achieve prestige. By discussing in public the symptoms of one's ills, real or imaginary, one proves that he can afford to be sick. Guajiros recently arrived in La Gloria spend almost no time or money on doctors or medicines; the greater the degree of acculturation, the greater the amount of time and money spent on sicknesses. Further prestige can be achieved if one boasts of the amount of money he spends for medicines and the amount of time he spends in the hammock recovering from injections, usually administered by himself or by a friend, without the advice of a doctor. A person suffering from amoebic dysentery may be receiving injections of solutions of calcium, of penicillin, or of any one of the modern wonder drugs instead of the specific cure for his disease. A person who accidentally falls into a tankful of the insecticide used to dip animals to rid them of their ticks will be given the "necessary" injections! A penicillin shot is better for a headache than aspirin, of course, because penicillin costs more and thus gives more prestige.

CULTURE, EDUCATION, AND LITERACY

Through culture—the body of material objects, traditions, and stereotyped mental processes—man is capable of developing a secondary environment that makes it easier for him to adapt himself to the physical conditions—and them to himself—in the area in which he is born and reared. The numerous human adjustments to the natural physical environment as well as to the artificial or cultural environment have to be acquired by each generation. Education has in general taken place simply by the influence of the surrounding and all-pervading cultural environment on the ripening mind of each individual in any given society; for thousands of years all over the world the family has been the first and most important educational institution for all; the older generation simply passed on to the children the skills, religious concepts, and traditions of the culture. Such education was simply the inculcation of the established tradition, and as such had nothing to do with literacy. Since literacy as such was not necessary to the Guajiro for coping with his physical and social environments, the language is still unwritten. Many are the Guajiros today—even in La Gloria—who feel no compulsion to learn Spanish. The women especially, the traditional carriers of the cultural pattern, particularly in a matriliny, have no urge to learn Spanish. Many of

them, living in La Gloria, in Paraguaipoa, or even in Maracaibo, are content to speak Guajiro all their lives, and of course to pass it on to their children, without so much as an attempt to learn Spanish.

Upon one occasion we arrived in the jeep at dusk at the well just south of La Gloria (pl. 6, fig. 1). A group of six or eight Guajiro men were in a palaver. One large, raw-boned individual, although so drunk he was lying flat on his back when we arrived, was helped to his feet by his indulgent and respectful fellows, never losing his dignity. Once his bleary, bloodshot eyes had told him that he was in the presence of *gente de pantalón*, or *civilizados*, he spoke in an imposing, somewhat boastful voice. His first words were, "I am an Indian, but I speak Spanish like anyone else." Obviously for this particular Guajiro the speaking of Spanish was a cultural achievement of which he was very proud and which added to his prestige among his own fellows. Indeed he was the only one among this particular group who could communicate, however brokenly, in that language.

Those born of parents of different cultures are confronted with the task of sorting out and choosing the values from both cultures most congenial to them. Those who show an aptitude for learning and using Spanish, as soon as they associate with others who know and use the language, are often the ones who avidly assume the other attitudes and attributes of Latin culture; for the degree of culture or of acculturation depends not only on the plasticity of innate endowment, but upon the sentiments and whims, the tastes and foibles of each individual. For instance some Guajiros and even mestizos in La Gloria—and some Latins—prefer to identify themselves with Guajiro culture, to buy several wives according to Guajiro law, and thus to have and to rear children who are culturally Guajiros; others marry one wife, use Spanish whenever possible, may even move to Maracaibo, and thus gradually become, with their family, incorporated completely into Latin culture.

By and large, however, the Guajiro is proud of his race, of being Indian, of speaking his Guajiro language, and this is equally true of many mestizos, Guajiro on the mother's side of the house. And although it is true that in most of Colombia and in certain sectors or social strata of Venezuela an Indian ancestry is something to be denied, ashamed of, or at least not to be boasted of, this is in general not true of those who have Guajiro blood. This is probably due to the fact that Guajiro culture itself contains many norms, values, and elements common to, or similar to, those found in the system of Spanish American values. For instance, Guajiros are proud, individualistic, and valiant (*muy valiente*) ; they have a highly developed sense of personal and human dignity, and an injury or insult to an individual is considered an attack upon the clan and must be paid for in money or animals, or even in blood; Guajiros live openly, according

to tribal law, with many wives—a desideratum, to be sure, of many men in divers cultures—and are certainly as possessive of their females and as intent upon being a he-man, a *macho*, as those of Spanish American culture. Perhaps it could be stated that in general the greater the number of values held in common by two cultures effecting fusion, the more gradual the process of acculturation.

EMIGRATION AND ACCULTURATION

The Guajiro has supplied a current of migration to other sectors of the Republics of Colombia and Venezuela—male relatives or those already established in the vicinity of Paraguaipoa visit their kinfolk in La Gloria, sometimes for a period of several months, before continuing on to the Perijá area in search of work. Those who have absolutely nothing often walk the whole long way from Maracaibo—sometimes even from Paraguaipoa—to the ranch area, looking for work on the way. This they do not consider an unusual hardship, accustomed as they have been since early childhood to walking great distances as they followed their flocks back and forth across their homeland, the Guajira Peninsula. By whatever means they arrive at the ranch, it is a fact that the labor force on the new ranches that have been and still are being opened up southwest of Maracaibo, in the foothills of the Perijá Mountains, consist almost 100 percent of Guajiros, many of whom spend some time in a kind of "proving ground" or zone of cultural transition, such as La Gloria.

Many Guajiros unfortunately are plunged into the foreign Latin culture instead of gradually absorbing it, and being absorbed in it, as are those in zones of acculturation like La Gloria. In the upper Guajira, hundreds of Guajiros are packed each week into old beaten-up trucks, transformed into buses by the simple expedient of placing heavy planks crosswise in the body of the truck to serve as seats; Thursdays and Fridays these lumbering trucks move their human cargo over the rocky, bumpy trails to Paraguaipoa, and thence over the paved highway to Maracaibo; there the Guajiros are thrust into the very thick of life in a modern metropolis, with all its pitfalls for the unwary who do not speak the official language; all too often they absorb only the less desirable features of modern urban life, perhaps beginning with overdrinking and all too often ending up in fights and brawls that may even land them in jail.

CONCLUSIONS

Will the modern improvements now being incorporated in Guajiro society change it root and branch, or will they merely strengthen the tough fibers of this vital, long-lived culture that has successfully withstood the impact of new races and new elements of material cul-

ture? Over the centuries the Guajiro way of life has altered in some phases, but its core has remained essentially the same.

What gives to Guajiro society its cohesive strength? What features make possible for its members a life of fulfillment? What are the elements that nourish in them a lasting loyalty? A culture which, to the outsider, appears to be characterized mainly by routine, monotony, and drudgery, may yet offer for those living in it so many intangible or psychic compensations, so much pleasure for the flesh and poetry for the spirit, that they find in it the ideal way of life. Only a prolonged analysis can provide the whole answer. Nevertheless a basic twofold aspect early impresses the observer: Guajiro society is interdependent, cooperative, and fraternal, and the bonds of family are strong. Surrounded in infancy by maternal and family love, accepted and protected—so long as there exist the barest means of subsistence—already in tender years contributing in their measure to the cooperative unit, with chores and duties and responsible demeanor, children early have a feeling that they belong, and acquire a sense of individual human dignity. The landscape of their larger environments to those who compel it to yield up a living, however meager, seems friendly rather than hostile, and, because it seems friendly, attractive. Most of us recall with nostalgic pleasure the physical scenes of our childhood, which we endow with semimagic qualities. The Guajiro feels the same charm in those wide stretches of lonely sand and scrub and cactus, windblown and sun-parched, the muted palette relieved by sudden flashes of bright-plumaged birds and a hint of the blue sea beyond the distant dunes: this is the home of his people, these the broad preserves of the close-knit brotherhood of the Guajiros.

The physical environment of the Guajira is so harsh as to seem at first glance to preclude the possibility of evolving or maintaining a culture. The fact that a society has succeeded in doing so in spite of the inhospitable physical environment speaks very highly for the intrinsic values preserved in the culture. To be sure, the manmade laws, rules of conduct and taboos that men live by, tend to be absolute, to allow of no deviations. Society establishes severe sanctions for those who strike out on untried paths. Nature is more pliable, more resilient, and physical factors seem often to allow of more leeway in adjustment by, for, and to man than does the cultural environment created by man himself.

All over the Guajira Peninsula there is a ferment of acculturation as the Guajiros sink their cultural roots, as it were, deep into both republics—beyond Machiques in Venezuela, and beyond Valledupar in Colombia; the process is relatively rapid in La Gloria, whose inhabitants, neither exclusively Guajiro in culture nor completely

"Latin American," or *Criolla*, are in a transitional stage between the two; they are in the process of selecting those elements and adopting those attitudes in the two cultures with which they feel physically and psychically most at home, most comfortable, and which they at the same time feel give most prestige and offer the best possibility of making a living within the framework of the newly adopted prestige structure. There are many valid values in Guajiro culture for both Indians and Latins, and the reciprocal process of acculturation proceeds gradually. The Guajiros in La Gloria are fortunate in having a zone in which they can maneuver their cultural forces, as it were, and slowly sort out the values that seem suitable.

In spite of droughts, hard work, and lean days, life in La Gloria is interesting and dynamic; everyone feels to a greater or less degree the pull of the two cultures, and the responses often depend on wholly intangible factors. One man will prefer monogamy because he is unashamedly in love with his wife, another because he always felt that his mother—one of the several wives of his father—did not have a fair deal, while still another will marry several wives *a la Guajiro* because he simply likes variety; one woman will give up painting her face black as a protection against the sun after once seeing Latin women of Maracaibo without black paint, while another will continue to paint her face, and that of her daughter, no matter how many times she goes to Maracaibo, because her mother before her always painted her face, and her mother always knew the right thing to do! And so on, and so on, with each individual case. It is impossible to predict beforehand which element of material or nonmaterial culture will be seized upon and held fast. Reason and logic are seldom invoked by human societies to determine what is decent or indecent, clean or unclean, valid or invalid, good or bad; the members of each society feel that what they do is decent, clean, valid, and good, "for thinking makes it so."

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The Braced-up Cliff at Pueblo Bonito[1]

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[With 6 plates]

The huge, detached section of sandstone cliff that long towered above the rear rooms of Pueblo Bonito finally collapsed January 22, 1941. And when it fell, as the Bonitians feared, it did vast damage to their beautiful village.

L. T. McKinney, custodian of Chaco Canyon National Monument at the time of the collapse, reported that the fall came with a tremendous roar at 3:24 p.m. following intermittent rumblings of several hours' duration. Frost action was doubtless a contributing factor, since the winter of 1940–41 is said to have been unusually cold and wet in Chaco Canyon. Between March 1934 and December 1940 the Southwestern Monuments Monthly Reports recorded periodic measurements to show that the famous cliff was slowly settling but I find nothing relative to its tragic end.

A mass of solid sandstone 150 feet long, 100 feet high, 20 to 30 feet thick, and weighing nearly 30,000 tons, the great cliff overhanging Pueblo Bonito was indeed a fearful, awe-inspiring body. It was a living, breathing thing! As one stood to admire, it seemed actually to lean forward to engulf one (pl. 2, fig. 2).

We cannot know whether the occupants of Pueblo Bonito endowed the monster rock with any mystical quality, but they probably did not. They certainly recognized it as an ever-present danger but they probably reasoned that it could be restrained or conquered more surely by human ingenuity and determination than by prayer and sacrifice to their gods. (In our examination we observed no trace of propitiatory offerings.) They conquered at least their fears of it by a succession of primitive engineering measures that succeeded far better than they could have hoped for, that has since commanded respectful attention from all thoughtful passers-by, that preserved the now-fallen cliff for several centuries and provided it with a most distinctive name, *tsē'*

[1] Published by permission of the President of the National Geographic Society. The author was leader of the Society's Pueblo Bonito explorations, 1921–27.

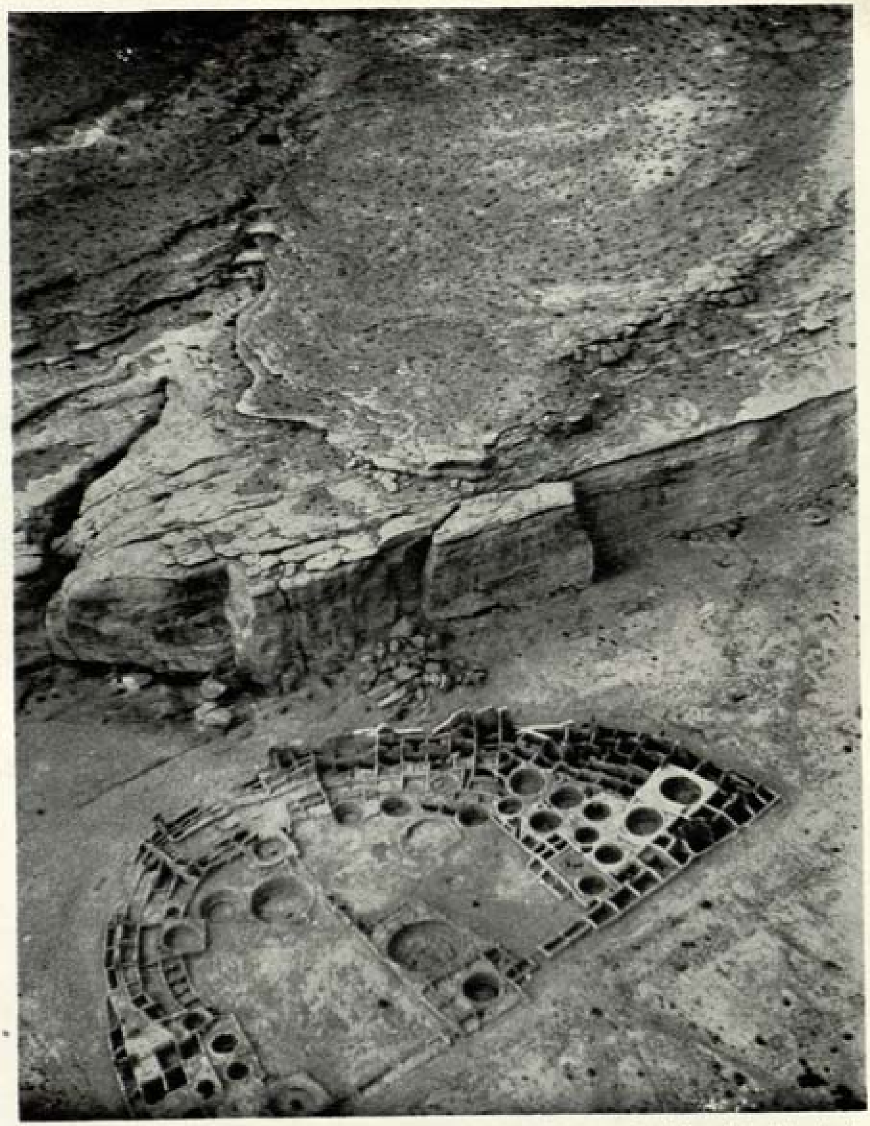
biya hanī' ā'hi (Franciscan Fathers, 1912, vol. 1, p. 228), "the cliff braced up from beneath" (translation by Mrs. John Wetherill).

The cliff-braced-up-from-beneath has been variously designated. Holsinger (MS., p. 14) says it was locally known as "the Elephant" in the days of the Hyde Exploring Expedition, 1896–1900. Nelson (*in* Pepper, 1920, p. 389) described it as "the shored-up Cliff Block." To Hewett it was "the balanced rock" in 1921; "the leaning cliff" a year later (Hewett, 1921, p. 18; 1922, p. 116). It has been "Threatening Rock" to personnel of the National Park Service and others since 1934. This latter name was entirely appropriate as long as the threat remained but one that will endure forever is the Navaho *tsē' biya hanī' ā'hi*. It is an individualistic, descriptive appellation that immediately and positively identifies Pueblo Bonito. There is no other place in all the Southwest to which this name applies.

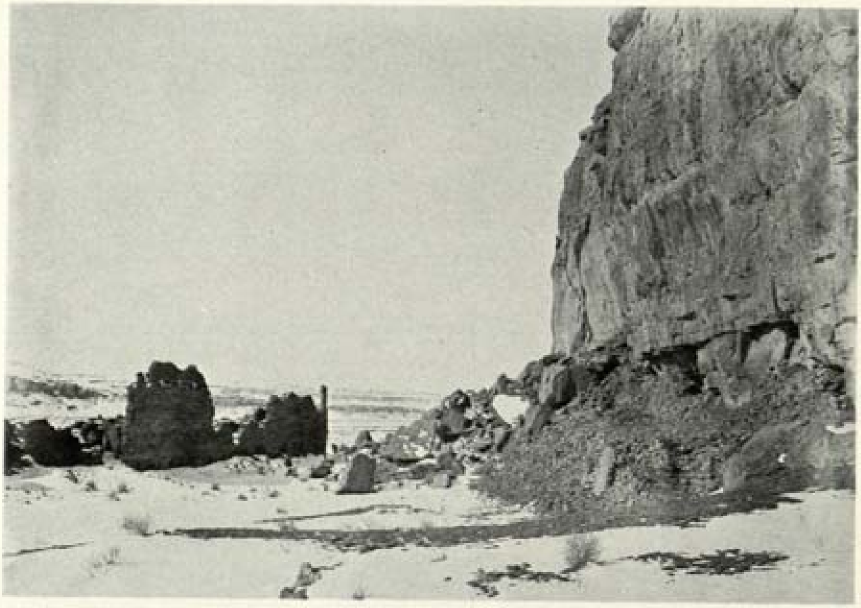
Throughout the length and breadth of the Navaho Reservation in Arizona and New Mexico every Navaho child knows of *tsē' biya hanī' ā'hi*. It is the kernel of many wintertime tales. In 1908 and 1909, on the edge of Monument Valley, Utah, long before Chaco Canyon had special significance for me, I heard of Pueblo Bonito as "the place where the cliff is braced up from beneath." Later I heard the name from Hopi who spoke Navaho and from the Apache. No other prehistoric ruin can boast an equally distinctive feature.

The now-fallen mass rose 100 feet above its terrace platform. Its west end, on a magnetic-north line, stood 117 feet from the outer northwest corner of Room 189, and its east end, half again as far from the nearest point on the southward-curving exterior of the pueblo. Wind and storm in pre-Bonito times had undercut the softer stratum of the great cliff as much as 15 feet in places. It could topple forward upon the terraced village at any time and without warning. Hence the very understandable and continuing concern of the Bonitians. They foresaw and undoubtedly delayed a major rockfall that finally took place years after they had abandoned the pueblo. It is possible, but quite unlikely, that they knew of a still earlier fall and one of even greater magnitude that happened long before they came to Chaco Canyon.

