Annual Report of the Board of Regents

of the

SMITHSONIAN INSTITUTION

PUBLICATION 4149

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

1953

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1954

LETTER OF TRANSMITTAL

SMITHSONIAN INSTITUTION,
Washington, December 31, 1953.

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, 1953. I have the honor to be,

Respectfully,

LEONARD CARMICHAEL, *Secretary.*

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June 30, 1953

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

Chancellor.—FRED M. VINSON, 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.
FRED M. VINSON, Chief Justice of the United States.
JOHN FOSTER DULLES, Secretary of State.
GEORGE M. HUMPHREY, Secretary of the Treasury.
CHARLES E. WILSON, Secretary of Defense.
HERBERT BROWNELL, JR., Attorney General.
ARTHUR E. SUMMERFIELD, Postmaster General.
DOUGLAS MCKAY, Secretary of the Interior.
EZRA TAFT BENSON, Secretary of Agriculture.
SINCLAIR WEEKS, Secretary of Commerce.
MARTIN P. DURKIN, Secretary of Labor.
OVETA CULP HOBBY, Secretary of Health, Education, and Welfare.

Regents of the Institution:

FRED M. VINSON, Chief Justice of the United States, Chancellor.
RICHARD M. NIXON, Vice President of the United States.
ROBERT A. TAFT, Member of the Senate.
CLINTON P. ANDERSON, Member of the Senate.
LEVERETT SALTONSTALL, Member of the Senate.
CLARENCE CANNON, Member of the House of Representatives.
JOHN M. VORYS, Member of the House of Representatives.
LEROY JOHNSON, Member of the House of Representatives.
ARTHUR H. COMPTON, citizen of Missouri.
VANNEVAR BUSH, citizen of Washington, D. C.
ROBERT V. FLEMING, citizen of Washington, D. C.
JEROME C. HUNSAKER, citizen of Massachusetts.

Executive Committee.—ROBERT V. FLEMING, *chairman*, VANNEVAR BUSH, CLARENCE CANNON.

Secretary.—LEONARD CARMICHAEL.

Assistant Secretaries.—JOHN E. GRAF, J. L. KEDDY.

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

Treasurer.—J. D. HOWARD.

Chief, editorial division.—PAUL H. OEHSER.

Librarian.—MRS. LEILA F. CLARK.

Chief, accounting division.—THOMAS F. CLARK.

Superintendent of buildings and labor.—L. L. OLIVER.

Assistant Superintendent of buildings and labor.—CHARLES C. SINCLAIR.

Chief, personnel division.—JACK B. NEWMAN.

Chief, publications division.—L. E. COMMERFORD.

Chief, supply division.—ANTHONY W. WILDING.

Photographer.—F. B. KESTNER.

UNITED STATES NATIONAL MUSEUM

Director.—A. REMINGTON KELLOGG.
Chief, office of correspondence and records.—HELENA M. WEISS.
Editor.—JOHN S. LEA.

SCIENTIFIC STAFF

DEPARTMENT OF ANTHROPOLOGY:

Frank M. Setzler, head curator; A. J. Andrews, J. E. Anglim, exhibits preparators; W. W. Taylor, Jr., collaborator in anthropology.

Division of Archeology: Waldo R. Wedel, curator; Clifford Evans, Jr., associate curator.

Division of Ethnology: H. W. Krieger, curator; J. C. Ewers, C. M. Watkins, associate curators; R. A. Elder, Jr., assistant curator.

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

Associate in Anthropology: Neil M. Judd.

DEPARTMENT OF ZOOLOGY:

Waldo L. Schmitt, head curator; W. L. Brown, chief exhibits preparator; C. H. Aschemeier, W. M. Perrygo, E. G. Laybourne, C. S. East, J. D. Biggs, exhibits preparators; Mrs. Aime M. Awl, scientific illustrator.

Division of Mammals: D. H. Johnson, H. W. Setzer, associate curators; Charles O. Handley, Jr., assistant curator; A. Brazier Howell, collaborator; Gerrit S. Miller, Jr., associate.

Division of Birds: Herbert Friedmann, curator; H. G. Deignan, associate curator; Samuel A. Arny, museum aide; Alexander Wetmore, research associate and custodian of alcoholic and skeleton collections; Arthur C. Bent, collaborator.

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

Division of Fishes: Leonard P. Schultz, curator; E. A. Lachner, associate curator; W. T. Leapley, Robert H. Kanazawa, museum aides.

Division of Insects: Edward A. Chapin, curator; R. E. Blackwelder, W. D. Field, O. L. Cartwright, Grace E. Glance, associate curators; Sophy Parfin, junior entomologist; W. L. Jellison and M. A. Carriker, collaborators.