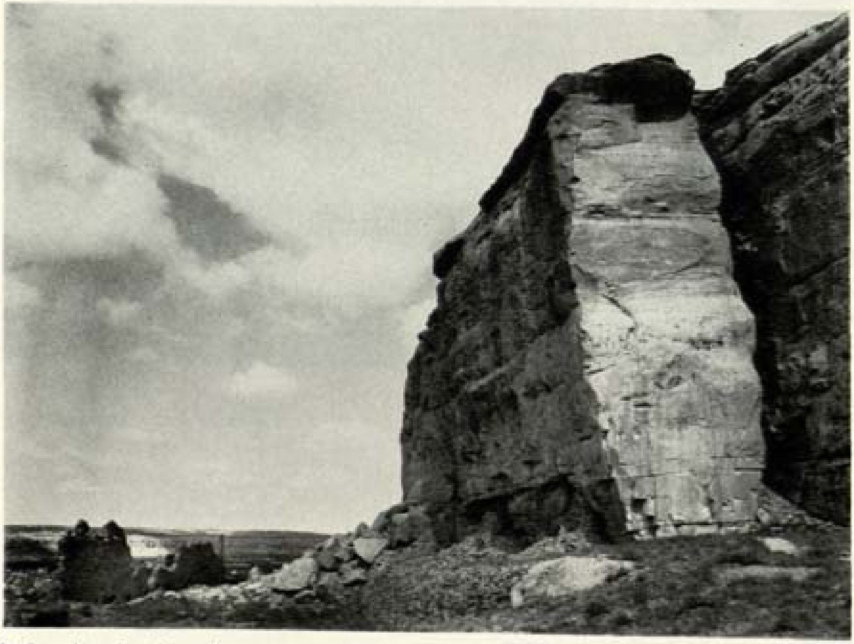
The original settlers of Pueblo Bonito, the "Old Bonitians," had built some of their dwellings between and upon jagged masses of rock cast from the canyon wall long previously, but we may only guess as to the time when the later immigrants, the "Late Bonitians," first recognized the Braced-up Cliff as a constant danger. So, too, we may only guess the order of the several projects by which they sought to control the threat—constructional projects of such magnitude that any one of them might have defeated a less determined people. These later immigrants propped the undercut cliff with pine posts and bedded those posts in rubble; they weatherproofed the rubble with a facing of



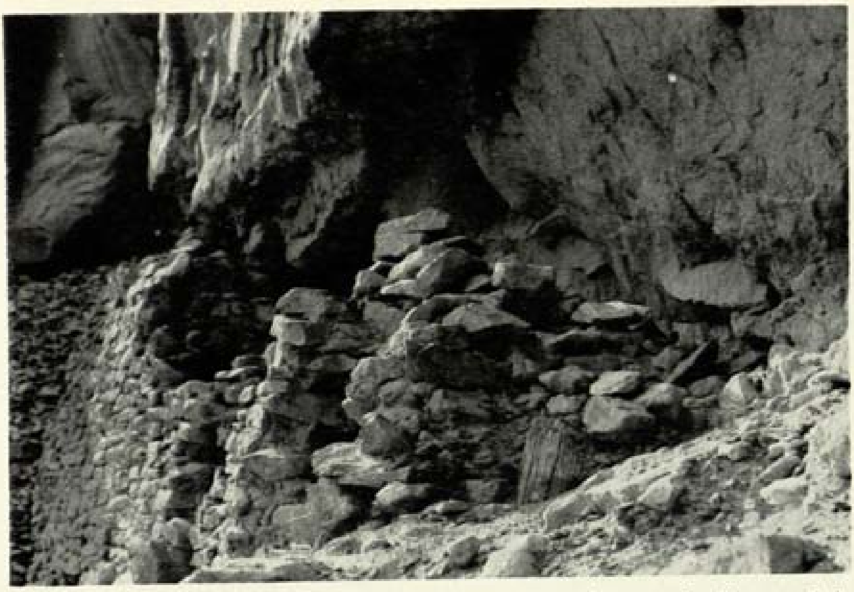
Pueblo Bonito and its Braced-up Cliff from the air. Photographed by Col. Charles A. Lindbergh, 1929; reproduced by courtesy of Dr. A. V. Kidder and the Laboratory of Anthropology, Santa Fe, N. Mex.



1. The Braced-up Cliff in relation to Pueblo Bonito, showing the lower terrace, the upper stonework, and a pre-1877 rockfall. Photograph by Victor Mindeleff, 1887. Courtesy of the Bureau of American Ethnology.

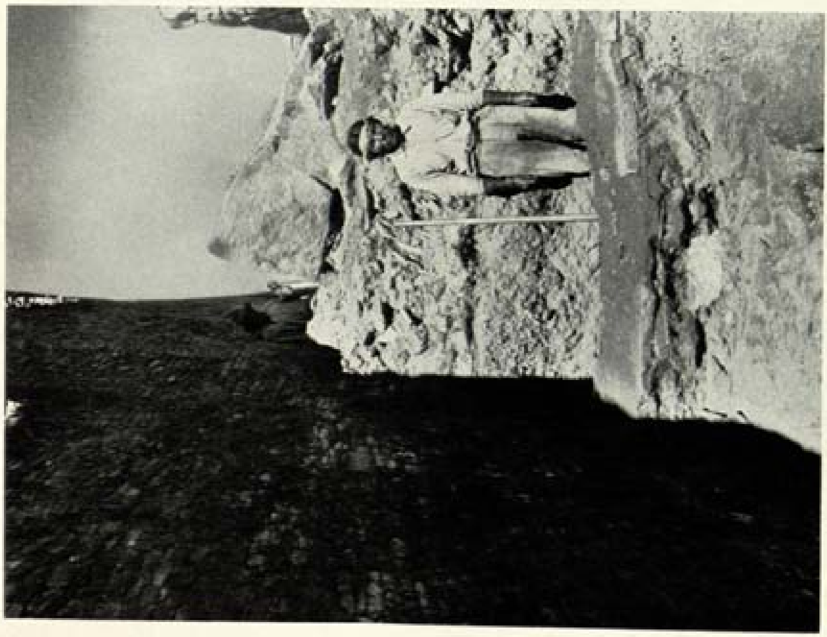


2. Standing free from the canyon wall, the Braced-up Cliff seemed actually to lean toward Pueblo Bonito. Photograph by Charles Martin, 1920. Courtesy of the National Geographic Society.



1. Part of the upper stonework with a post fragment in the foreground. Photograph by Deric O'Bryan, 1940. Reproduced through courtesy of Dr. O'Bryan.

2. The lower terrace masonry and the upper stonework. Photograph by Neil M. Judd, 1922. Courtesy of the National Geographic Society.



1. Blocks of sandstone from the pre-1877 rockfall came to rest within 2 feet of Pueblo Bonito's high north wall. Photograph by Neil M. Judd, 1923. Courtesy of the National Geographic Society.

2. A slope-faced mud embankment supported the lower terrace wall. Photograph by O. C. Havens, 1923. Courtesy of the National Geographic Society.

1. The 4-story north wall of Pueblo Bonito, with luggage in front of open Room 14b. Photograph by Victor Mindeleff, 1887. Courtesy of the Bureau of American Ethnology.

2. Our Zuñi workmen repeatedly climbed the Braced-up Cliff to view the ruin below and the far-reaching Chaco Canyon. Photograph by Neil M. Judd, 1926. Courtesy of the National Geographic Society.

1. Pueblo Bonito after fall of the Braced-up Cliff, January 22, 1941, as seen from the northeast. Courtesy of the National Park Service.

2. The damaged northeast section of the ruin. A conical mass of sandstone lies in Kiva G. Courtesy of the National Park Service.

masonry, slanted rearward to the overhang, and they built an enormous terrace to support the masonry.

In 1920 when I first saw the Braced-up Cliff, portions of its buttressing walls still stood two-thirds their original height, but time and the elements had taken their toll (pl. 2, fig. 2). Seekers after firewood had cut off or pried out every post within reach; sheep and goats had found shelter behind the standing masonry. Two years later, 1922, with our research program well under way, I cleared a portion of the lower terrace wall in order to ascertain the character of its stonework. That wall, which proved to be only a veneer, was composed of laminate sandstone blocks separated at intervals by single courses of dressed friable sandstone, the whole forming a variety of local masonry that I have elsewhere described as Type 3 (pl. 3, fig. 2). It identifies construction of the terrace with the heyday of Pueblo Bonito, during or shortly following the first major rebuilding program of the Late Bonitians. Behind the veneer, tons of sandstone fragments, laminate and friable, lie bedded in tons of adobe mud.

More of this terrace facing was visible in 1887 when Victor Mindeleff photographed it (pl. 2, fig. 1). From what now remains, I believe the platform to have been 18 or 20 feet high when intact and with an average width of 25 feet. Its facing, anchored at the east on an outcropping of sandstone, extends thence almost due west 187 feet where the end is lost under a pre-1877 rockfall. Throughout its visible length the terrace front inclined cliffward perceptibly. Gathering the sandstone fragments and mixing mud for the rubblework behind were an enormous task, and the need must have seemed very real and compelling to those who ordered it.

In August of the following year, 1923, after we had discovered a hard, fairly smooth adobe pavement 2 feet below the north foundation of Room 184, we promptly undertook to follow that pavement toward the terrace. To our surprise it continued to and under a sloping bank of mud mortar piled steplike against the terrace masonry (pl. 4, fig. 2). At the time it seemed so obvious that this masonry must extend down to the pavement that I resisted the temptation to destroy part of the bank in order to be positive. Below the pavement is a deposit of hard clay, in part broken and granular; above it, 4 feet of windblown sand containing clay pellets, silt streaks, and occasional potsherds. Although no indication of weakness was apparent in the 5-foot-wide section we laid bare, it may be that the terrace front had bulged somewhat from pressure of the rubble behind and that the adobe bank was piled up against it in support.

A second surprise was the difference in the stonework here and that in the section, only a few feet to the east, we had exposed the year before. The earlier exhibit resembled our third-type masonry, but

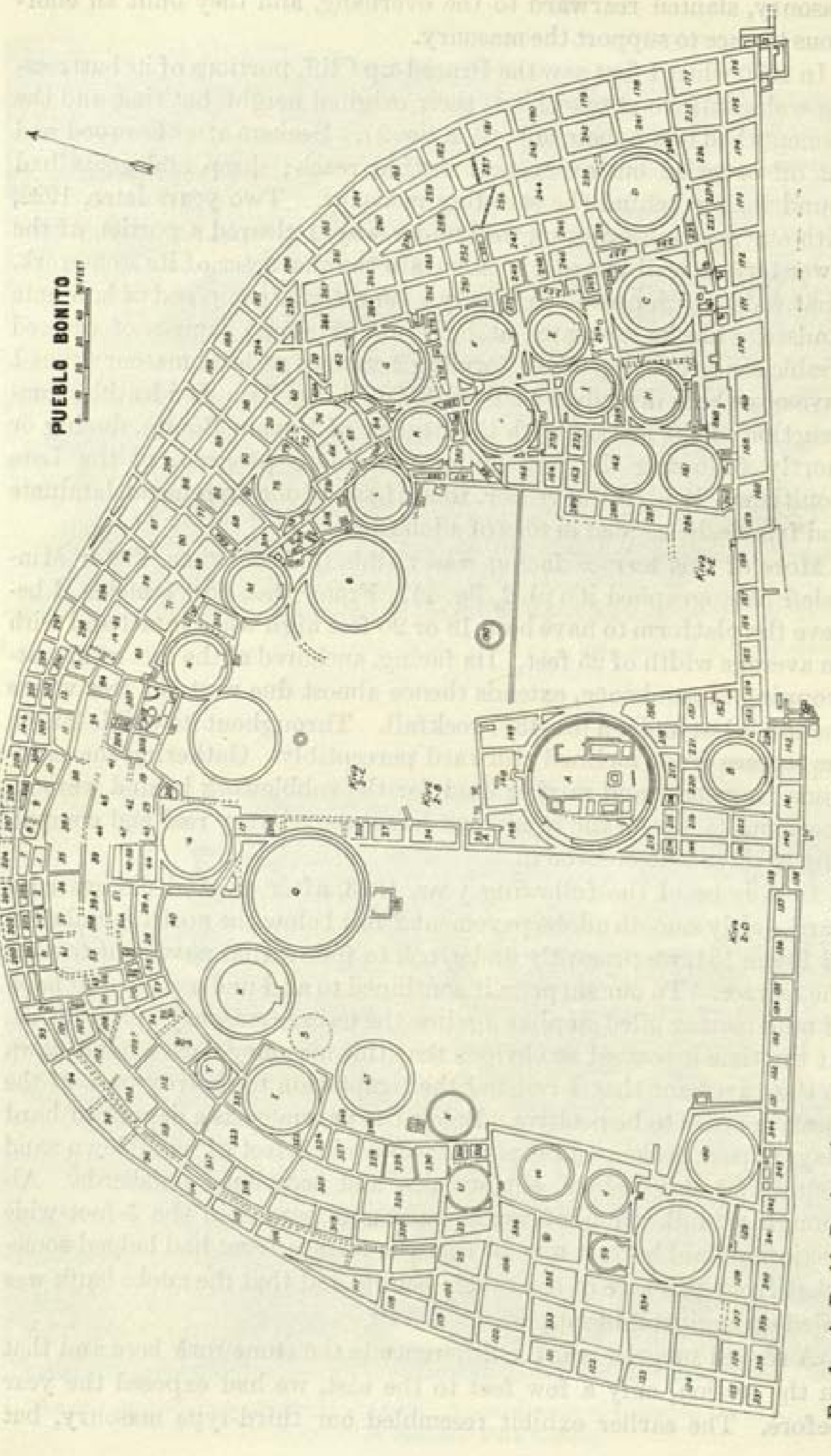


FIG. 1.—At Pueblo Bonito subterranean ceremonial chambers or kivas ringed the two plazas with houses terraced up to the rear. Courtesy of the National Geographic Society.

here it was nondescript, with more blocks of dressed friable sandstone and fewer of laminate. Nevertheless the two varieties identify the terrace front as entirely a work of the Late Bonitians.

During July and August 1933, Prof. John Y. Keur of the Department of Biology, Long Island University, undertook a study of various factors pertaining to the Braced-up Cliff and subsequently filed a report with the National Park Service (Keur, MS., 1933). Through the courtesy of Hurst R. Julian, at that time custodian of Chaco Canyon National Monument, I received a copy of that report and, inasmuch as it supplements my own field notes in several important respects, I shall refer to it for pertinent details not visible at the time of our observations which entailed no excavations other than those already mentioned. The Southwestern Monuments Monthly Report from October 1933 to the final number, June 1941, contains additional data from Professor Keur and Park Service personnel.[2]

Keur (MS., p. 4) dug pits at 50-foot intervals along the entire face of the terrace wall and found "near the base . . . several piles of mixed clay mortar." From this I infer that the abutting adobe bank exposed in 1923 by our 5-foot-wide trench, although perhaps in reduced proportions and with occasional interruptions, continues the full length of the terrace.

Keur's trenches atop the platform revealed that the rubblework behind the frontal veneer did not extend to the Braced-up Cliff, as I had assumed, but ended at about half the distance. A trench at right angles to the cliff and midway, where underlying walls are lacking, shows (ibid., p. 5) the 32-foot-wide platform to consist of 16 feet of rubble (the "stone pier" of the manuscript) at the front, a packed-clay embankment near the base of the cliff, and a sand fill between clay and rubble. At the surface the embarkment measured 6 feet wide and the sand fill 10 feet, but at a depth of 7 feet the sand occupied only a 3-foot space while the clay bank had widened to 13 feet. This adobe embankment is doubtless the one indicated on our plan (fig. 2), only two sections of which were visible at the time the field sketch was made. Professor Keur regards the wedge-shaped sand fill between clay bank and stone pier as a sort of cushion intended to absorb any pressure resulting from the forward tilt of the Braced-up Cliff.

It will seem incredible to the reader, as it does to me, that the Late Bonitians could have had such confidence in the cohesive properties of Chaco Canyon mud as to believe a manmade bank of it could prevent collapse of the great cliff towering 100 feet above. And yet I can imagine no other motive that would have caused them to construct with such prodigious labor a hand-packed mud embankment, 13 feet

[2] An earlier but cursory study of the braced cliff was made in 1916 by N. C. Nelson, of the American Museum of Natural History, and is briefed in Pepper (1920, pp. 389–390).

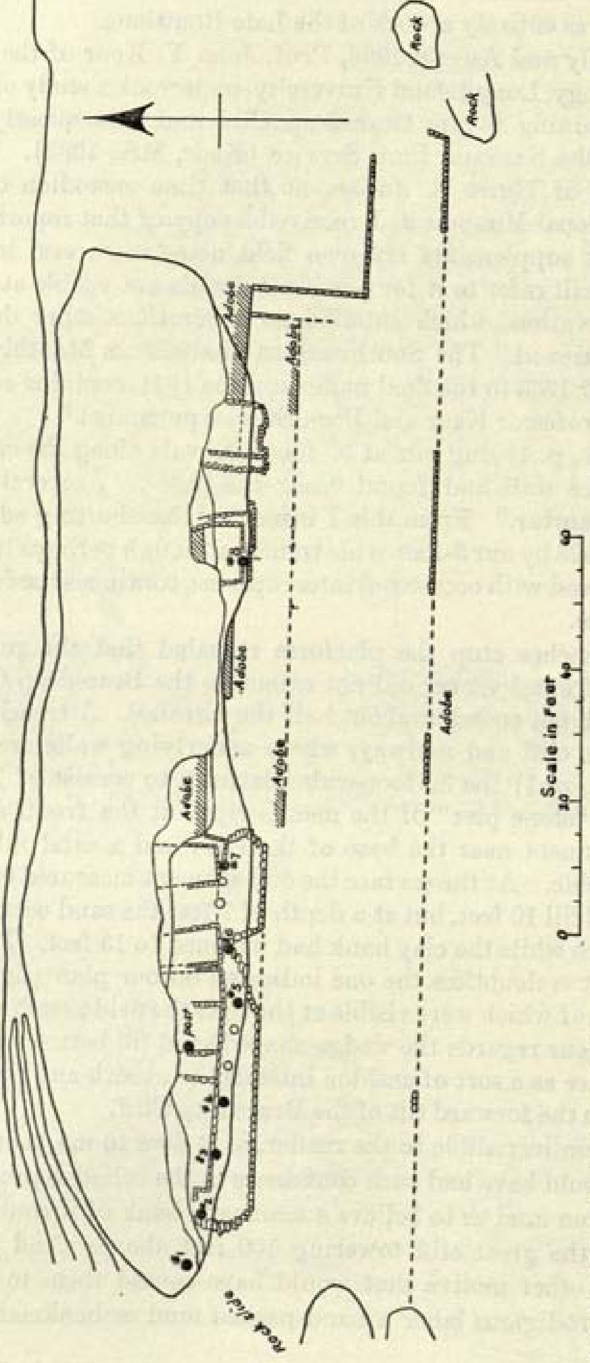


FIG. 2.—Ground plan of supporting masonry and known posts under the Braced-up Cliff. From the original field sketch by Frans Blom, 1924. Courtesy of the National Geographic Society.

wide at the bottom and 6 feet wide on top, 7 feet high, and at least 80 feet long.

But the Bonitians were not content with this achievement. Before, or perhaps after, completion of that embankment they undertook to support the undercut cliff directly by adding wooden props, rubblework, and more adobe mud, concealing all behind a buttresslike construction I shall describe as the "upper stonework," in order to distinguish it from the terrace and the terrace wall.

This upper stonework likewise consisted of a masonry veneer screening the mud and broken rock massed behind. But here the purpose of the hidden rubblework clearly was to replace the softer sandstone that had weathered away and thereby created an irregular, cavelike recess varying in depth from 0 to 15 feet. The rubblework behind the veneer had filled every nook and hollow of the cave and crowded its roof, as evidenced by mud mortar still adhering. Unlike that of the lower terrace, however, the facing of this upper stonework is nondescript and utterly without character; its finished appearance is due solely to the fact that its component fragments were positioned with their wider edges to the fore. Built as a wall perhaps 5 feet thick at the base, standing fairly erect at the back but with a pronounced cliffward batter in front, this facing masonry reached to the cleavage plane that marks the top of the underlying softer stratum and there, reduced to a probable thickness of 2 feet, was fitted snugly against the overhang. Minimizing labor, the builders erected their buttressing stonework only where the undercutting was deepest, a 30-foot section at the east end of the cliff and one twice as long at the west. The height approximated 15 feet (pl. 3, fig. 2).

Behind the sloping exterior of the upper stonework are a number of casual partitions dividing the rubble fill and a dozen pine props, the feature that gave the Braced-up Cliff its Navaho name. Spaced irregularly, these props vary in diameter from 10 to 12 inches. We counted nine, one of them at the extreme rear of the cavity, and the empty holes of four more (fig. 2). All but the two most inaccessible had been cut off as low as possible with steel axes or had been burned long ago and subsequently weathered (pl. 3, fig. 1). Each post slanted rearward to meet the roof of the cave; each had been tightly packed about with rubblework. We sectioned Nos. 2 and 7 (JPB 156, 157) which later were dated by Dr. A. E. Douglass at A.D. 1057 and 1004. Douglass (1935) and Smiley (1951) both list these two specimens in their tables of tree-ring dates but do not specifically identify them. For Gila Pueblo in 1940, Deric O'Bryan sampled posts 2, 3, 4, 5 (?), and 7 and obtained cutting dates of, respectively, 1058, 1072, 1064, 1061, and 1073 (personal communication). The 15-year spread in these latter readings and a date 54 years earlier for Douglass' No. 7 suggests that each prop may have been the leftover

end of a timber originally felled and brought in as a ceiling beam. All but No. 7 come within the known range of Late Bonitian constructional activity.

Between and behind the posts, loosely built walls divide the cave into haphazard compartments, each filled with sandstone-and-adobe rubble. They are binlike structures, erected solely to confine the rubble fill while it was being packed in, cave-roof high. Mud alone lies under the rear middle of the rock and, again, under the east end. None of the stonework resembles that of the Old Bonitians.

Blind old Hosteen Beyal (Judd, 1954, pp. 343–346), who came to Chaco Canyon as a boy about 1840, surprised me with the accuracy of his description of constructional details here. His only error, as far as I know, was in remembering the posts as oak rather than pine.

There are those who hold that the veneered rubble under the Braced-up Cliff was designed to shield the basal zone of soft sandstone from erosion and, to be sure, its presence undoubtedly did accomplish that function. But this fortunate consequence was accidental rather than the result of deliberate planning. If protection from wind and water had been their sole intention the Bonitians assuredly would not have gone to the trouble of wedging in a dozen 10-inch posts, each slanted against anticipated pressure from overhead. And they would have been content with a narrow protective wall under the outer edge of the overhang instead of the sturdy, slope-faced structure they actually erected. If erosion control were the only desideratum there would have been no need for the casual, rubble-filled bins behind the facing, or for the terrace and 80-foot adobe bank below the level of the cave floor.

It was fear that drove the Late Bonitians to brace their cliff—a persistent fear lest 30,000 tons of sandstone topple upon them. If that same fear was shared in any degree by the actual founders of Pueblo Bonito we discovered no evidence of it. There is nothing behind the upper stonework or in the facing of the lower terrace that even remotely resembles Old Bonitian masonry. Nevertheless the danger latent in the overtowering cliff was there when the Old Bonitians began their ancient settlement and if they failed then to sense that danger it is probably because the great blocks of sandstone previously fallen from the cliff were already concealed under a blanket of windblown sand.

A "boulder," thus distinguishing it from normal building stones, was utilized as it lay in the bench of an abandoned kiva 8 feet below the floor level of Old Bonitian Room 83 (Pepper, 1920, p. 269). Describing the constructional confusion he found in the adjoining room, 85, Pepper (ibid., p. 282) notes that "a large sandstone boulder" likewise was incorporated in the wall of a west-end storage bin. Pepper correctly identified partially razed Old Bonitian walls beneath the floor

of Room 87 but did not dig deep enough to learn that the foundations of those old walls were built upon several large, irregular blocks of friable sandstone that rest upon clean sand 9 feet 10 inches below the Room 87 floor level.

The external north wall of this original Old Bonitian settlement, and nearest the cliff, was banked high with blown sand when the Late Bonitians arrived and erected a row of abutting dwellings. One of these latter, Room 297, has its floor about 6 feet higher than that of the adjoining Old Bonitian room, 298. An exploratory trench lengthwise of Room 298 revealed large sandstone blocks in situ and surrounded by clean sand from 1 to 2 feet beneath the floor. Both the east and south foundations stand, in part, directly upon some of these blocks, and the fact that their upper surfaces, in several observed instances, slope down and toward the north clearly identifies them with an early fall from the cliff. Part of that same fall underlies the northwest corner of Old Bonitian Room 296.

Kiva N is a second-type Late Bonitian ceremonial chamber built against the south wall of Old Bonitian Room 83, previously mentioned. In 1923 the north arc of Kiva N stood 9 feet 3 inches high; we estimated its original ceiling height at 9 feet 6. Four feet 7 inches below its floor or 14 feet below the estimated ceiling height at ground level, we came upon a massive section of friable sandstone, its upper cleavage plane slanting downward and to the northeast, as with those under Room 298.

There can be no doubt that these several occurrences of native sandstone deep under the floors of Old Bonitian houses represent collapse of a portion of the canyon wall long before the village site was permanently occupied. Spreading cliffward and fanwise from Kiva N, these buried fragments apparently broke away from approximately the same section of cliff as did the next major fall, that which Mindeleff photographed in 1887 and which shows so clearly on Lindbergh's 1929 airview (pl. 1).

It was this latter fall, occurring perhaps in the last half of the 12th century after the Late Bonitians had left the valley, that crushed the west end of the broad terrace they had built with such great expectations and that hurled several massive chunks of sandstone dangerously close to their high north wall (pl. 5). The accumulation of broken masonry and windblown sand that had collected here before the hurtled blocks came to rest seems so scant (pl. 4, fig. 1) as to bring the incident almost within reach of recorded history in Chaco Canyon. Simpson (1850) had nothing to say of these farflung pieces when he entered Room 14b and carved his name on the wall plaster August 28, 1849, but he must have seen them.

W. H. Jackson saw the great blocks in 1877, for he remarked that the rockfall of which they are a part occupied almost all the space

between the cliff and the north wall of Pueblo Bonito (Jackson, 1878, p. 442). They were still there, clean and sharp-edged, when Mindeleff photographed them 10 years later (pl. 2, fig. 1; pl. 5, fig. 1). Comparison of Mindeleff's 1887 views and that of Martin (pl. 2, fig. 2) shows that many of the scattered fragments had disappeared before 1920. Because of their accessibility, it is reasonable to suppose that these missing ones had been split and broken into smaller pieces and used in the several buildings Richard Wetherill constructed locally between 1897 and 1910.[3]

Our Bonitians feared the Braced-up Cliff. All the diverse features they built beneath it—pine props, rubblework, buttressing masonry, and banked adobe—were underpinnings designed to prevent the cliff from toppling upon their village. Their fears were amply justified as we now know from the destruction caused when the giant cliff finally gave way in midafternoon of January 22, 1941. House-sized fragments and countless tons of lesser pieces hurtled forward and laid waste the spectacular northeast quarter of Pueblo Bonito, including its outside wall from Room 189 south and east to Room 182 and inwardly to Rooms 99, 70, 266, 263, and 258. A 2-ton block of sandstone half fills Kiva G (pl. 6). Fortunately, the three- and four-story north wall of Rooms 14b, 299, and 297 appears to have escaped with only minor damage.

The Braced-up Cliff has fallen, but our data show that two other major, if less destructive, falls occurred previously and that both came from the section of canyon wall next on the west. This section, which still stands and still offers a daily threat to the empty ruin, apparently gave the Bonitians little if any concern. They did nothing to support it but, on the other hand, built several houses and a kiva at its very base. Herein lies a new and unsuspected danger to Pueblo Bonito.

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[3] The one fall for which we have a date is that reported by Frank McNitt (1957, p. 111). In the autumn of 1895 while Richard Wetherill and the S. L. Palmer family were camped at the base of the cliff immediately north of Pueblo Bonito a mass of sandstone dropped from above and narrowly missed members of the party. Throughout the years there may have been other, equally close escapes.

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A Century of American Indian Exhibits in the Smithsonian Institution

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Museum of History and Technology
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[With 8 plates]

The opening of a modernized hall of North American Indians on December 8, 1957, had a special significance in the history of the Smithsonian Institution. It marked the end of the first century of the Smithsonian's experience in interpreting the historic American Indian tribes to the public through museum exhibits. During this century these exhibits evolved from a small cabinet of curiosities viewed by a few thousand persons to an interpretation of the ways of life of the Indians of the hemisphere seen by millions of museum visitors. Changing methods of presenting the subject over the years reflected the immense growth of the collections, the special skills and interests of staff members, and the increase of historical and scientific knowledge of the Indians. Furthermore, the experience gained in planning Indian exhibits at the Smithsonian Institution and for the Smithsonian at great international expositions contributed significantly to the development of ethnology as a science.

INDIAN CURIOSITIES IN THE SMITHSONIAN BUILDING

In the year 1857 the National Cabinet of Curiosities, which for 16 years had been housed in the Patent Office, was transferred to the Smithsonian Institution. In his first report of progress made in installing these national collections in the then new Smithsonian Building, Secretary Joseph Henry wrote: "This has already been done by Mr. Varden for the ethnological collections at the west end of the hall." (Ann. Rep. Smithsonian Inst., 1858, p. 56.) It is certain, therefore, that American Indian materials were included among the Smithsonian's first museum exhibits.

Sixty-six-year-old John Varden (pl. 1, fig. 1), who installed these exhibits, was not an ethnologist. At that time there was no trained ethnologist in this country. But Varden was no novice at displaying

Indian artifacts to the public. In 1836 he had opened his Washington Museum, the first museum in the Nation's Capital, as "a rational place of amusement." Five years later he turned over his collection to the National Institute, and he served as curator of the enlarged national collections while they were displayed in the Patent Office. He was the logical person to plan and install the collections in the Smithsonian. No other man in Washington could have matched his long experience in museum work.

The original accession book of Varden's Washington Museum, preserved in the Smithsonian Archives, reveals that, like other museum proprietors of his time, Varden had been an omnivorous collector of rare and curious objects in the fields of natural history, history, and art. Among his many and varied specimens he listed some 31 American Indian artifacts. They composed the nucleus of the National Institute's Indian collection which came to the Smithsonian in 1857.

Although Varden made two collecting trips westward as far as New Orleans and St. Louis in the 1830's, he obtained his Indian materials from local collectors and travelers rather than from the Indians directly. His knowledge of the specimens was limited to the information these men gave him. A few of the artifacts were tribally identified, such as a "War Club of the Crank-a-war (Karankawa) Indians of Texas," and "Three Bowles made by the Indians of the Six Nations in Alabama" (Choctaw). But a larger number were of a more nebulous origin, such as: "A Pair of Indian Moccasins," "Indian Knife Scabbard from Canady," and "2 Pipe Stems from the Old Stock of General Clark of St. Louis, from the Rockey Mountains." [1]

A description of the exhibits in the Smithsonian Institution, appearing in the 1859 guidebook, indicates that the American Indian exhibits then occupied one case and portions of two others located on the upper galleries at the west end of the great hall. (Pl. 1, fig. 2.)

One case must have been quite completely filled with a North American Indian miscellany "including Head Dresses . . . Canoes . . . Feather Blankets . . . Water-Baskets . . . Indian Pillow, stuffed with Buffalo hair . . . Bows and Arrows . . . Pipes, etc. etc." (Rhees, 1859, p. 69). This group of specimens undoubtedly included a number of artifacts made by the Indians of California and the northwest coast collected by the United States Exploring Expedition under the command of Lt. Charles Wilkes, USN, during its long sea voyage in 1838–42. Titian Peale's catalog of the ethnological collections made by that expedition, preserved in the division of ethnology of the U.S. National Museum, indicates that many of the Indian specimens were

[1] These pieces are of particular historical interest. William Clark, who will always be remembered as the courageous coleader of the Lewis and Clark Expedition, had founded the first museum west of the Mississippi River in a building attached to his residence in St. Louis in 1818. Clark died in 1838, and the fate of his excellent Indian collection has been a matter of speculation.

no more precisely identified than were Varden's. They comprised such items as a "Blanket made of feathers by the natives of California" and "Wooden masks carved by the natives of the north west coast of America."

Some other Indian specimens in the Smithsonian collections at that time had been collected by Army exploring expeditions in the trans-Mississippi west. The so-called "Indian Pillow, stuffed with Buffalo hair" was almost certainly a Blackfoot pad saddle obtained by Capt. Howard Stansbury on his overland explorations to the Great Salt Lake in 1851.[2]

A second case contained a number of Indian artifacts as well as bats, minerals, woods, and other natural history specimens collected by Navy Lt. W. E. Herndon during his explorations of the Amazon River and its tributaries in 1851–52. A group of South American Indian specimens, including some weapons from the Indians of Tierra del Fuego collected by the Wilkes Expedition, shared a third case with weapons and other ethnological materials from southeast Asia.

Although the guidebook introduced the ethnological collections as "one of the most extensive and curious in the world," the American Indian portion of those collections was actually quite small. The tribal origins as well as the true functions of many of the specimens were unknown. As curiosities these objects comprised a limited sampling of handicrafts made and used by American Indians.

ENLARGING THE COLLECTIONS

Secretary Henry realized the inadequacy of the American Indian collections and took vigorous steps to add to their numbers both more and better-documented pieces. Through personal contacts he encouraged men who resided in or near the Indian country or who planned to travel among the Indians to collect for the Smithsonian. One of those men was James Swan, secretary to the first congressional delegate from Washington Territory, who became a pioneer student of the Makah and Haida Indians and an industrious collector of northwest coast Indian materials. Another was young Robert Kennicott of Chicago, who explored the Canadian Northwest and enlisted the aid of Hudson's Bay Co. traders in collecting both vocabularies and artifacts among the then little-known northern Athapascan tribes.

In 1863 Joseph Henry had printed *Instructions for Research relative to the Ethnology and Philology of America* (prepared by George Gibbs), earnestly soliciting the collaboration of "all officers of the United States government, and travellers, or residents who may have in their power to render any assistance." These instructions, written for the Smithsonian by George Gibbs, an experienced field collector

[2] This specimen is referred to as an "Indian Pillow" in the old accession records.

among the Indians of the Northwest, stressed both the urgency of collecting Indian materials and the need for accurate identifications of the artifacts obtained. Gibbs wrote:

> . . . It is especially important to make immediate collections, as many articles are of perishable nature, and the tribes themselves are passing away or exchanging their own manufactures for those of the white race. It is hardly necessary to specify any of particular interest, as almost every thing has its value in giving completeness to a collection . . . In making these collections, care should be taken to specify the tribes from which they are obtained, and where any doubt may exist, the particular use to which each is applied. (Gibbs, 1863, p. 4.)

Cooperation was enthusiastically offered by men in the Army and Navy, Indian agents and agency doctors, consular employees in Latin America, and by missionaries and other individuals. Especially important were the contributions of field officers of the Army Medical Corps, men of scientific training and interests, who, while stationed at isolated frontier forts in the West, devoted their spare time to collecting artifacts from Indians whose confidence they enjoyed. A decade before the battle of the Little Big Horn these men were collecting among the warlike Sioux, Cheyenne, Kiowa, and Comanche of the Great Plains. Before the Apache Wars in the Southwest they were collecting Apache weapons, costumes, and handicrafts. In 1869 the Army Medical Museum began to transfer these Indian materials, obtained by Army doctors at many field posts, to the Smithsonian.

The approach of the great Centennial Exposition in Philadelphia, which was planned for 1876, offered still another major opportunity for the Smithsonian to enlarge its North American Indian collections. The Indian Bureau of the Department of the Interior and the Smithsonian Institution received an appropriation to develop a joint display of the ethnology and archeology of the United States at that exposition. Since the specimens were to be transferred to the Smithsonian after the exposition's close, field collecting for this display was confined primarily to "those parts of the United States which were not already properly represented" in the museum. (Ann. Rep. Smithsonian Inst., 1875, p. 60.)

The Smithsonian still had no ethnologist on its staff, but a number of experienced and able men were active collectors of Indian materials for this popular exposition. Swan collected on the Northwest coast, Stephen Powers among the Indians of California, Maj. John W. Powell in the Great Basin, and Governor Arny in the Southwest. Prof. Otis T. Mason of Columbian (now George Washington) University was engaged to prepare a pamphlet listing over 600 classes of artifacts desired for the exhibition. Copies of this pamphlet were sent by the Indian Bureau to all its field agents and by the Smithsonian Institution to its correspondents. The response was heartening. Among the many small but important collections received was

one of Nez Percé artifacts collected by Indian Agent John B. Monteith more than a year before Chief Joseph's masterful retreat made the name and the courage of that tribe known throughout the civilized world.

Some of the most popular exhibits at the Centennial Exposition were the tall Haida totem poles, collected by James Swan, and a buffalo hide tipi, the home of an Arapaho Indian family, obtained in the field by Vincent Colyer, talented artist and secretary of the Board of Indian Commissioners. (Pl. 2, fig. 2.)

By the time the exhibit materials from the Philadelphia exposition reached Washington the Smithsonian certainly did possess one of the most extensive North American Indian collections in the world. Its Northwest coast and Plains Indian materials were outstanding, although some of the tribes of those regions still were very poorly represented. The collections were weak in artifacts from the historic tribes east of the Mississippi, from the Indians of the Southwest, from the Eskimos and the majority of the Canadian Indian tribes, and from the very great majority of the Indian tribes living south of the United States.

TECHNOLOGICAL EXHIBITS IN THE ARTS AND INDUSTRIES BUILDING

By 1877 the very wealth of potential exhibit materials possessed by the Smithsonian Institution had become a handicap to effective exhibition. Collections in the natural sciences, in archeology, and in the ethnology of Old World peoples had also grown rapidly. It was impossible to interpret these subjects in addition to history and art within the limited confines of the Smithsonian Building. A new and larger museum was needed, and until that structure (the Arts and Industries Building, which stands east of the Smithsonian Building) was available, little improvement of exhibits was possible.