Section of Hymenoptera: W. M. Mann, Robert A. Cushman, assistant custodians.

Section of Diptera: Charles T. Greene, assistant custodian.

Section of Coleoptera: L. L. Buchanan, specialist for Casey collection.

Division of Marine Invertebrates: F. A. Chace, Jr., curator; Frederick M. Bayer, associate curator; Mrs. L. W. Peterson, museum aide; Mrs. Harriet Richardson Searle, Max M. Ellis, J. Percy Moore, collaborators; Mrs. Mildred S. Wilson, collaborator in copepod Crustacea.

Division of Mollusks: Harald A. Rehder, curator; Joseph P. E. Morrison, R. Tucker Abbott, associate curators; W. J. Byas, museum aide; Paul Bartsch, associate.

Section of Helminthological Collections: Benjamin Schwartz, collaborator.

Associates in Zoology: T. S. Palmer, W. B. Marshall, A. G. Böving, C. R. Shoemaker, W. K. Fisher, Austin H. Clark.

Collaborator in Zoology: R. S. Clark.

Collaborator in Biology: D. C. Graham.

DEPARTMENT OF BOTANY (NATIONAL HERBARIUM):

Jason R. Swallen, head curator.

Division of Phanerogams: A. C. Smith, curator; E. C. Leonard, E. H. Walker, Lyman B. Smith, associate curators; Velva E. Rudd, assistant curator; E. P. Killip, research associate.

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

Division of Grasses: Ernest R. Sohns, associate curator; Mrs. Agnes Chase, F. A. McClure, research associates.

Division of Cryptogams: C. V. Morton, acting curator; Paul S. Conger, associate curator; John A. Stevenson, custodian of C. G. Lloyd mycological collections and honorary curator of Fungi; David G. Fairchild, custodian of Lower Fungi.

DEPARTMENT OF GEOLOGY:

W. F. Foshag, head curator; J. H. Benn and Jessie G. Beach, museum aides.

Division of Mineralogy and Petrology: W. F. Foshag, acting curator; E. P. Henderson, G. S. Switzer, associate curators; F. E. Holden, museum technician; Frank L. Hess, custodian of rare metals and rare earths.

Division of Invertebrate Paleontology and Paleobotany: Gustav A. Cooper, curator; A. R. Loeblich, Jr., David Nicol, Arthur L. Bowsher, associate curators; W. T. Allen, museum aide; J. Brookes Knight, research associate in paleontology.

Section of Invertebrate Paleontology: T. W. Stanton, custodian of Mesozoic collection; J. B. Reeside, Jr., custodian of Mesozoic collection; Preston Cloud, research associate.

Section of Paleobotany: Roland W. Brown, research associate.

Division of Vertebrate Paleontology: C. L. Gazin, curator; D. H. Dunkle, associate curator; F. L. Pearce, A. C. Murray, exhibits preparators.

Associates in Mineralogy: W. T. Schaller, S. H. Perry, J. P. Marble.

Associate in Paleontology: R. S. Bassler.

DEPARTMENT OF ENGINEERING AND INDUSTRIES:

Frank A. Taylor, head curator.

Division of Engineering: Frank A. Taylor, acting curator.

Section of Civil and Mechanical Engineering: Frank A. Taylor, in charge.

Section of Marine Transporation: Frank A. Taylor, in charge.

Section of Electricity: K. M. Perry, associate curator.

Section of Physical Sciences and Measurement: Frank A. Taylor, in charge.

Section of Land Transportation: S. H. Oliver, associate curator.

Division of Crafts and Industries: William N. Watkins, curator; Edward A. Avery, William E. Bridges, and Walter T. Marinetti, museum aides; F. L. Lewton, research associate.

Section of Textiles: Grace L. Rogers, assistant curator, in charge.

Section of Wood Technology: W. N. Watkins, in charge.

Section of Manufactures: Edward C. Kendall, associate curator, in charge.

Section of Agricultural Industries: Edward C. Kendall, associate curator, in charge.

Division of Medicine and Public Health: George B. Griffenhagen, associate curator; Alvin E. Goins, museum aide.

Division of Graphic Arts: Jacob Kainen, curator; J. Harry Phillips, Jr., museum aide.

Section of Photography: A. J. Wedderburn, Jr., associate curator.

DEPARTMENT OF HISTORY:

Mendel L. Peterson, acting head curator.

Divisions of Military History and Naval History: M. L. Peterson, associate curator; J. R. Sirlouis, assistant curator; Craddock R. Goins, Jr., junior historian.