Meanwhile, the Smithsonian appointed its first specialists in anthropology to supervise the work of accessioning and cataloging the large and growing collections and to begin the systematic classification of the materials on hand. In 1876 Dr. Charles Rau, of New York, was appointed to classify and arrange the anthropological collections in the museum, and Frank H. Cushing became his assistant in ethnology.

In 1879 the Bureau of (American) Ethnology was established and its vigorous head, Maj. John Wesley Powell, declared its mission "to organize anthropologic research in America." He inaugurated an extensive program of fieldwork in the Southwest which led to the enrichment of the museum's previously limited Pueblo Indian collections. Cushing and Col. James Stevenson assumed very active roles in this Southwestern research. Meanwhile, Powell and his staff were engaged in a series of classic projects which did not involve the study

of museum specimens but which were of basic importance to the scientific progress of American Indian studies—the classification of North American Indian languages, the identification of Indian tribes and villages, the history of Indian land cessions, and the estimate of early Indian population.

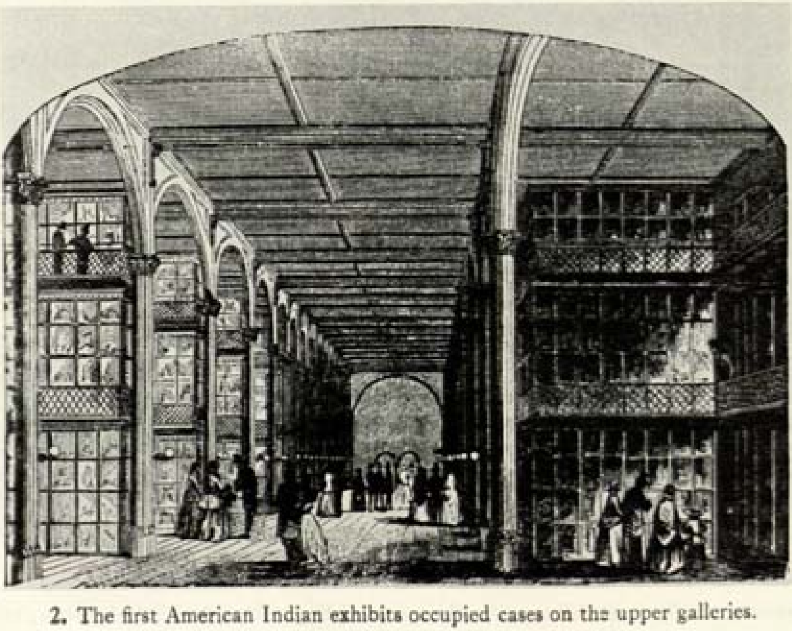
These classification studies were paralleled in the museum by equally intense efforts to describe and classify American Indian artifacts on the basis of their methods of manufacture, form, and function. The emphasis given to comparative technology by both archeologists and ethnologists during this period reflected their efforts to establish anthropology on a sound scientific basis by applying the taxonomic principles of the natural sciences. It also reflected the biologist's interests in evolution by extending that principle to a search for the origin and early development of man's inventions.

During the 1880's anthropologists in the museum experimented with primitive tools to determine how Indians worked stone, bone, shell, and copper. They analyzed the techniques Indians employed in dressing skin, weaving baskets, and making pottery, as well as in making fire. They classified American Indian bows and arrows, harpoons, throwing sticks, knives, pipes, cradles, fire-making apparatus, and other artifacts in the collections. The major publications of the museum anthropologists during the 1880's and 1890's were concerned with problems of comparative technology.

This technological approach, which absorbed the interests of ethnologists in the museum laboratories, was adopted by them in planning and arranging the American Indian exhibits for the public. Two principal types of exhibits predominated. One of them illustrated the great variety of forms of a single class of objects that existed among the Indians—whether the subject was bows and arrows, harpoons, throwing sticks, pottery, textiles, sculpture, pipes, or necklaces. Dense concentrations of objects of each class proved an orderly method of displaying the greater part of the museum's vast Indian collections. The visitor could not but be impressed with the wealth of the museum in American Indian materials. If he tarried to view the exhibits in some detail, he learned that the Indians were clever workers in a variety of primitive industries and the tribal distribution of these traits. In this technological arrangement the handicrafts of each tribe were widely scattered. It was impossible to determine from these exhibits how any Indian tribe lived. (Pl. 3, fig. 1.)

The second type of exhibit purported to show the evolution of common tools, such as those used for cutting, sawing, drilling, etc. These exhibits portrayed assumed technological advances, from the simple to the complex, without regard for the history of the actual objects selected. (Pl. 3, fig. 2.)

1. John Varden, who installed the exhibits in 1857.



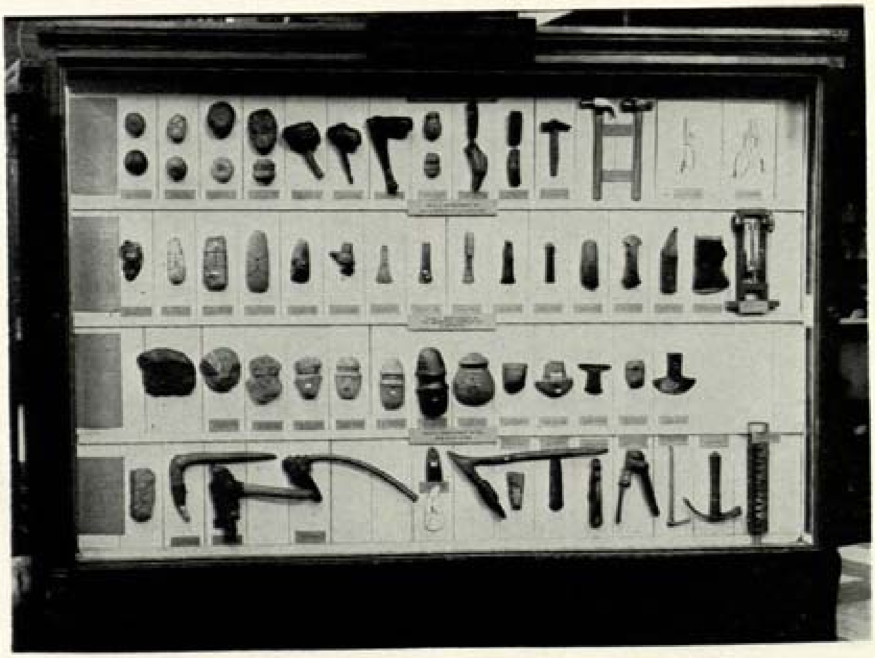
2. The first American Indian exhibits occupied cases on the upper galleries.

1. Cases contained costumed figures as well as artifacts.

2. An Arapaho tipi and Haida totem poles were feature exhibits.

American Indian exhibits at the Centennial Exposition in Philadelphia, 1876.

1. Comparative exhibits of ceramics.



2. Exhibit suggesting the evolution of tools.

Exhibits in the Arts and Industries Building.

1. Small groups at the World's Columbian Exposition in Chicago, 1893.

2. Small groups in the Arts and Industries Building in the 1890's.

Early life-sized groups.

1. William H. Holmes's design for the group, c. 1900.

2. The group as it appears today.

The Polar Eskimo group.

1. Hopi kachina dolls.

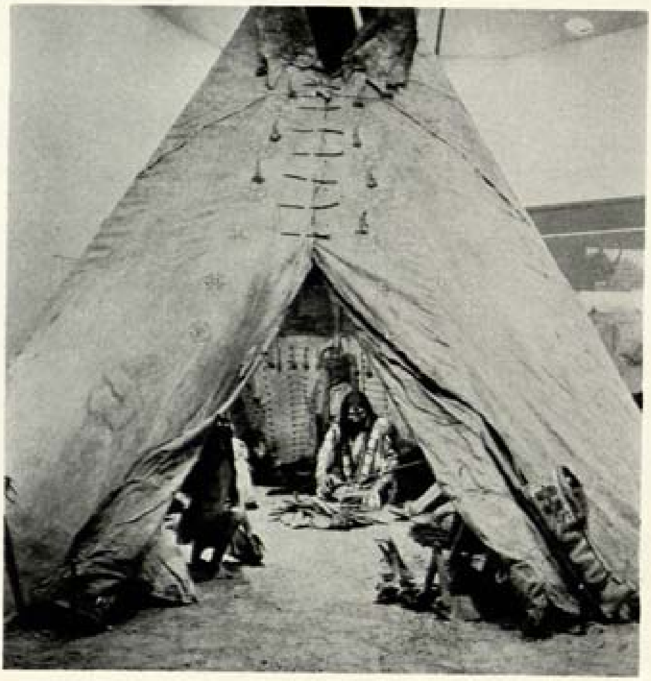
2. Plains Indian specimens.

Early exhibits in the Natural History Building.

1. Hopi kachina dolls.

2. The Buffalo—staff of life of the Plains Indians.

Modernized exhibits in the Natural History Building.



1. Arapaho life-sized group.

2. Diorama portraying Lucayan Indians "discovering" Columbus.

New groups in the Natural History Building.

Methodical arrangement of the ethnological exhibits along these lines was begun by Otis T. Mason shortly after he became curator of ethnology in 1884. Mason was one of the most able students of American Indian technology. His writings are classics in the field. With Mason in charge, the Smithsonian announced its plan "to continue this system in the remaining portions of the collections, with the view of better unfolding through the arts of savagery the origin and development of civilization." (Ann. Rep. Smithsonian Inst., 1885, p. 32.)

DEVELOPMENT OF THE LIFE-SIZED GROUP

As early as 1870 the Smithsonian Institution had employed life-sized wax figures to display the costumes worn by the Arctic explorer Dr. E. K. Kane and members of his party. A number of costumed figures were shown in the Indian exhibits at the Centennial Exposition in 1876. (Pl. 2.) Thereafter, individual life-sized figures were installed in the museum to display costumes, to show the characteristics of the different races, and to illustrate the methods of use of weapons and instruments and the process of various arts and handicrafts.

In the early nineties, under the direction of William H. Holmes, who combined to a remarkable degree the talents of an artist with a knowledge of the American Indians, the Smithsonian Institution began to experiment with a new type of exhibit, a grouping of two or more costumed figures to provide a lifelike portrayal of some of the typical activities of a particular Indian tribe. The first series of these exhibits was prepared under the direction of Holmes for exhibition at the World's Columbian Exposition in Chicago in 1893. Holmes himself designed a group of Powhatan Indians quarrying material for the manufacture of stone implements. The figures were modeled, then cast in plaster by the Washington sculptor U. S. J. Dunbar, and wigs were added. Additional groups were made to portray typical activities of the Zuñi, Navaho, Kiowa, Sioux, Hupa, and Kutchin Indians for exhibition at the 1893 fair. Although these groups were placed in small, poorly lighted cases, they proved to be very popular exhibits. The viewer gained the impression that he was actually watching Indians at work or play. These groups were placed on exhibition in the Smithsonian after the close of the Chicago Fair. (Pl. 4.)

By 1901, when the Smithsonian Institution exhibited at the Pan-American Exposition in Buffalo, Holmes had further perfected the life-sized group. In addition to several smaller ones, he presented two groups housed in roomy 12-by-8-foot cases. These he termed "family groups" composed of men, women, and children with their appropriate clothing and accessories engaged in typical group activi-

ties. One group portrayed a Tehuelche Indian family of Patagonia packing its belongings on horseback in preparation for moving camp. The most appealing of these new groups showed a family of Polar Eskimos of Smith Sound, Greenland. In the foreground a young man bent over a very small seal he had clubbed at a hole in the ice. Beyond him stood the members of his family with their dog team and sled. The father was pointing to the small seal and laughing heartily because the boy had called for the dog team to bring home such a little animal. Not only did this exhibit illustrate the details of Eskimo material culture, but the episode selected portrayed clearly the good humor of these hardy people who had found solutions to the many problems of living on the northernmost frontier of human habitation. After more than 50 years' "run" at the Smithsonian Institution this dramatic display is still a favorite of museum visitors. It is undoubtedly one of the great masterpieces of museum exhibition. (Pl. 5.)

THE CULTURE AREA CONCEPT

The opportunities to interpret the American Indian to large crowds of busy sightseers at the World's Fairs offered a stimulating challenge to the Smithsonian staff. They were not content merely to duplicate existing exhibits for display at these great expositions. Rather they sought new approaches to the presentation of the subject which would result not only in the development of attractive, eye-catching exhibit units such as the life-sized groups, but would make the entire subject more meaningful to the public.

When Otis T. Mason was called upon to plan the American Indian exhibition for the World's Columbian Exposition to be held in Chicago in 1893, he decided to organize the exhibit around the linguistic map of North America which had recently been published by the Bureau of American Ethnology. The compilation of that map had occupied scholars of the Bureau and a host of collaborators for 12 years. Its completion was an important landmark in the history of American Indian studies. Never before had an effort been made to organize an exhibit that would combine tribes, languages, and artifacts in one presentation.

For several months Mason struggled with the difficulties presented by this challenge. Some of the linguistic stocks of North America could not be interpreted through objects because there were no artifacts made by the speakers of those languages in the Museum's collections. Either the tribes had become nearly extinct or their ways of life had become so modified through white contact that it would be impossible to obtain a group of objects that would portray their traditional customs. Some of the most prominent linguistic stocks were represented by tribes spread out over vast areas in quite different

geographical environments so that the contrasts in material traits among tribes of the same language stock were greater than those between neighboring tribes speaking quite different languages. Thus the Shoshonean-speaking Hopi resembled the other Pueblo tribes of the southwestern desert who spoke different languages. much more closely in their way of life than they did the Shoshonean-speaking Comanche buffalo hunters of the Great Plains.

Mason compared the distribution of traits of Indian material culture with Dr. C. Hart Merriam's biogeographic map of North America published by the Department of Agriculture and found that the distribution of artifacts corresponded much more closely with it than with Powell's linguistic map. He concluded that "the materialistic activities were controlled by the environment."

So in the exhibit at Chicago Otis T. Mason organized the exhibits around this new principle—the influence of environment upon American Indian life, grouping the exhibits by what he termed "culture areas." In briefly describing this display in the Annual Report of the U.S. National Museum for 1893 Mason wrote:

> Enough was displayed . . . to bring into prominence the statement that the earth, with its climate and natural resources, has much to say about the material and the form of human industries. Blood and language and social life and religion have their say also in the arts of life, but their influence is superadded, and not fundamental. (Ann. Rep. U.S. Nat. Mus., 1893, pp. 127–129.)

In a popular lecture at the Smithsonian on May 2, 1896, entitled "Influence of Environment upon Human Industries or Arts," Otis T. Mason grouped the historic American Indians and Eskimos into 18 culture areas on the basis of common environments providing common plant and animal resources for the use of Indians for food, clothing, shelter, arts and crafts, implements and utensils, and means of travel. He proceeded to outline the basic natural resources and typical artifacts made and used by the Indians of each of these culture areas. (Mason, 1896.)

By 1897 Mason was busy rearranging a portion of the American Indian exhibits in the Arts and Industries Building in accordance with his new principle of "culture areas." In 1901 Mason's colleague at the Smithsonian, William H. Holmes, in a closely reasoned paper on "Classification and Arrangement of the Exhibits of an Anthropological Museum," published a map of North American Indian culture areas and advocated a culture-area organization for the arrangement of exhibits in museums of anthropology. (Holmes, 1903, p. 267.)

Today the concept of "culture areas" is generally accepted by ethnologists as a basis for classifying the ways of life of primitive peoples. Yet very few anthropologists are aware that this important classificatory tool of their profession was discovered by Otis T. Mason during his experience in planning the Smithsonian's exhibits for the

World's Columbian Exposition. By many it has been credited to Clark Wissler of the American Museum of Natural History, who elaborated and refined the principle in his widely read work "The American Indian," first published in 1917.[3]

However, both Mason and Holmes were greatly interested in the study of technology. Neither of them was willing to abandon the earlier type of exhibit of comparative technology. Holmes proposed the culture area as "the first and most important method" of exhibit organization, but he suggested that it be supplemented by synoptic exhibits illustrating the evolution of tools, textile arts, etc. New comparative technological exhibits also were developed. In 1904 several cases of Indian baskets were added to the exhibits following the publication of Mason's classic treatise on North American Indian basketry.

By that time the museum had again outgrown its quarters. So crowded were the exhibit halls in the Arts and Industries building that there were scarcely passegeways for visitors between the cases. Much of the effectiveness of the life-sized groups was lost in the overcrowded halls. Large portions of the study collections had to be stored in other buildings. A new building was sorely needed to house the Smithsonian's exhibits and study collections in natural history and anthropology.

With the completion of the new Natural History Building on the north side of the Mall, the department of anthropology was moved to new and more spacious quarters. By the summer of 1911 most of the ethnological exhibits had been installed. The American Indian materials were arranged in two adjoining halls on the first floor providing nearly 15,000 square feet of display space. In accordance with Holmes's recommendations of a decade earlier, the life-sized groups were placed in line down the centers of the halls allowing room for visitors to view them through all four of their glassed sides. In rows and alcoves of cases flanking the life-sized groups were placed objects from the culture areas typified by the life-sized groups. Intermixed with these culture-area exhibits were series of cases illustrating comparative technology.

RECENT MODERNIZATION OF EXHIBITS

For nearly 40 years after the American Indian exhibits were installed in the Natural History Building no major changes were made in these displays. Meanwhile the attendance at the museum tripled and the number of school groups who came to the museum to see how Indians lived greatly increased. The life-sized groups retained their

[3] Wissler reduced Mason's 18 American Indian culture areas to 15 and renamed most of them. However, in his earliest published classification of North American Indian culture areas, he acknowledged his debt to Mason. (Wissler, 1914, p. 449.)

interest for children and adults—but few people ventured into the crowded alcoves to view the thousands of artifacts displayed in cases inadequately illuminated by natural light. Hundreds of near duplicate specimens—964 examples of Pueblo pottery, more than 200 Pomo baskets, 119 Hopi kachina dolls—ranged on shelves or hung in layers within the cases, presenting the monotonous appearance of visual storage rather than the lively attractiveness of educational exhibits. (Pl. 6.)

Meanwhile, also, great strides had been made in the use of artificial lighting, color, and design in store window and commercial displays—techniques that could be readily adapted to museum exhibition. At the same time research on American Indian cultures had shed new light upon the history and functions of artifacts.

Gradually the dissatisfaction with existing exhibits grew among visitors and staff members alike. It became increasingly apparent that the old exhibits could not be brought up to date simply by making minor changes here and there. It was not a problem of polishing and repairing the old Rolls Royce. The entire exhibition needed streamlining.

Planning of a complete revision of the American Indian halls was begun in the 1940's. After World War II, A. Joseph Andrews and John E. Anglim prepared two miniature dioramas in the anthropological laboratory under the writer's scientific supervision. At a scale of 1½ inches to a foot these exhibits portrayed typical camps of the Yahgan Indians of Tierra del Fuego and of the Yosemite Indians of California, showing the homes and activities of these people in their appropriate natural settings. These dioramas were temporarily installed, one at each end of Hall 11 in association with revised exhibits of artifacts from their respective cultures. Light boxes were added to the old wall cases and a few carefully selected specimens were installed against backgrounds of contrasting colors. A marked improvement was apparent in these sections of the hall.

In 1954 funds were made available to completely modernize the entire hall, employing new cases and artificial lighting throughout. There was never any question of the basic organization of exhibits. Mason's fundamental concept of culture areas had gained general acceptance. Even writers of children's books had adopted it in their descriptions of American Indian cultures, devoting separate chapters to the Indians of the Woodlands, of the Plains, of the Northwest coast, and others. In our new exhibits children would see the typical artifacts they had read about and in the same cultural contexts. In the two halls available plans were made to interpret the historic cultures of the native peoples of the Americas, beginning with the Eskimos of the far north and continuing geographically southward to the Fuegians at the southernmost extremity of South America. The halls were

subdivided into alcoves, each devoted to a culture, and the exhibits were planned to illustrate the ingenuity of the people in using the natural resources of their environment for food, clothing, shelter, weapons, household utensils, religious paraphernalia, and the production of arts and crafts. (Pl. 7.)

The majority of the life-sized groups were completely refurbished and reinstalled in larger cases against monochrome backgrounds and were dramatically lighted. A new life-sized group was developed around a full-scale Arapaho tipi. Six dioramas portrayed in miniature interesting aspects of Indian life. Of these the scene showing Lucayan Indians of the Bahamas at the moment of their discovery of Columbus's ships approaching their island village has become a favorite exhibit of many children. Like the Polar Eskimo group it combines ethnological detail with dramatic incident. (Pl. 8.)

Within each culture area wall-case exhibits interpreted Indian uses of natural resources. These exhibits employed artifacts to illustrate ideas and the objects were supplemented by such graphic devices as were needed to show their functions. Under the direction of John E. Anglim and Rolland O. Hower, talented artists combined light, color, and design to create exhibits which would be as attractive as they were meaningful.

OUR SMITHSONIAN HERITAGE

It may seem a far cry from the small display of Indian curiosities exhibited in the Smithsonian Building a century ago to the Smithsonian's many educational exhibits of today. However, these contrasts are no more remarkable than has been the continuity of the Smithsonian's American Indian program over this hundred-year period. In reality today's displays have been more than a century in the making. They could not have been developed without the aid of the many farsighted men of the past who collected, recorded, and preserved the basic ingredients of these exhibits—the artifacts themselves.

In the American Indian halls are still displayed specimens collected by John Varden and by the Wilkes Expedition which were shown in the Smithsonian's first exhibits. Here, also, are artifacts sent to the Smithsonian by collaborators in response to Secretary Henry's call for assistance in the 1860's, objects collected by Army physicians stationed at lonely frontier posts before and during the Plains Indian wars, grotesque masks and a totem pole obtained by James Swan for the Centennial Exposition of 1876, and the Arapaho tipi collected by Vincent Colyer for that exhibition more than 80 years ago. After more than 50 years William H. Holmes's life-sized groups continue to delight and instruct visitors to the Smithsonian Institution. And it is especially noteworthy that the culture-area concept, conceived by Otis T. Mason while planning Smithsonian ex-

hibits for the World's Columbian Exposition of 1893, still provides the best guide to arranging exhibits on the American Indians that has ever been devised.

Our heritage is rich indeed.

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The Childhood Pattern of Genius[1]

By Harold G. McCurdy
Department of Psychology, University of North Carolina

Genius by any definition is rare. If, following Galton, we make lasting fame one of the requirements, it is very rare indeed, and we are reduced to studying it at a distance through biography. Now, biographies have their limitations; as Havelock Ellis noted, one may search through them in vain for the most ordinary vital statistics. Above all, they cannot be expected to yield information on those details of early life, such as nursing and weaning and toilet training, to which psychoanalysis has attached so much importance. When, therefore, one proposes as I do here to explore the question whether there is some pattern of environmental influences operating on children of genius which might help to account for their later achievement, it should be self-evident that the question is necessarily adjusted to something less than microscopic precision. Not only so, but, because the factor of heredity cannot be controlled, any answer whatsoever must be regarded as partial and tentative and ambiguous. Nevertheless, there may be some profit in asking the question, and insofar as it is directed simply toward the discovery of uniformity of environmental pattern there is no inherent reason why it should not be answerable, provided we do not insist on minute detail.

Table 1 presents the 20 geniuses into whose childhood this paper will inquire. The selection was partly deliberate, on theoretical grounds, and partly random, as will be explained. In Cox's monumental study of great geniuses [7] [2] the main sample consists of 282 men drawn from the list of 1,000 which was compiled by J. McKeen Cattell on the principle that the amount of space allotted to them in biographical dictionaries could be taken as an objective measure of their true eminence. Though one may certainly quarrel with some of Cattell's results, the sifting process applied by Cox was admirable.

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[1] Reprinted by permission from the Journal of the Elisha Mitchell Scientific Society, vol. 73, No. 2, November 1957

[2] Numbers in brackets indicate references at the end of the text.

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She arrived at her smaller list by requiring: (1) that the attained eminence should clearly depend upon notable personal achievement; and (2) that the biographical material available should be sufficient to permit a reliable estimate of early mental ability. Men born before 1450 were eliminated. The chief task of Cox's investigation was to estimate the intelligence level displayed by these rigorously selected geniuses during childhood and youth. For this purpose the appropriate information was extracted from biographical sources and submitted to the judgment of three raters thoroughly experienced in the use of intelligence tests and the evaluation of IQ from behavior. Their three independent ratings, expressed as IQ's, were combined. Separate estimates were made for two periods of life: from birth to age 17, and from age 17 to age 26. As might be expected, the reliabilities of the estimates increased in proportion to the amount of biographical information, and, in general, the IQ's based on the more adequate material were higher. Consequently, one in search of illumination on the early environment of genius would naturally turn most hopefully to the geniuses in Cox's list who had been assigned the highest childhood IQ's. This I did. From her list I chose as my preliminary sample the 27 men whose IQ's in childhood had been estimated at 160 or higher. The final sample of 20, as given in table 1, was reached by dropping out those individuals for whom the biographical material in the University of North Carolina Library appeared to be inadequate.[3] As will be observed, the order of listing in the table is from the highest childhood IQ downward. The reputation of each man is indicated in the column headed "Fame" by his rank number in Cox's sample, as based on Cattell. With respect to fame the sample appears to be a fair cross section of Cox's larger group; with respect to IQ, as explained, it is highly selected. One sees at a glance that here are individuals who did extraordinary work in science, law, literature, or politics, and who fully deserve to be called geniuses. Their biographies should be relevant to the proposed question.

It should be understood from the outset that Cox did not neglect the problem of environment. Her biographical sketches furnish some very pertinent information, and she states as an important conclusion that, on the whole, youths who achieve eminence have superior advantages in their early days. Though she notes exceptions, she says: "The average opportunity of our young geniuses for superior education and for elevating and inspiring social contacts was unusually high. . . . The extraordinary training for leadership received by Pitt the younger, John Quincy Adams, Niebuhr, and the Humboldt brothers; the specialized instruction of Mozart, Weber, and Michael-

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[3] The seven omitted were Schelling, Haller, Wolsey, Sarpi, Constant, Brougham, Bossuet. In order to retain Leibniz an interlibrary loan was arranged for Guhrauer's biography.

angelo undoubtedly contributed to the rapid progress of these great men among the great" [7, p. 216]. The object of the present study is to push forward in the same direction of inquiry, but with more pointed attention to the social relations and their repercussions.

In table 1, one column briefly summarizes facts concerning order of birth. Considerable theoretical importance is sometimes attached to the chronological position of a child in the family. In particular, Galton, who was not prone to overemphasize environment, thought enough of order of birth to pay some heed to it in his investigation

TABLE 1.—*Twenty geniuses selected from Cox's list*

	Estimated IQ in childhood	Fame (rank in 282)	Birth order	Age at marriage
J. S. Mill (1806–1873)	190	103	1 in 9	45
Leibniz (1646–1717)	185	19	Only	-------
Grotius (1583–1645)	185	72	1 in 5	25
Goethe (1749–1832)	185	4	1 in 6	39
Pascal (1623–1662)	180	35	2 in 3	-------
Macaulay (1800–1859)	180	53	1 in 9	-------
Bentham (1748–1832)	180	181	1 in 2	-------
Coleridge (1772–1834)	175	157	10 in 10	23
Voltaire (1694–1778)	170	2	5 in 5	-------
Leopardi (1798–1837)	170	280	1 in 5	-------
Chatterton (1752–1770)	170	163	3 in 3	-------
Niebuhr (1776–1831)	165	135	2 in 2	24
Mirabeau (1749–1791)	165	30	9(?) in 11	22
J. Q. Adams (1767–1848)	165	274	2 in 5	30
Wieland (1733–1813)	160	152	1 in ?	32
Tasso (1544–1595)	160	48	3 in 3	-------
Pope (1688–1744)	160	50	Only	-------
Pitt (1759–1806)	160	9	2 in 5	-------
Musset (1810–1857)	160	261	2 in 2	-------
Melanchthon (1497–1560)	160	77	1 in 5	23

of British scientists; and he comments that "the elder sons have, on the whole, decided advantages of nurture over the younger sons. They are more likely to become possessed of independent means, and therefore able to follow the pursuits that have most attraction to their tastes; they are treated more as companions by their parents, and have earlier responsibility, both of which would develop independence of character; probably, also, the first-born child of families not well-to-do in the world would generally have more attention in his infancy, more breathing-space, and better nourishment, than his younger brothers and sisters in their several turns" [13, p. 26]. There is an intuitive appeal in the argument, but Galton does not support it by any precise analysis of his data. What may be said about the present sample? First, it must be admitted that there are several ways of stating the facts, depending on whether one includes or excludes half-siblings and siblings who died at an early age. The figures given in the table stand for full siblings and include all births. The half-

siblings excluded in the three cases involved (Leibniz, Coleridge, Pope) were children by previous wives of their fathers. The impression produced by inspection is that there may be an excess of only and first children among these 20 geniuses. But an analysis of the probabilities does not favor this view very strongly. The average likelihood of being born in first place in the 20 families works out to about one-third, and the observed frequencies deviate from the theoretically expected only enough to yield a chi square of 2 in support of the hypothesis; since this corresponds to a confidence level of between 0.2 and 0.1 for the one degree of freedom, one is left in doubt. Pascal, Niebuhr, and Adams were first sons. If we estimate in terms of first sons, a total of 13, and adjust the probabilities to the expectation that about half the children in multiple births would be girls, the chi square is 1.8, again too small to support the hypothesis firmly.

Though the figures do not support a birth order hypothesis, there may nevertheless be something about position in the family which is significant. Let us look at the seven who do not rank as first-born children or first-born sons. Coleridge was born in his father's old age and was his "Benjamin"; Voltaire was so sickly during the first year of his life that there was daily concern over his survival, and his mother, an invalid, was incapable of having any more children; Chatterton was a posthumous child, and the previous boy in the family had died in infancy; Mirabeau was the first son to survive after the death of the first and a succession of girls; Tasso was the only surviving son, his older brother having died before he was born; Pitt was in the interesting position of being able to follow his father in a parliamentary career in the House of Commons, as his older brother could not do so because of the inherited title; and Musset, the second of two sons, was younger than the first by a significant span of 6 years. When we weigh these additional facts, the general notion of some sort of positional effect begins to reassert itself.

One way in which position in the family might favor the development of a child would be by giving it higher attentional value for the parents. Close examination of the biographical data leads to the conclusion that these 20 men of genius, whether because of their position in the family or not, did as children receive a high degree of attention from their parents, as well as from others. In several cases it is clear that the attention exceeded that accorded to their brothers and sisters. Both very decided and very positive parental interest was displayed toward Mill, Leibniz, Grotius, Goethe, Pascal, Macaulay, Bentham, Coleridge, Niebuhr, Adams, Wieland, Pope, Pitt, and Melanchthon. Voltaire and Musset were far from neglected, but the attention bestowed upon them may have lacked some of the intensity of focus notable in the preceding cases. If any

of the children suffered comparative neglect or abuse, they would be Leopardi, Chatterton, and Mirabeau. Chatterton had no father from the time of his birth, and the fathers of Leopardi and Mirabeau were lacking in sympathy or worse. On the other hand, Chatterton's mother and sister helped him to learn to read, saw that he went to school, and were good enough to him that the promise he made them when a child to reward them with all kinds of finery when he grew up was fulfilled in the last year of his short life; Leopardi was provided with tutors and had access to his father's rich library; and Mirabeau, cuffed and persecuted as he finally was by his erratic father, was received into the world with an outburst of joy and was always provided for educationally, even though the arrangement may have been savagely disciplinary.

Favorable parental attention may take the two forms of displays of affection and intellectual stimulation. There is strong evidence for both in most of the cases in our list. Remarkable indeed are the educational programs followed by Mill, Goethe, Pascal, Bentham, Niebuhr, Adams, Wieland, Tasso, and Pitt, under the encouragement, guidance, and powerful insistence of their fathers. Yet it is not the educational program itself which requires our notice so much as it is the intimate and constant association with adults which it entails. Not only were these boys often in the company of adults, as genuine companions; they were to a significant extent cut off from the society of other children. The same statement can be made, on the whole, for others in the list whose educations proceeded less directly, or less strenuously under the guidance of fathers.

Warm attachments to children outside the family circle seem to have been rare, and there are several cases of isolation within the family, too. Yet it is within the family that most of the recorded intimacies between these geniuses and other children developed. Goethe, Pascal, Niebuhr, Macaulay, Voltaire, and Mirabeau experienced some intensity of affection for sisters; Musset for his older brother. Macaulay and Voltaire remained attached to their favorite sisters throughout their lives, becoming devoted uncles to their sisters' children; Goethe's and Pascal's affection for their younger sisters approached passion; and Mirabeau speaks of incestuous relations with his.

The reality and nature of the pattern to which I am pointing—the very great dominance of adults in the lives of these children, and their isolation from contemporaries outside the family and, sometimes, within—can be adequately appreciated only through a more detailed statement about each individual.

Mill, under his father's personal and unremitting tutelage, began hard intellectual work before he was 3. From very early he was given the responsibility of acting as tutor to his brothers and sisters. This

did not increase his affection for them. In fact, he came to share some of his father's own antipathy toward them and toward his mother. He explicitly states in his autobiography that his father kept him apart from other boys. "He was earnestly bent upon my escaping not only the ordinary corrupting influence which boys exercise over boys, but the contagion of vulgar modes of thought and feeling; and for this he was willing that I should pay the price of inferiority in the accomplishments which schoolboys in all countries chiefly cultivate" [21, p. 24 f]. And again: "As I had no boy companions, and the animal need of physical activity was satisfied by walking, my amusements, which were mostly solitary, were in general of a quiet, if not a bookish turn, and gave little stimulus to any other kind even of mental activity than that which was already called forth by my studies" (p. 25).

Leibniz, his mother's only child, lost his father, a prominent university professor, when he was 6. He retained two vivid memories of him, both of them expressive of the high esteem in which his father held him. His mother, who died when he was 18, devoted the remainder of her life to caring for him. He lived at home, free from "the doubtful liberties, the numerous temptations, the barbarous follies of student life" [18, p. 12]. Before he was 10 his father's carefully guarded library was opened to him, and he plunged into its treasures eagerly. It was conceivably no small thing to Leibniz that his father had regarded his christening as marked by a symbolic movement which seemed to promise that his son, as he wrote in his domestic chronicle, would continue in a spiritual and burning love for God all his life and do wonderful deeds in honor of the Highest [15, p. 4].

Grotius was close to his father. He signed his early poems Hugeianus, thus joining his own name Hugo with his father's name Janus or Joannes. At 8 he reacted to the death of a brother by writing his father consolatory Latin verses. He had competent teachers at home, and entered the University of Leiden at 11; there he dwelt with a devoutly religious man who impressed him deeply. He was famous in the literary world very early, and received high praise from distinguished men. He sought his father's advice when he chose a wife. One would infer from the limited evidence that his association from early childhood was primarily with adults.

Goethe throughout his childhood was carefully and energetically supervised in his varied studies by his father. He associated frequently with numerous skilled and learned and eminent men in Frankfort, among whom was his grandfather Textor. He enjoyed considerable freedom of movement through the city, in the intervals of his studies, and struck up several acquaintances outside the home among boys and girls; but these were certainly far outweighed by his adult

contacts, and by his intimacy with his sister, who had much less freedom than he and who became increasingly embittered by the educational discipline of their father. In his autobiography he notes that he was not on friendly terms with a brother, 3 years younger, who died in childhood, and scarcely retained any memory of the three subsequent children who also died young. How close he and his sister were may be gaged by these words regarding the aftereffects of his love affair with Gretchen, at about 14: "my sister consoled me the more earnestly, because she secretly felt the satisfaction of having gotten rid of a rival; and I, too, could not but feel a quiet, half-delicious pleasure, when she did me the justice to assure me that I was the only one who truly loved, understood, and esteemed her" [14, p. 192].

Pascal was so precious in the eyes of his father, after his mother's death when he was 3, that, as the older sister tells us, the father could not bear the thought of leaving his education to others, and accordingly became and remained his only teacher. At 18 Pascal's health broke down from ceaseless application. He was frequently in the company of the learned men surrounding his father. His primary emotional attachment was to his younger sister, Jacqueline; her religious retirement strongly influenced his own religious development.

Macaulay early became absorbed in books, but his studies were more unobtrusively guided by his father and mother and other relatives than in the cases preceding. He was especially attached to his mother in early childhood, and at home among his brothers and sisters was overflowingly happy and playful. A sister writes: "He hated strangers, and his notion of perfect happiness was to see us all working round him while he read aloud a novel, and then to walk all together on the Common" [30, p. 67]. He was reluctant to leave home for school for even a single day, and he was acutely homesick when placed in a boarding school at about 12; there, though tolerated and even admired by his fellow pupils, he had little to do with them, living almost exclusively among books. The children at home passionately loved him. It should not be overlooked that his father was a deeply religious man of great force of character, energetic in religious and political reform movements of considerable scope.

Bentham's father, ambitious to make a practical lawyer of his first and for 9 years his only child, kept him to a rigorous schedule of instruction in everything from dancing and military drill to Greek from a very early age. From 7 to 12 he spent the winters at a boarding school, which he did not enjoy; in the vacations at home his schooling, under private tutors, was much more intensive. He was happiest on visits to grandparents in the country, where he could talk to an old gardener or climb up a tree and read a novel. Too small and weak to win the admiration of his fellows, "he tried to be in-

dustrious and honest and noble and dutiful, finding that such a course brought praise from his elders" [10, p. 20 f.]. When the death of his warmhearted mother desolated his father and himself, Jeremy "was just turned twelve, and was ready for Oxford, if a frail and undersized boy of twelve could be said to be ready for anything" [10, p. 22].

Coleridge's father, though unambitious in general and not very attentive to the education of his numerous other children, took special pride in him and endeavored from the beginning to prepare him for the church. Coleridge was the last of 14 children (10 by his mother), and the extreme fondness of his parents aroused the hostility of the older boys toward him. They drove him from play and tormented him. On one occasion, when he was 8, he ran away from home after a ferocious combat with the brother whom he had displaced as baby of the family; he was found only after a prolonged search, and he remembered all his life the tears of joy on his father's face and his mother's ecstasy when he was recovered. Death of the father, when he was 9, deprived him of his most valued companion. Shortly afterward he was sent to a charity school in London. Here he made a few friends, notably Lamb, but he lived a great deal in books and in his own imagination.