Division of Civil History: Margaret W. Brown, associate curator; Robert Leroy Morris, museum aide.

Division of Numismatics: S. M. Mosher, associate curator.

Division of Philately: Franklin R. Bruns, Jr., associate curator.

NATIONAL GALLERY OF ART

Trustees:

FRED M. VINSON, Chief Justice of the United States, *Chairman.*
JOHN FOSTER DULLES, Secretary of State.
GEORGE M. HUMPHREY, Secretary of the Treasury.
LEONARD CARMICHAEL, Secretary of the Smithsonian Institution.
SAMUEL H. KRESS.
FERDINAND LAMMOT BELIN.
DUNCAN PHILLIPS.
CHESTER DALE.
PAUL MELLON.

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Vice President.—FERDINAND LAMMOT BELIN.
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Director.—DAVID E. FINLEY.
Administrator.—HARRY A. MCBRIDE.
General Counsel.—HUNTINGTON CAIRNS.
Chief Curator.—JOHN WALKER.
Assistant Director.—MACGILL JAMES.

NATIONAL COLLECTION OF FINE ARTS

Director.—THOMAS M. BEGGS.
Curator of ceramics.—P. V. GARDNER.
Chief, Smithsonian Traveling Exhibition Service.—MRS. JOHN A. POPE.
Exhibits preparator.—ROWLAND LYON.

FREER GALLERY OF ART

Director.—A. G. WENLEY.
Assistant Director.—JOHN A. POPE.
Assistant to the Director.—BURNS A. STUBBS.
Associate in Near Eastern art.—RICHARD ETTINGHAUSEN.
Associate in technical research.—RUTHERFORD J. GETTENS.
Assistant in research.—HAROLD P. STERN.
Research associate.—GRACE DUNHAM GUEST.
Honorary research associate.—MAX LOEHR.

BUREAU OF AMERICAN ETHNOLOGY

Director.—MATTHEW W. STIRLING.
Associate Director.—FRANK H. H. ROBERTS, Jr.
Anthropologists.—H. B. COLLINS, Jr., PHILIP DRUCKER.
Ethnologist.—JOHN P. HARRINGTON.
Collaborators.—FRANCES DENSMORE, RALPH S. SOLECKI, JOHN R. SWANTON, A. J. WARING, Jr.
Scientific illustrator.—E. G. SCHUMACHER.
RIVER BASIN SURVEYS.—FRANK H. H. ROBERTS, Jr., *Director.*

INTERNATIONAL EXCHANGE SERVICE

Chief.—D. G. WILLIAMS.

NATIONAL ZOOLOGICAL PARK

Director.—WILLIAM M. MANN.
Assistant Director.—ERNEST P. WALKER.
Head Animal Keeper.—FRANK O. LOWE.

ASTROPHYSICAL OBSERVATORY

Director.—LOYAL B. ALDRICH.
DIVISION OF ASTROPHYSICAL RESEARCH:
Chief.—WILLIAM H. HOOVER.
Instrument makers.—ANDREW KRAMER, D. G. TALBERT, J. H. HARRISON.
Research associate.—CHARLES G. ABBOT.
DIVISION OF RADIATION AND ORGANISMS:
Chief.—R. B. WITHROW.
Plant Physiologists.—WILLIAM H. KLEIN, LEONARD PRICE, V. B. ELSTAD, MRS. ALICE P. WITHROW.

NATIONAL AIR MUSEUM

Advisory Board:
LEONARD CARMICHAEL, *Chairman.*
LT. GEN. LAURENCE C. CRAIGIE, *U. S. Air Force.*
REAR ADM. T. S. COMBS, *U. S. Navy.*
GROVER LOENING.
WILLIAM B. STOUT.
Head curator.—PAUL E. GARBER.
Associate curator.—R. C. STROBELL.
Manager, National Air Museum Facility.—W. M. MALE.
Museum aides.—STANLEY POTTER, WINTROP S. SHAW.

CANAL ZONE BIOLOGICAL AREA

Resident Manager.—JAMES ZETEK.

Report of the Secretary of the Smithsonian Institution

LEONARD CARMICHAEL

For the Year Ended June 30, 1953

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 which ended on June 30, 1953.

GENERAL STATEMENT

My duties as the seventh Secretary of the Smithsonian Institution were assumed on January 2, 1953. Thus, during approximately half the year covered by the present report the Institution was under the able direction of its eminent former Secretary, Dr. Alexander Wetmore. Detailed statements covering the work of the several bureaus and divisions of the Smithsonian during the full year are presented elsewhere in this report.