Voltaire was born 5 years after the death in infancy of the next preceding child, and his own life was despaired of daily for the first year. His mother was an invalid; his father was a busy lawyer and does not seem to have concentrated any particular attention on him, beyond desiring that the boy should himself be prepared for law. His education at home proceeded under the guidance of three distinguished and learned men, particularly the Abbé Chateauneuf, his godfather. The two other surviving children were considerably older than he; the brother he disliked, but he was fond of his 7-year-older sister, and, after his mother's death when he was 7, it was she to whom he was chiefly attached in the family. At 10 he was quartered in the best Jesuit school in France by his ambitious and wealthy father; here he made the warmest and most lasting friendships in his life, but they were with the teachers rather than with the boys.

Leopardi, the oldest of five children, remained until he was 24, practically immured, in the house of his father, the Count, in a town which he despised. In Leopardi's own words: "Had no teachers except for the first rudiments, which he learned under tutors kept expressly in the house of his father. But had the use of a rich library collected by his father, a great lover of literature. In this library passed the chief portion of his life, while and as much as permitted by his health, ruined by these studies; which he began independently of teachers, at 10 years of age, and continued thenceforth without intermission, making them his sole occupation" [29, p. 2]. His closest companion was his brother Carlo, a year younger; but he was reticent even with him.

With the other children he liked to produce plays in which the tyrant (his father) was worsted by the hero (himself). At a later age he regarded his home as a prison from which he had to break out.

Chatterton, born 3 months after his talented father's death, was the second surviving child of his very young mother, who had borne her daughter 4 or 5 years earlier before her marriage was legalized. Under their instruction, he learned the alphabet from an old illuminated music manuscript of his father's, which his mother had been about to throw away, and learned how to read from an old blackletter Testament. He had been dismissed from his first school as a dullard. Later, he went to the uninspiring charity school which had been attended by his father. A note on his relations with playmates before he was 5 speaks of him as "presiding over his playmates as their master and they as his hired servants" [20, p. 22]. Already at 5 he was greedy for fame, and asked that a cup which had been presented to him by a relative should have on it "an angel with a trumpet, '*to blow his name about*,' as he said" [20, p. 23]. He did form friendships at school, one in particular; and the death of this boy plunged him into melancholy. But with none of these, or with his sister, was he intimate enough to share the secret of his Rowley poems, those impressive forgeries which seem to have been written under the inspiration and tutelage of the beautiful church of St. Mary Redcliffe rather than any human preceptor.

Niebuhr's father, who had been a military engineer and explorer, took up residence after his marriage at 40 in a retired little town and devoted himself to his wife and family of two children. He liked to entertain his own and other children with stories, games, and music; but he concentrated particularly on the instruction of his son, for whom he also provided tutors from about 4 or 5. A cultured neighbor, Boje, who was editor of a literary periodical, took much interest in the boy; and Boje's wife began his instruction in French. Her death when he was 10 overwhelmed him with grief and inclined him even more seriously to his studies. Between 14 and 18 he spent most of the day in hard work and general reading. When he was 16 his father, thinking that his attachment to home was excessive and that he was studying too much alone, sent him off to a school in Hamburg in the hope that he would become more sociable; but he was unhappy, and insisted on coming back. From an early age ill health and his mother's anxiety contributed their share to his inclination to solitude.

Mirabeau, the first surviving son of a family of the nobility, was in the beginning his father's pride. Later, after disfigurement by smallpox at 3 and displacement from the position of only son by the birth of a brother when he was 5, he became increasingly the object of his erratic father's dislike. Intense marital discord made him the more hateful because he resembled his mother's side of the house. He was

unfavorably compared with the other children, and repeatedly put under severe disciplinarians as tutors. Eventually his father had him imprisoned more than once. In the face of this persecution, Mirabeau, helped partly by the affectionate interest of an uncle, succeeded nevertheless in developing an extraordinarily winning manner in speech and personal contacts, even charming his jailers into relaxing their punishments. Whether or not he was inclined to solitude, it was forced on him by his father; much of his learning and literary production took place in prisons or their equivalents. He was highly erotic, and may have had sexual relations with his younger sister; for so he asserts.

Adams regarded even his name, John Quincy, which was his great-grandfather's, as a perpetual admonition to live nobly. The Revolutionary War and the Battle of Bunker Hill, which he witnessed, confirmed a serious habit of mind from early childhood. As his father was absent from home a great deal, he was already as a small boy depended upon by his mother as if he were a man. His education commenced at home under a tutor, and continued in Europe in the company of his father and other men notable in the governmental service. It was not until he entered Harvard that he attended a regular school for any length of time. Both his mother and his father tried to keep him from the corrupting influence of other boys, and it is evident from the nature of his life that his chief contacts were with grown men of serious and intellectual character. He read a great deal under the guidance of his father, whom in his earliest letters he obviously wished to please.

Wieland was educated at home under the eyes of his father, a pastor, in somewhat the same severe manner as was Goethe. He studied hard from 3 years of age. He says of his childhood: "I was deeply in love with solitude and passed whole days and summer nights in the garden, observing and imitating the beauties of nature" [26, p. 19]. He was much more attached to books than to people. Prior to age 17, says his biographer, "We encounter not a single friend of his own age, only books and those who helped with them!" [26, p. 24]. He was sensitive and unsociable when away at school, and when he returned home he lived alone or associated only with older men. His biographer makes no mention of his relations with his several siblings.

Tasso, whose old father was often compelled to be away from home, lived with his young mother and his sister until he was separated from them forever at 10, to join his father at the court of his patron prince. Even while he remained at home he was being strictly educated, first by an old priest, and then in a Jesuit school, which he loved. His mother, of whom he was passionately fond, died 2 years after he went to join his father. Of his childhood, Boulting says: "The prolonged absences of his father, the tears of his mother, the straitened circumstances and this sudden death were not healthy influences for a sensitive lad, and

there was a great deal too much educational pressure put upon him. Bernardo was proud of Torquato's talents and ambitious as to his future. He forced him on and took scudi from a slender purse to pay for special lessons in Greek. But a cousin came to Rome from Bergamo to share in Torquato's studies. No bookworm was this lad, but full of fun and a thorough boy. Nothing could have been luckier" [3, p. 31]. A little later he had as his companion in the study of the graces (horsemanship, jousting, etc.) a boy of 8, son of Duke Guidobaldo. Otherwise he seems to have associated primarily with men, often men of great dignity and learning.

Pope, the only child of his mother (there was a half-sister more than 9 years older), was from the earliest period a domestic idol, as Stephen says. His father and mother, both 46 at his birth, and a nurse, concentrated their affection upon him, which must have been all the more intense because he was sickly, and humpbacked like his father. "The religion of the family made their seclusion from the world the more rigid, and by consequence must have strengthened their mutual adhesiveness. Catholics were then harassed by a legislation which would have been condemned by any modern standard as intolerably tyrannical" [28, p. 2]. Most of his education was accomplished at home, with some help from a family priest and his father, who corrected his early rhymes. From 12 he threw himself into his studies so passionately that his frail constitution threatened to break down.

Pitt was born at the high peak of his father's career as Prime Minister of England. When the title of Earl of Chatham was conferred on him, this second son, then 7, exclaimed, "I am glad that I am not the eldest son. I want to speak in the House of Commons like papa." Partly because of his feeble health, the boy was brought up at home under the instruction of his father and a tutor. His father concentrated upon developing his oratorical powers. At 14 he was sent to Cambridge, where he was placed in the care of a sound scholar, who remained his inseparable companion, and practically his only one, for more than 2 years. He had no social life there. He read with facility such books as Newton's "Principia" and the obscurest of the Greek poets. "Through his whole boyhood, the House of Commons was never out of his thoughts, or out of the thoughts of his instructors" [17, p. 129].

Musset was the second son in a family devoted to literature, "an infant prodigy on whom the intelligence of his brother, 6 years his elder, did not fail to exercise a stimulating effect. Alfred developed his mind in the constant companionship of Paul much more rapidly than he would have in the company of children his own age" [5, p. 12]. He was notable from early childhood for his sensitivity, charm, emotional ardor, dramatic power, and susceptibility to feminine beauty. At a very tender age he was already disappointed in love.

He went to school for a short time with his brother, but sickness and the hostility of the other children toward these Bonapartists soon led to their being tutored at home, by a young man who knew how to combine pleasure with instruction.

Melanchthon always remembered the dying injunction of his father: "I have seen many and great changes in the world, but greater ones are yet to follow, in which may God lead and guide you. Fear God, and do right" [25, p. 6]. Before this time (his father died when he was 11) he was, by his father's express wishes, strictly educated, for a while in a local school, and then by a tutor, a conscientious teacher and stern disciplinarian. Afterward he came more directly under the influence of the celebrated scholar Reuchlin, who was his relative. It was Reuchlin, impressed by the scholarship of the little boy, who changed his name from Schwartzerd to its Greek equivalent Melanchthon. Of his earlier childhood it is related that he often gathered his schoolfellows around him to discuss what they had been reading and learning; and his grandfather delighted to engage him in learned disputes with traveling scholars, whom he usually confounded.

The brief sketches preceding tend to confirm the rule, I believe, that children of genius are exposed to significantly great amounts of intellectual stimulation by adults and experience very restricted contacts with other children of their age. Nor should we overlook the fact that books themselves, to which these children are so much attached, are representatives of the adult world. This is true in the superficial sense that they are provided by adults and, more significantly, may be drawn from a father's sacred library (one thinks of Leibniz, Leopardi, even Chatterton); it is true in the profounder sense that they are written by adults, and, in the case of most of the reading done by these children, for adults. Books extend the boundaries of the adult empire.

There is an effect in this constant intercourse with the adult world which may be especially important in the development of genius. Not only is there an increase of knowledge, which is the usual aim of the instructors; there is also, in many cases, a profound excitement of imagination. Even John Stuart Mill confesses that he did not perfectly understand such grave works as the more difficult dialogs of Plato when he read them in Greek at 7. What, then, happens to such adult material pouring into the child's mind? Mill does not elucidate his own case; but there is evidence in a number of the biographies before me that the dynamic processes of fantasy go to work on it and richly transform both what is understood and what is not.

Much of Goethe's association with other children was simply an occasion for expressing his vivid fantasy life; he entranced them with stories of imaginary adventures. Musset, also, reveled in a world of make-believe based upon the Arabian Nights and similar literature,

and bewitched his enemies by the magic power of imagination. These were to become poets. But Bentham, who was no poet, imagined himself growing up as a hero like Fénelon's Telemachus and was stirred to moral fervor by sentimental novels. And two of the practical politicians in the list, Pitt and Niebuhr, may give us some insight into the process. When Pitt was around 13 or 14 he had written a tragedy, of which Macaulay has this to say: "This piece is still preserved at Chevening, and is in some respects highly curious. There is no love. The whole plot is political; and it is remarkable that the interest, such as it is, turns on a contest about a regency. On one side is a faithful servant of the Crown, on the other an ambitious and unprincipled conspirator. At length the King, who had been missing, reappears, resumes his power, and rewards the faithful defender of his rights. A reader who should judge only by the internal evidence, would have no hesitation in pronouncing that the play was written by some Pittite poetaster at the time of the rejoicings for the recovery of George the Third in 1789" [17, p. 68 f.]. Out of his learning Pitt had constructed a dream prescient of his own future career. And who can say that the actions of a Prime Minister are not as much the expression of a private drama as they are the realistic application of the sciences and the laws? Niebuhr, who became a practical man of business and politics as well as the historian of Rome, writes explicitly about his own childhood experience, in a letter to Jacobi in 1811: "Our great seclusion from the world, in a quiet little provincial town, the prohibition, from our earliest years, to pass beyond the house and garden, accustomed me to gather the materials for the insatiable requirements of my childish fancy, not from life and nature, but from books, engravings, and conversation. Thus, my imagination laid no hold on the realities around me, but absorbed into her dominions all that I read—and I read without limit and without aim—while the actual world was impenetrable to my gaze; so that I became almost incapable of apprehending anything which had not already been apprehended by another—of forming a mental picture of anything which had not before been shaped into a distinct conception by another. It is true that, in this second-hand world, I was very learned, and could even, at a very early age, pronounce opinions like a grownup person; but the truth in me and around me was veiled from my eyes—the genuine truth of objective reason. Even when I grew older, and studied antiquity with intense interest, the chief use I made of my knowledge, for a long time, was to give fresh variety and brilliancy to my world of dreams" [4, p. 354].

My point is that fantasy is probably an important aspect of the development of genius, not only in those cases where the chief avenue to fame is through the production of works of imagination in the ordinary sense, but also in those where the adult accomplishment is of

a different sort. Instead of becoming proficient in taking and giving the hard knocks of social relations with his contemporaries, the child of genius is thrown back on the resources of his imagination, and through it becomes aware of his own depth, self-conscious in the fullest sense, and essentially independent. There is danger, however, in the intense cultivation of fantasy. If it does not flow over into the ordinary social relations by some channel, if it has to be dammed up as something socially useless, then it threatens life itself. An expression of what I am referring to is given in that powerful scene in the first part of Goethe's "Faust" where the physician-magician, tampering with incantations, raises a spirit of overwhelming presence and quails before him. Something nearer to an outright demonstration is furnished by the life of Chatterton and his suicide.

Before he was 18 Chatterton was dead by his own hand. If we examine his life, we see that it breaks apart into two distinct regions: an outer shell of schoolboy, apprentice, pretended antiquarian, and writer of brittle satire; and a core—the serious and deeply emotional 15th-century poet Rowley, whose connection with himself he never publicly acknowledged. One must not forget that Chatterton's fantasy existence as Rowley has points of contact with his father, the musician schoolteacher who died before his son was born, but who, in a sense, presided over the boy's education through the music manuscript from which he learned his letters and the blackletter Testament in which he learned to read, and who, by his connection and the connection of his family with the magnificent church of St. Mary Redcliffe, which overshadowed the place of Chatterton's birth and was his favorite resort from the brutalities of Bristol, might surely continue to hold converse with the imaginative boy. The Rowley poems furthermore are related to Chatterton's search for a pedigree. In short, through Rowley, Chatterton established relations with the world of the dead; and since he could not admit that he himself was the author of the Rowley poems, but had to pretend to have found them in his role as antiquary, and was thus rejected as an impostor by Walpole, he could not through Rowley establish contact with the world of the living. The surface which he was able to present to the world was hard, brittle, violent, unreal. Yet even in his relations with the world he appeared to be doing the same thing he was doing through the Rowley fantasies, namely, seeking a father to love and protect him. He evidently placed great hopes in Walpole; but he had also tried and been disappointed in the patronage of men of lower caliber in Bristol. Eventually he came to a dead end in London, where he had no friends even of the quality of Bristol's Catcott. Just before he committed suicide he was Rowley once again in the most beautiful of his poems, the "Balade of Charitie," which sums up his experience of the world and his yearning for a loving father. If it was Rowley who enabled Chatterton to live, it was also Rowley who opened the door of death

for him and ushered him out of a world of constant bitter disappointment into a world of kindly and Christian spirits.

Chatterton is a supreme example of the dangers and costs of genius. Having no father or other appreciative adult to link him to the world, he was swallowed up by his imagination. But it is too often overlooked in the textbooks that genius in less tragic cases is generally a costly gift. Superficially an enviable piece of luck, it is actually a fatality which exacts tribute from the possessor. Extreme absorption in very hard work is one of the penalties, and sometimes broken health. Isolation from contemporaries, often increasing with the years, is another. Whether we should include heterosexual difficulties as another, I am not sure, but I have indicated some of the facts in the last column of table 1 and wish to consider the matter briefly. Fifty-five percent of our sample did not marry at all. There may be no special significance in this, since according to statistics for the United States [11] the marriage rate for the total population of males above 15 is only about 60 percent and may have been lower in earlier times. On the other hand, this group, with the exception of Chatterton, ranges in age from 39 to 84 and should be compared with the higher age groups. According to the 1930 census in the United States marriage had been entered into by 86 percent of men in the age range from 35 to 44, and by age 60, which is about the median for our group of geniuses, it had been entered into by about 90 percent. I will only note further that some delay or reluctance or dissatisfaction attended the marriages of Mill, Goethe, Coleridge, Mirabeau, Wieland, and perhaps Melanchthon, but it would not be desirable here to go into greater detail because of the impossibility of making appropriate comparisons. It may be that for marriages both freely contracted and happily sustained a rate of 3 in 20 is not out of the ordinary, though I should be inclined to say that here, too, we have an expression of the costliness of genius.

In summary, the present survey of biographical information on a sample of 20 men of genius suggests that the typical developmental pattern includes as important aspects: (1) a high degree of attention focused upon the child by parents and other adults, expressed in intensive educational measures and, usually, abundant love; (2) isolation from other children, especially outside the family; and (3) a rich efflorescence of fantasy, as a reaction to the two preceding conditions. In stating these conclusions I by no means wish to imply that original endowment is an insignificant variable. On the contrary. Galton's strong arguments on behalf of heredity appear to me to be well founded; and in this particular sample the early promise of these very distinguished men cannot be dissociated from the unusual intellectual qualities evident in their parents and transmitted, one would suppose, genetically as well as socially to their offspring. It is upon a groundwork of inherited ability that I see the pattern operating. Whether

the environmental phase of it summarized under (1) and (2) is actually causally important, and to what extent the environmental factors are related to the blossoming out of fantasy, are questions which could be examined experimentally, though obviously any thorough experiment would require both a great deal of money and a certain degree of audacity. It might be remarked that the mass education of our public school system is, in its way, a vast experiment on the effect of reducing all three of the above factors to minimal values, and should, accordingly, tend to suppress the occurrence of genius.

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The New England Porringer: An Index of Custom

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[With 8 plates]

OBJECTS are but imperfect records of action. However valid their authenticity, their design and pattern are seldom so critical as to have determined the exact course of the events with which they are related. Thus despite the markings which a firearm may leave upon a deadly ball, many other weapons of like or similar design can inflict an equally serious wound. The angle of the shot, the distance that separated victim and weapon, and all other details must be ascertained from the words of witnesses or the careful analysis of circumstantial evidence. The Deringer (pl. 1, fig. 1), however incontrovertibly linked to the bullet by the indisputable marks of its barrel, gives no clue as to motive for its use, the provocation, or a host of other pertinent questions. All these must be answered apart from the weapon. Certainly very few artifacts can describe a particular action. Most, like an assassin's firearm, become mere curiosities whose significance is buried in a plethora of sentiment. All the rich detail and human significance of the original event become obscured by what is at best incidental.

In 1824 the Marquis de Lafayette revisited the United States. His landing was recorded in the press, by correspondents, diarists, and artists. In England, the Clews pottery in Cobridge, Staffordshire, was quick to take advantage of popular interest and manufactured, among other pieces, a handsome platter with a view of the arrival of the Marquis at Castle Garden (pl. 1, fig. 2). Produced in blue-and-white glaze with the view adapted to the curvature of the piece, it describes little of the event. The flags, the ships, the harbor, the buildings, have all become patently distorted by the many persons who have adapted the original view to the requirements of the platter. Moreover, the piece tells little but the obvious facts about English ceramic manufactures of the period which any other vessel might do equally well.[1]

[1] Platter by James & Ralph Clews of Cobridge. Ellouise Baker Larsen, American historical views on Staffordshire china, p. 57. New York. 1950.