I should like first to express my deep appreciation to the Honorable Fred M. Vinson, Chancellor of the Smithsonian Institution, to the chairman of our executive committee, and individually to our regents, all of whom have most unselfishly performed many services essential to the effective operation and progress of the Institution during the year covered by this report. I wish also to thank Dr. Wetmore for the great assistance he has given me as his successor, and the entire Smithsonian staff for the cooperation they have extended to me as the new occupant of the office of Secretary.

The Smithsonian has many pressing needs and unsolved problems, but it is fortunate in possessing a staff that is in an outstanding degree professionally qualified and is superlatively loyal to the best interests of the Institution. Many former employees, some long retired, return regularly to carry on research and follow the progress of the Institution with keen interest. In a striking way present and past staff members correctly feel that they truly belong to the old and distinguished Smithsonian family. In this respect and in many others I find the Institution similar to a great university.

The Smithsonian is unique because it is the Nation's principal research center in a number of basic scientific and cultural fields. Because of its unequaled natural-science collections, which contain a vast number of "type specimens," it is a continuing repository of standards

for much work in biology and geology. In its collections of history and technology, of aviation, and of the fine arts the Smithsonian has special distinctions and responsibilities in maintaining a proper and complete record of our national achievements and of preserving in trust for the Nation valuable gifts from its citizens. Its expeditions and researches in anthropology in our own and other American countries have brought to light much of the past that was hidden and have preserved much that would otherwise have been lost. Its researches in solar radiation continue to be a principal source of special information in a field of growing practical importance. Its library of more than a million and a half titles is one of the world's great repositories of published scientific information and by far the greatest in the Western Hemisphere. Through its extensive publication program, its international exchange service for scientific literature, its museum exhibits and traveling exhibitions, and in the answering of thousands of individual inquiries yearly the Smithsonian is surely a world center not only for the increase of knowledge but for the proper diffusion of exact information.

In some ways, this means that the Smithsonian may be thought of as a living encyclopedia that is always being kept up to date. Research workers connected with industrial development as well as scientific investigators all over the country continually call upon our expanding collections and records for the identification and description of plants, animals, minerals, and unknown or puzzling objects of human workmanship, especially works of art, and for information pertaining to our other fields of scholarly interest.

In these first months of my service as Secretary it has become clear to me that the Smithsonian has, through its more than a century of service, won a special place in the hearts and minds of American citizens from the Atlantic to the Pacific. Taking all our buildings together, more than 8,200,000 visitors entered our various halls last year. It is reported at the USO information desk in Washington's Union Station that 9 out of 10 members of the Armed Forces inquire for the Smithsonian Institution. A Gallup poll of last summer, attempting to sample the opinion of the estimated 35 million adult Americans who have visited Washington at least once, indicated that except for the Capitol and the White House, the Smithsonian Institution is regarded as "the most interesting thing for a visitor to see in Washington." Car and bus loads of individuals from the Pacific Coast States and from every other part of the Nation come day after day to the Smithsonian. These visitors are of all ages. Many of them are impressionable high-school seniors on what may well be their one trip to Washington. It is thus borne in upon everyone connected with the Smithsonian Institution that our exhibits must be prepared in such a way that they will most effectively tell these eager and

earnest visitors the story of America's national history and of the rise of the industrial and scientific greatness of America. These future leaders of our Nation cannot help being wiser in all that they do concerning our country if they see in our halls examples of the ingenious productions of the great inventors and leaders of the past. The very fact that other countries of the world in recent years have voiced their pride in their eminent inventors indicates something of the importance of emphasizing America's great inventive contributions of human society in building our own Nation's morale.

This year certain facts were presented to the Congress concerning the fundamental needs of the Smithsonian Institution. Without exception, the press comments on these statements from all parts of the country agreed that the Smithsonian has a significant place in our Nation's life and that its work should be adequately supported.

The history of the Smithsonian makes clear how the present financial situation of the Institution has arisen. Almost all our endowments were given for various specific purposes. Therefore, little of the income from the invested funds of the Institution is available for alteration or growth from year to year. In this connection, it is a pleasure to report that a few small funds from bequests have come to the Smithsonian during the current year. Those who are connected with the administration of the Smithsonian are delighted at any time to discuss with prospective donors the means by which their gifts can support the general work of the Institution.

The bureaus of the Smithsonian which are financed in varying degrees by congressional appropriations have developed through the years in an uneven way. In general, it may be said of the continuing activities of the Institution that instead of expanding in the last 20 years, which have seen so much growth in many activities of the Federal Government, the Smithsonian has financially remained static or even in some respects has retrogressed. A comparison of the situation in 1934 and in the present year is illuminating. In the period since 1934 the national collections in charge of the Smithsonian have increased 130 percent. The number of visitors to our 5 exhibition buildings on the Mall have increased by more than 150 percent and our correspondence in answering scientific and other questions has grown several times that amount.