Although the platter lacks the accidental association which the Deringer enjoyed, its pictorial evidence seems, when first examined, of very little more value to the historian. But let us suppose for a moment that our questions be made more subtle and somewhat indirect. Instead of asking the platter to perform the verbal task of the manuscript or the eyewitness, let us ask it to act as an index of values and ideas seldom expressed verbally. However inferior as a reporter, it contains a superb record of the English estimate of American values and loyalties. Moreover, since the design became popular, it is clear that the British estimate did not miss the mark and that in fact the event excited American imagination. Finally, the evidence of the plate and its popularity rivals the best contemporary written opinion because, however discerning the latter, its bias remains indestructible. Since, in fact, each sale of the plate measures a minutia of popular opinion, the design gives thereby an insight which only an exhaustive survey could present. Moreover, as historians are well aware, Englishmen seldom committed any but their gravest misgivings about America to paper; the platter suggests a wider range of sympathetic if inarticulate feeling among English manufacturers.[2]

From the 19th century to which the Booth Deringer and the platter belong, so many objects have survived as to make their interpretation a statistical as well as an analytical problem. From the late 17th century and early 18th century, so few Colonial artifacts remain, the very real danger of overweighting the available objects exists. At the same time, this very paucity makes the neglect of any clues given by authentic objects more culpable.

One of the most common vessels of early New England silver is the porringer. Quite unrelated to English silver vessels of the same name, it most closely resembles the English bleeding bowl (pl. 2, fig. 1; pl. 5, fig. 2), but seems to have been seldom if ever designed for that purpose.[3] Its size varies from 4 to 6 inches in diameter with a bowl 1 to 2 inches deep. Handles, while not of uniform size, range from 1¾ to 3 inches from the vessel's rim to its tip. The vessel form is common in pewter and often listed in American inventories of the 17th and 18th centuries.[4] However, despite the wide variety of American Protestant church plate, Alfred Jones was unable to list a single silver porringer among their holdings. Since tankards, standing cups, English porringers, mugs, beakers, flagons, and many domestic vessels all appeared

[2] A similar exercise with the Deringer might stress that role of honor in 1826 in America which convinced its outstanding elite of the necessity and correctness of the personal firearm.

[3] A very full discussion of terminology has recently appeared which stresses the inaccuracy of the English use of "porringer" and "bleeding bowl" and adapts American practice. The Stuart period, 1603–1714, ed. Ralph Hughes and L. G. G. Ramsey, pp. 82–83. New York and London. No date.

[4] Suffolk County (Mass.) Probate Record, Book XXIII, p. 331, Inventory of Samuel Tower, June 10, 1724; "To Pewter vizt. Platters, plates, tankard, basons, porringers 3£ . . . 16."

on American altars or communion tables, the absence of the American porringer strongly suggests that it not only did not fit Protestant ritual but also that it was seldom used for drinking quantities of mildly alcoholic liquors.[5]

Moreover, this comparative independence cannot be laid to New England's provincial isolation or sturdy independence. In the matter of silver design, constant cultural contact and interchange took place. The migration of silversmiths, the semipublic church collections, and the descent of personal property by inheritance created a constantly shifting and changing pool of silver forms available to the curious artisan. Should he wish, he might closely follow English forms as did Robert Sanderson in his two-handled cup of 1670–85 which he chose to ornament heavily with the native American turkey and a farmyard hen.[6] Yet even in this seemingly natural choice, he had been anticipated by Henry Greenway of London who in 1659 placed a parrot and a similar turkey cock among the tulips and asters(?) of a nearly identical repoussé caudle cup.[7]

That New England should accept and develop the American porringer, despite such a close interchange of ideas and craftsmen, while Englishmen largely neglected the form, argues that in New England these porringers had a function not indicated by their name or by modern usage, and that their popularity, in fact, arose from their intimate adaptation to Puritan concepts and customs. Moreover, the evolution of the New England porringer suggests that many aspects of its design evolved as a consequence of Puritan idealism and homogeneity and that, with the decline of the Puritan theocracy, the New England silver porringer tended to lose its individuality and eventually to disappear.

The basic form of the New England porringer is not unique. Small, comparatively shallow silver vessels with one or sometimes two handles enjoyed popularity whenever exceedingly strong or thick alcoholic drinks became popular. The Scottish quaich[8] and English wine tasters both served much the same purpose as the New England porringer, but at the same time differed too markedly to have served as its progenitors.

In base metals, porringers likewise were common. Introduced from France as écuelle or potage dishes, pewter porringers retained their form and domestic and medical usefulness from the mid-16th century until the mid-19th century (pl. 2, fig. 1). Because of the softness of the metal and heavy usage, surviving domestic examples are rare, but

[5] E. Alfred Jones, The old silver of American churches, p. LXXII. Letchworth. 1913.

[6] Index of American cultures, Historical Massachusetts, No. 14, pp. 1–2.

[7] Parke-Bernet Galleries, "An Important Collection of Early English Silver, 1580–1820." Catalog 1789, p. 37. New York. 1957.

[8] Ian Finlay, Scottish gold and silver work, pls. 46–47. London. 1956. Two handles designed for passing; small size for strong drink.

the use of molds tended to maintain the popularity of anachronistic designs long after abandonment by fashionable silversmiths.[9] Clearly, with so many precedents the American silver porringer cannot be claimed as an innovation of British or Dutch colonists. It represents, however, a selection from European models which gained, if numbers and care of manufacture are any clue, a new meaning and importance in the colonies.

Few American silver porringers can be dated earlier than 1685. At least two of the most celebrated of these claimants have either the handle or monogram located in the fashion of posset pot or skillet covers designed to serve as dishes for hot sauces.[10] In this they follow established, though not common, English practice.[11] Close indeed to the later American porringers, these covers have straight sides, crescent piercings, and distinctive initials on the bottom or the side of the bowl. Initials placed here indicate that they are intended to be read when the vessel is placed upside down as a cover on a skillet or sauce pot. Any use as a vessel would be secondary to their function as a cover (pl. 2, fig. 2).

The use of the true American porringer must remain somewhat problematic. Its single handle suggests the probable need of a spoon, and the comparatively shallow depth that the mixture was often alcoholic since without that precious ingredient a few ounces of gruel would give little strength, physical or spiritual. The absence of the second handle reduces the primary use of the vessel as a wine or cool-drink taster, and the absence of an insulating material in the handle the use of the porringer in warming or preparing mixtures over an open flame.[12] Moreover, the large size of the American type precludes its design as a bleeding bowl. What remains then is a vessel designed for tasty dishes of strengthening gruel with a substantial but not excessive alcoholic content.[13]

That the rise of the American silver porringer should occur in the 17th century is not surprising, since in this period it found some

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[9] In addition to The Stuart period, pp. 82–83, a full discussion of the pewter porringer has appeared: Percy E. Raymond, "What is a Porringer?" Pewter Collectors Club of America, Bull. No. 8, pp. 5–7. January 1941.

[10] Mrs. Russel Hastings, Verifying a Hull and Sanderson porringer, Antiques, vol. 32, pp. 116–118, September 1937. Edwin J. Hipkiss, The Philip Leffingwell Spalding Collection of early American silver, pp. 13–14. Boston. 1943.

[11] An English posset pot with cover and handle similar to $\overset{\text{M}}{\text{A I}}$ piece is illustrated in Antiques, vol. 32, p. 118, and another in G. Bernard Hughes, Small antique silverware, p. 79. London. 1957.

[12] Holding such vessels over an open flame would only be possible for a very short time, and a simple experiment refutes the traditional English view. J. H. Buck, Old plate, its makers and marks, p. 103. New York. 1903.

[13] The alternative position of describing all porringers as bleeding bowls because some were so used is clearly confuted in the very catalog which gave the practice its greatest prestige. Victoria and Albert Museum, Catalogue of English silversmith's work, civil and domestic, No. 78. London. 1920.

popularity in London. Its close resemblance to the French écuelle and the existence of a few porringers with covers suggest the possibility that it was introduced by Huguenot craftsmen migrating to both England and America.[14] Certainly the porringer by René Grignon, Huguenot emigre (pl. 3, fig. 1), strongly resembles work done in Canada by other French silversmiths (pl. 3, fig. 2), and at the same time seems to have been closely followed by Jeremiah Dummer in his porringer for unknown patrons whose initials were $\overset{\text{P}}{\text{E A}}$ (pl. 4, fig. 1). Moreover, both the Grignon porringer marked for a couple married in 1692 and the Dummer porringer have initials cut so as to read when the vessel is placed lip upward, as when used for service and not as a dish cover.

At this point, the Huguenot, the English, and the American porringer seem very close in purpose, design, and ornament. All have initials on the open bowl side of the handle and piercings of the handle of tulips, crescents, and hearts contained in a vinelike silhouette.

However, after 1690 the American silver porringer rapidly developed along highly individual lines. In England the porringer gained little popularity and became restricted to the medical practice of cupping and bleeding. The French écuelle continued to develop as a large covered two-eared soup dish elaborately decorated in the Rococo fashion.[15] But in America and especially in the Calvinistic colonies of New England and of New York the porringer, as introduced by the Huguenots or as developed from the skillet pot cover, represented a new and welcome addition to church plate models commonly available.[16] That it was closely associated with the refugee Calvinistic Huguenots robbed it of the Papist taint which hung over the great hoards of pirated Spanish plate occasionally seen in Boston.[17]

The basic chronology of American porringers rests upon the working and death dates of their makers. The attribution of initials, while informative and of great interest, can only suggest the date of manufacture. The following table indicates (1) the working dates of the silversmiths whose work is illustrated or discussed, and (2) the dates of those illustrated by Bigelow together with the handle types of each example:

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[14] The best example of these, unmarked, but with a handle similar to John Coney's work is in the Metropolitan Museum. An elaborate cover with gadrooning and cut card work surmounts a 6¾-inch bowl. Francis H. Bigelow, Historic silver of the colonies and its makers, pp. 310–311. New York. 1931.

[15] Louis Carre, A guide to old French plate. New York. 1931. Illustrations unmarked.

[16] Samuel Sewall speaks of special measures taken to accommodate the Huguenots. S. Sewall, Diary, vol. 2, p. 262, note 407.

[17] Most famous was that of William Kidd, Gillam, Bradshaw and Witherly. "Iron chest of plate and pearls, 40 bails of East India goods, 13 other cases, and two slaves or servants." February 1699–1700. Samuel Sewall, Diary, vol. 2, pp. 3–5, 7.

	Maker	Date	Handle type
1.	John Hull	c. 1644–1683	Skillet.
	Robert Sanderson	c. 1630–1693	Skillet.
	Rene Grignon	c. 1691–1713	Huguenot.
	David Jesse	c. 1690–1705	Puritan.
	Jeremiah Dummer	c. 1665–1718	Huguenot, Puritan.
	John Coney	c. 1676–1722	Puritan.
	Peter Oliver	c. 1702–1712	Huguenot.
	William Jones	c. 1715–1730	Puritan–Rococo transition.
	Jonathan Clarke	c. 1734	Rococo.
	Samuel Edwards	c. 1725–1762	Rococo.
	Rufus Greene	c. 1727–1777	Chinese Chippendale.
	William Cowell, Jr	c. 1733–1761	Chinese Chippendale.
2.	Peter Oliver	c. 1702–1712	Huguenot.
	Jeremiah Dummer	c. 1665–1718	Huguenot, Puritan.
	Samuel Vernon	c. 1703–1735	Puritan.
	Andrew Tyler	c. 1712–1741	Rococo.
	John Edwards	c. 1691–1746	Puritan, Chinese Chippendale.
	Edward Winslow	c. 1689–1753	Puritan, Rococo.

In both lists the order of appearance of handles seems to be Skillet, Hugenot, Puritan, Rococo, Chinese Chippendale. In exceptionally long lives, like that of Edward Winslow or John Edwards, more than one type appears.

Moreover, the marking of porringers suggests an erotic significance as the mark of the fertility of a married couple. Just as the tankard is closely though not exclusively associated with communion and the concept of election, the porringer seems to have marked another step in the hierarchy of the ideal Puritan life.[18] The point at which fertility was celebrated remains obscure. It seems to be marked occasionally after the birth of a single child, but much more often in middle adult years shortly after the birth of the last of several children.[19] The occasional association of spoons might imply use at confinement for strengthening gruels. (Pl. 7, fig. 1.) Since the initials were most often those of man and wife and not of child, and since the dishes lacked the additional silver loop below and at right angles to the main handle commonly found in pap bowls, it can be assumed that the valuable silver porringer was like the silver tankard, principally a mark of status shared by man and wife and not a functional weaning appliance to be loosely handled by nurse and infant.[20]

The voids of porringer handles, while not altogether explicit in their iconography, represent an apparently conscious effort on the part

[18] Edmund S. Morgan, The Puritan family, p. 10. Boston. 1956. Samuel Willard. A compleat body of divinity, p. 679.

[19] The conclusion is tentative and based upon published porringers and a cursory examination of those in the Yale Gallery of Fine Arts and a comparison of makers' work dates and owners' life dates.

[20] This point has been largely overlooked, but of Bigelow's selection of 12 New England porringers between 1685–1753, 7 have been attributed to man and wife, 2 are not identified, 3 have other attributions. Bigelow, Historic silver, pp. 305–314; Ramsey Traquair, The old silver of Quebec, pl. III. Toronto. 1940.

of Colonial silversmiths to create a meaningful symbolism, a symbolism which reflects the New England divergence from English views on church and state followed by the gradual substitution of Royal authority and merchant goals in the place formerly held by the theocratic government and ideals of the Massachusetts Bay Company.

French colonial work of the period seems to have combined heart and scallop-shell motifs in various ways. (Pl. 3, fig. 2.) The heart as a symbol of sanctioned love and divine fervor and the scallop as the vehicle of Venus which carried strong and possibly direct sexual connotations were combined sometimes with the vine of the Lord's vineyard and sometimes with an escutcheon suitably initialed. Despite the use of the escutcheon, a typical British and Puritan device, the early porringer remained in part an uncovered écuelle, French in feeling. (Pl. 4, figs. 1 and 2.)

This handsome design seems to have persisted only in the brief career of Peter Oliver (1682–1712) (pl. 5, fig. 1). More typical of New England were the so-called geometric handles which might be more appropriately termed Puritan design. Diverging sharply from both London and French practice, these handles closely paralleled official Puritan views on love and marriage and symbolized at once religious concern and married love. (Pl. 5, fig. 2.)

"There is, therefore, no comparison so much used in the Scriptures to represent the mutual love between *Christ* and His *Church* as that which is between a *Man* and his *Wife*."[21] Or again from the New England Primer of 1727:

H My Book and Heart
Shall never part.

These piercings have at their base , a small opening cut to imitate the tablets of the Decalogue required by law to hang in English churches as the primary symbol of the English Reformation and its attack on Catholic iconography.[22] The tablets especially suited the Puritan in New England since they combined a reference to the Old Testament with a reminder of the virtue of religious learning and at the same time gave no undue concessions to the role of the crown in the determination of religious practice.[23] They were so used on the title page of the popular and influential "New English Tutor." The other piercings are less clear. The quatrefoil occurs commonly in both a symmetrical and asymmetrical shape and in many different positions. Trefoils are less common decorative piercings. Whether either had a commonly understood symbolism, it is difficult to say.

[21] Samuel Willard, A compleat body of divinity, p. 679. Boston. 1726.

[22] G. W. O. Addleshaw and Frederick Etchells, The architectural setting of Anglican worship, p. 35. London. No date. The Royal Order of 1561 made official a recent custom.

[23] This last made the use of Royal Arms and symbols especially objectionable to Puritans. Sewall, Diary, vol. 1, p. 158; vol. 3, p. 159.

Regular quatrefoils appear on communion tables where their Christian significance and association must have been understood.[24] Irregular quatrefoils suggest knots, a well-understood symbol of marriage. On the other hand, many tombstone makers put on grave markers fully rounded bands of fruit and leaves. These fruits hang in pairs and have been described as pomegranates or figs. The one, the symbol of Resurrection, would be incongruous with the other elements of the porringer handle. The latter, a symbol of earthly prosperity, would fit the porringer in design and purpose. Figs would seem the most likely symbol since they might appropriately fit both the trefoil and the quatrefoil of the Coney or Puritan porringer.[25]

Tulips or lilies are the closest link to earlier styles and seem also to reflect a conscious symbolism. Their presence on a porringer as upon household articles suggests Christian love or even the ecstasy of divine revelation, a doctrine strongly emphasized by the Puritan concept of election. This correlation of physical love and the vision of divinity seemed, of course, a reasonable one borne out by the use of the tulip or lily on New England marriage chests. Moreover, this link is closely forged in the decorative motifs of Pennsylvania where the symbolism is made doubly apparent in poetic imagery. Combined with the tablets, hearts, trefoils and quatrefoils, and with initials most usually attributed to married couples, the porringer gave a very real and positive affirmation of orthodox Puritan doctrine which heartily applauded lusty and legitimate unions as the foundation of God's chosen people.

> . . . Now a conjugal *Love* is that which is adapted for conjugal *Society* and by it Persons are fitted to a cheerful Discharge of all the Duties which belong to them in that Relation: Nor can they be truly and sincerely discharged without it. And as this *Love* is that which only can make the married state truly *Comfortable* and *Happy* . . . and the want of it is that which makes so many Matches so unhappy as is too obvious among men.[26]

The other piercings of this Puritan porringer are more controversial. Crescents have a nearly universal lunar symbolism and certainly 17th-century poetry often refers to the moon as the guardian of lovers. Single circles are less clear. Often present, they may represent a simplified version of the flaming host often engraved upon English communion cups and the sun of Judgment Day common on tombstones, or, on the other hand, may only serve as a functional purpose in the design. Significantly, whatever their interpretation, they introduce no false note in the combination of Puritan symbols of love and scripture which fill the larger part of the handle.

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[24] Wallace Nutting, Furniture treasury, vol. 1, pl. 811. New York. 1948. For an English example with grapevine and wheat(?), see Luke V. Lockwood, Colonial furniture in America, vol. 2, p. 169. New York. 1951.

[25] Harriette M. Forbes, Gravestones of early New England, 1653–1800, pp. 23, 28, 29, 122, 123. Boston. 1927.

[26] Willard, Compleat body of divinity, pp. 679–680.

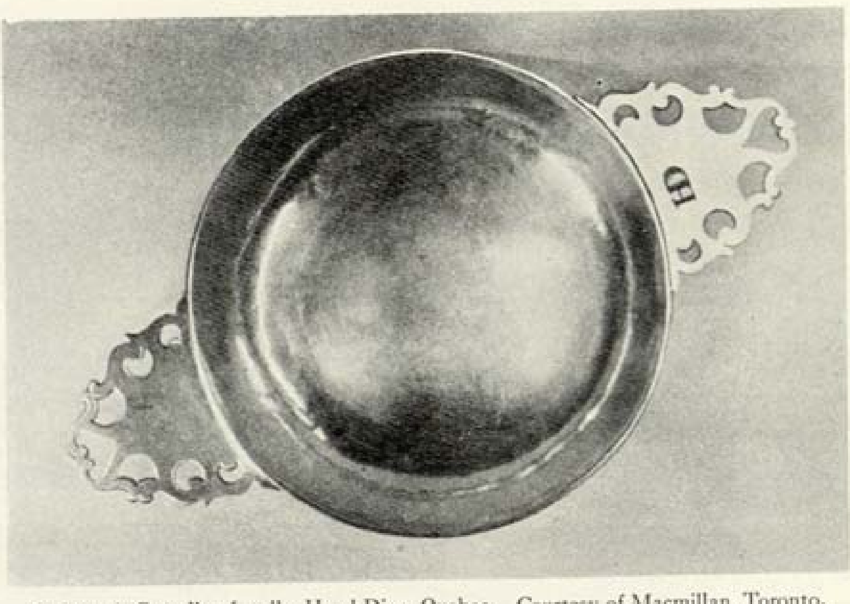
1. Deringer used by John Wilkes Booth to assassinate Abraham Lincoln.
Courtesy of National Park Service.

2. Platter, "Landing of General LaFayette at Castle Garden, New York, 16 August 1824." Marked: Clews warranted Staffordshire. Courtesy of Henry F. DuPont Winterthur Museum.

1. Pewter bleeding bowl by John Foster, London, after 1741.

2. Porringer by John Hull and Robert Sanderson (c. 1655–83). Courtesy of Museum of Fine Arts, Boston.

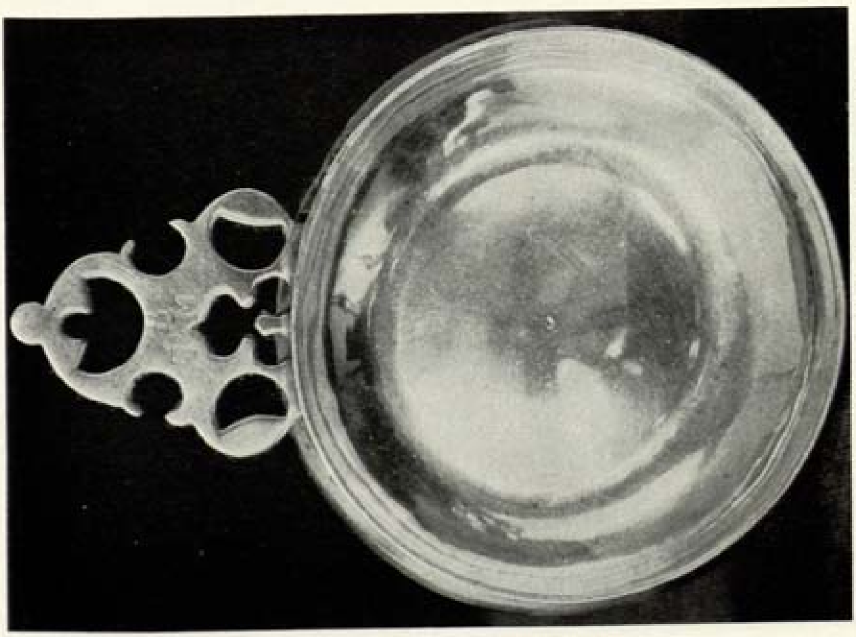
1. Porringer by René Grignon after 1692. Courtesy of Mabel Brady Garvan Collection, Yale University Art Gallery.



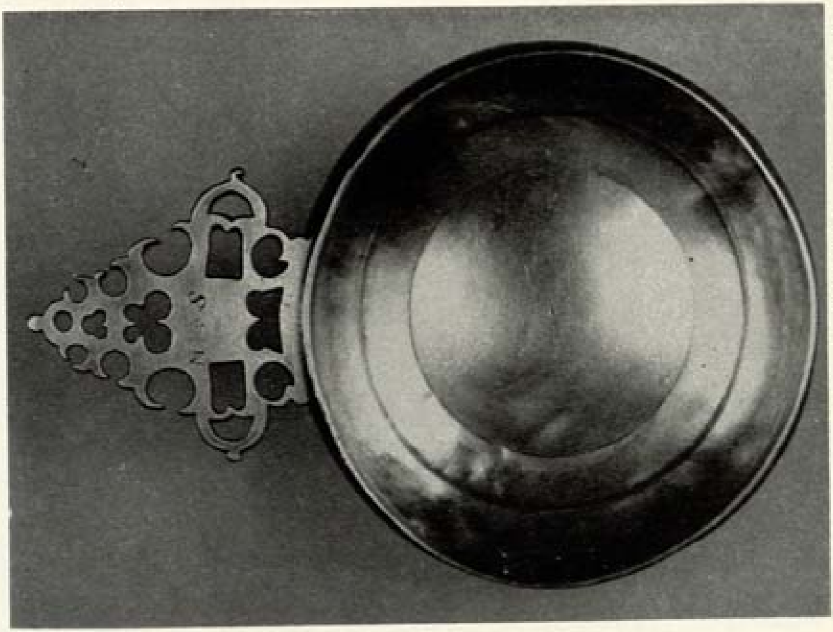
2. French Canadian écuelle, Hotel Dieu, Quebec. Courtesy of Macmillan, Toronto.

1. Porringer by Jeremiah Dummer (c. 1665–1718). Courtesy of Worcester Art Museum.

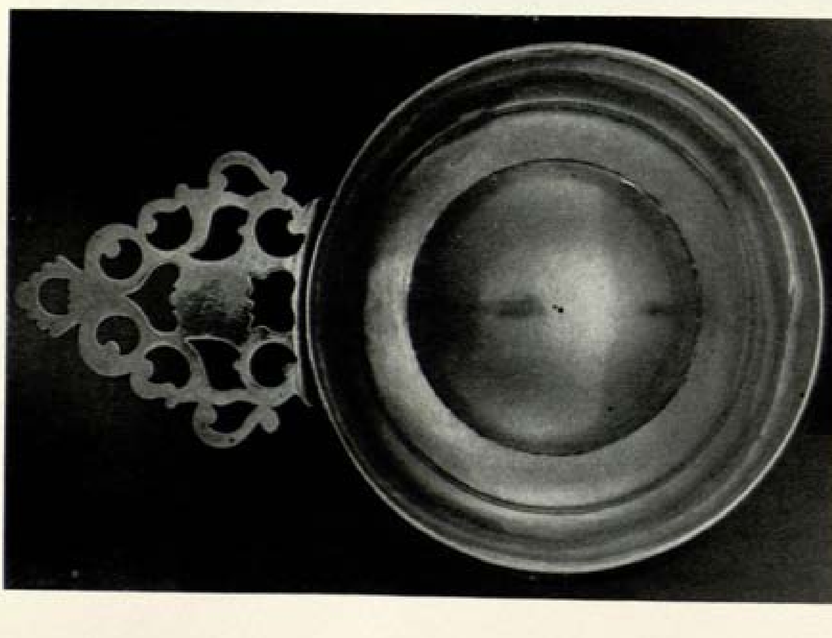
2. Porringer by Jeremiah Dummer (c. 1670–80). Courtesy of Museum of Fine Arts, Boston.



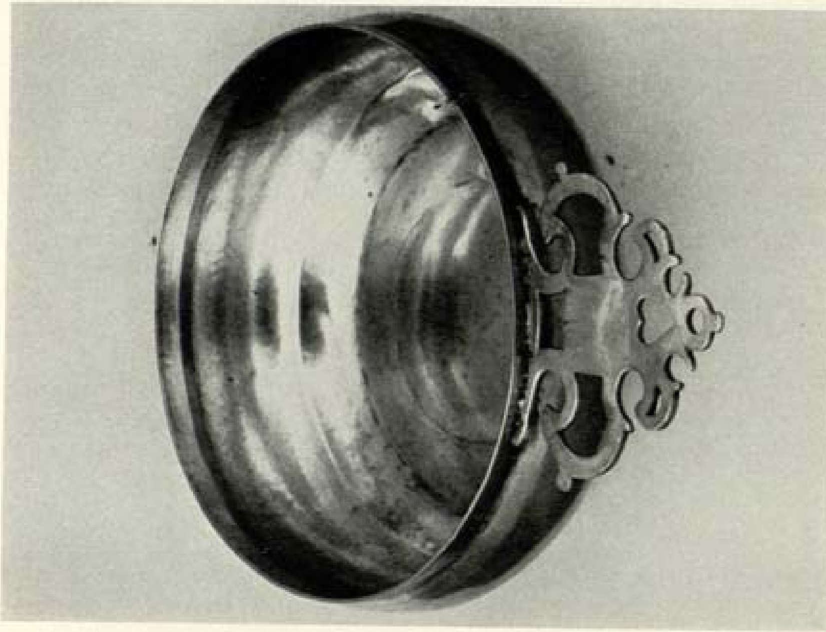
1. Porringer by Peter Oliver (c. 1702–12). Courtesy of Museum of Fine Arts, Boston.



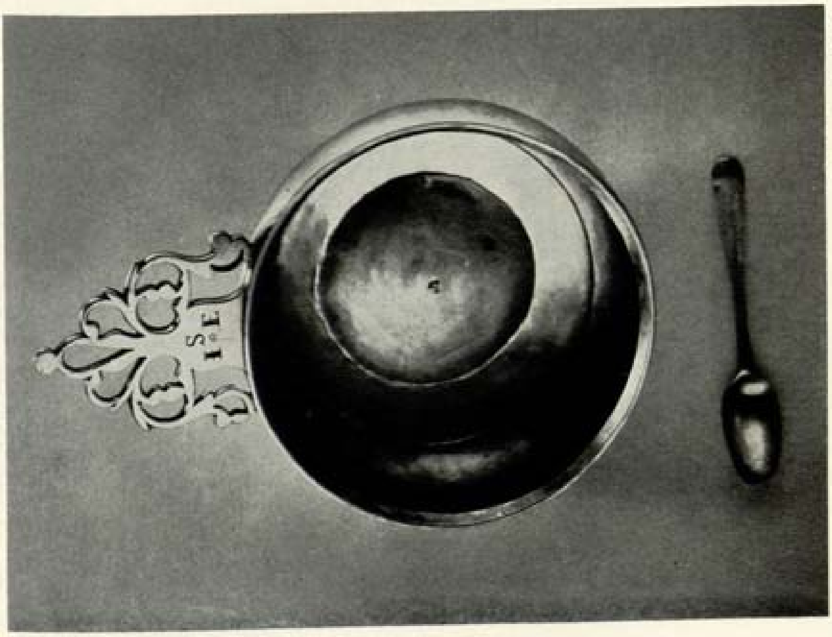
2. Porringer by John Coney (c. 1676–1722). Courtesy of Mabel Brady Garvan Collection, Yale University Art Gallery.



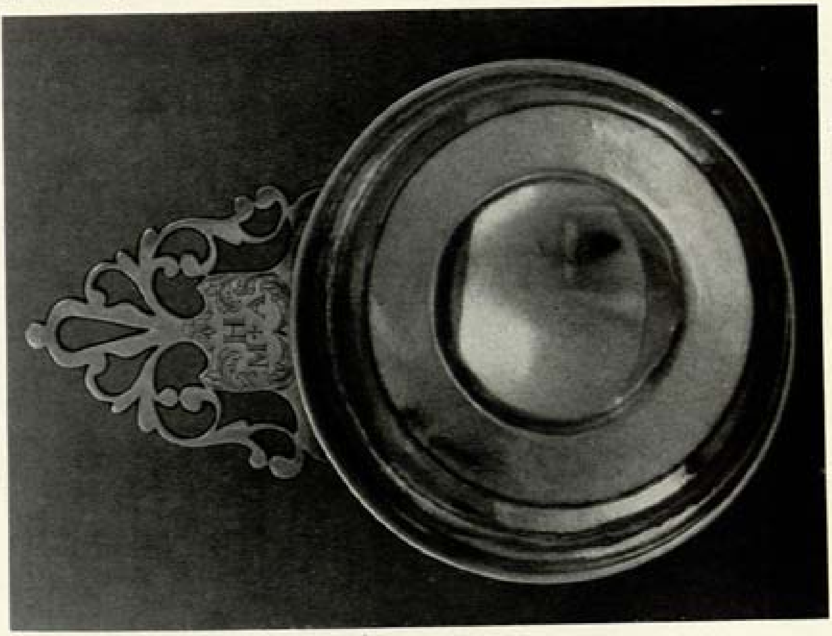
1. Porringer by John Coney (c. 1676–1722). Courtesy of Mabel Brady Garvan Collection, Yale University Art Gallery.



2. Porringer by William Jones (c. 1715–30), in the Smithsonian Institution collections.

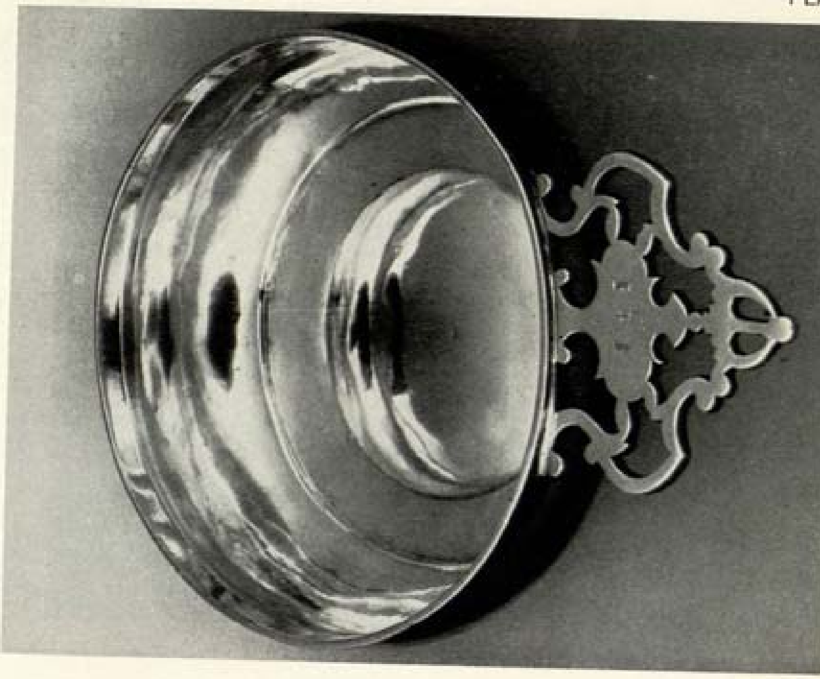


1. Porringer and associated spoon by Samuel Edwards (c. 1725–62), in the Smithsonian Institution collections.



2. Porringer by Jonathan Clarke, Newport (c. 1734). Courtesy of Mabel Brady Garvan Collection, Yale University Art Gallery.

1. Porringer by Rufus Green (c. 1727–77). Courtesy of Mabel Brady Garvan Collection, Yale University Art Gallery.



2. Porringer by William Cowell, Jr. (c. 1733–61), in the Smithsonian Institution collections.

Makers' marks provide additional confirmation of the basic trend in piercing design. Since they are the consequence of the careful and exact manufacture of punches, they combined the artisan's concept of a significant outline with what he was certain would not offend his patrons. Significantly, the heart appears in the marks of five of the most celebrated early silversmiths—Robert Sanderson, John Hull, Jeremiah Dummer, John Coney, and Peter Oliver. It was rivaled in frequency only by the shield of John Edwards, Benjamin Hiller, George Hanners, Joseph Glidden, John Burt, and John Coney. The tablet appears in the mark of Sanderson and Hull only, the sunburst most notably in Sanderson's work. Rarest of all, a book on stand(?) suggesting the outline of a pulpit framed the EW of Edward Winslow. How to weigh the clear division between the earlier heart mark and the later escutcheon must remain indeterminate. Both are common in English marks, among many other forms almost totally unknown in New England. Both represent aspects of religious values strongly emphasized by Puritanism: on the one hand, divine love or revelation, on the other, personal achievement. The gradual emergence of the latter closely paralleled the rise of Royal government and the decline of the theocratic party after 1690.

The development of the iconography of the Puritan handle likewise seems to follow closely the decline of Puritan prestige. Significantly the first element to disappear is the silhouette of the tablets which in one Coney piece seems to have been actually reshaped into an ample tulip (pl. 6, fig. 1), and in another piece by David Jesse (Smithsonian) to have been altered by filing. Coincidentally, or soon thereafter, the trefoils, quatrefoils, and circles vanish before the onslaught of sheafs of wheat and other new forms. Hearts, crescents, and tulips (lilies) maintain for a time their importance, but become distorted and agitated into more violent angles and shapes (pl. 6, fig. 2; pl. 7, fig. 1).

Significantly, these shapes no longer determine the pattern of the handle but must adapt themselves to the sinuous vinelike outline of the handle's outside edge. While remaining symmetrical, the handle manages to suggest the movement and distortion of the Rococo. Mantlings added to initials mark the increased role of personal achievement (pl. 7, fig. 2). Meanwhile, new openings unfamiliar in their pattern to Puritan iconography have begun to appear. Sometimes the vine encloses horns of plenty, at another time cockle shells. Gradually the vine becomes more explicit and realistic until, as in Chinese Chippendale furniture, it quite dominates the design. (Pl. 8, figs. 1 and 2.) A significant aberration of this handle type was made by Joseph Richardson, Sr., in 1775, when for Thomas Paine he

cut a star directly in the center of the porringer handle which Paine gave "his esteemed friend Dr. Rush." [27]

The maker of the porringer shown in plate 8, figure 1, Rufus Greene, died in 1777, 85 years after the René Grignon porringer of 1692. In that period, a silver form, probably borrowed from the persecuted Calvinistic Huguenots or from neglected English practice, had been modified and developed by Puritan craftsmen according to Puritan ideology and accepted iconography. This complete, if somewhat self-conscious, form had in turn yielded to the sinuous enchantments of the Rococo, of a rediscovered nature, and the awakening of a naturalistic iconography, as Puritanism itself had fallen victim to the Enlightenment on the one hand and to the Great Awakening on the other.

The handles, then, of the porringers call attention to the role of the Huguenot in Boston society at the turn of the 18th century. The acceptance of his écuelle as a suitable form for a gift measures his acceptance by Puritan orthodoxy, the appeal of his novel skill to Bostonians, and suggests the boredom of a homogeneous society with the Puritan temper. The initial purging of the French forms and their recombination into an acceptable Puritan formula indicate the strength of the orthodox party and the extraordinary extent of its influence. The rise of Rococo ornament more closely associated with natural forms and the corresponding decline of Puritan symbols parallel the increasing importance of materialism and of Royal government in the determination of taste and, by implication, of society itself. Such matters difficult to measure in the partisan writings of the few sometimes find their best reflection in the overt suggestion of customary artifacts.

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[27] Collectors notes, Antiques, vol. 75, p. 194, February 1959. This choice of handle indicates the maker's and possibly the donor's direct concern with the iconography of the voids in the porringer handle.

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