In spite of this growth in work load, the total number of man-hours per week available at the Smithsonian has actually decreased during the past 20 years. In cash, the appropriations for functions other than personnel is $11,000 less than it was in 1933. This means that in purchasing power the Smithsonian has had its funds cut more than in half during this period.

The Honorable Charles R. Jonas, Member of Congress from North Carolina, in a published news report to his constituents this year com-

paring our national expenditures for military affairs with those at the Smithsonian, said in part, "So there are two of our outstanding national collections—the study at the Smithsonian of man's constructive progress, and the study at Aberdeen of man's destructive progress. In both cases we can marvel at and feel proud of American ingenuity and energy . . . But at Aberdeen, there is mixed with our pride a certain sadness and shame that American thought and wealth must of necessity be spent on a collection of terrible weapons to use against other men. Billions for war, pennies for cultural life . . . what a tragic arrangement of accounts."

The Smithsonian is not an "inflated agency," but rather one that in recent decades has not been permitted to perform for the citizens of this country its many basic functions as well as it would have been able to do if it had been given more financial support. During this time, however, the loyal but numerically declining staff of the Institution has carried on approximately 150 percent more work than was required of their more numerous predecessors.

All who are interested in the welfare of the Smithsonian must, therefore, it seems, be prepared to explain its unique and fundamental place in American life to all responsible individuals, both inside and outside our Government, who can assist in its development. I am happy to report that appropriations made to the Smithsonian for the fiscal year 1954 will allow the Institution to take some first steps in the long-overdue rehabilitation of its exhibitions and in the needed renovations of certain of its buildings. Funds to continue modernization and renovation will be most urgently needed in the succeeding years. In the near future plans must also be made for new buildings to relieve the now almost intolerable overcrowding of our present structures.

In its basic charter the Smithsonian was established, as Smithson its wise donor directed, to provide for "the increase and diffusion of knowledge among men." The importance of these functions in the welfare of a nation becomes more clear with each passing year. Can anyone doubt that the sensible and constructive growth of our free institutions is based upon a clear knowledge by most of our citizens of the factors that have made our past achievements and activities possible? Our American conception of social progress is based on a realization that advancement is founded on a willingness to take advantage of improvements in the existing way of doing things. We do not intend to have here the destructive and self-defeating chaos produced by revolutionary upheavals. We must thus insure as wide a dissemination as possible of a knowledge of the past achievements of our Nation and of its natural resources.

It is symbolic of the mission of the Smithsonian that what has been called "the No. 1 Museum Item of America," the great flag Fran-

cis Scott Key watched as he wrote the "Star-Spangled Banner," is proudly displayed in our halls. In this dangerous time of the world's history, when free institutions continue to be challenged by totalitarian ideologies, a true knowledge on the part of our citizens of the story of our country's rise to preeminence is important. This amazing national growth is illustrated in many Smithsonian exhibits. Thus the honored old Smithsonian Institution provides today one of the means by which a forward-looking American can pass on to new generations a true understanding of our free heritage as a society that stands for liberty under law.

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

The Institution suffered a great loss during the year in the death of two of its most valued regents. Eugene E. Cox, member from the House of Representatives, died on December 24, 1952, and to fill the vacancy created the Speaker of the House appointed Representative Leroy Johnson, of California, to serve until the fourth Wednesday in December in the second year succeeding his appointment. The death of Harvey N. Davis, which occurred on December 3, 1952, created a vacancy in the class of citizen regents, but this had not been filled at the end of the year.

When the opposite political party becomes the majority party, it is required that one of the members of the Board resign. Senator Walter F. George, therefore, submitted his resignation to the Vice President since he was the most recent Democrat to be appointed to the Board of Regents. This vacancy was filled by the appointment of Senator Robert A. Taft, of Ohio, on March 9, 1953.

On January 20, 1953, Vice President Richard Nixon became an ex officio member of the Board to succeed the Honorable Alben W. Barkley.

The roll of regents at the close of the present fiscal year was as follows: Chief Justice of the United States Fred M. Vinson, Chancellor; Vice President Richard Nixon; members from the Senate: Clinton P. Anderson, Leverett Saltonstall, Robert A. Taft; members from the House of Representatives: Clarence Cannon, Leroy Johnson, John M. Vorys; citizen members: Vannevar Bush, Arthur H. Compton, Robert V. Fleming, and Jerome C. Hunsaker.

On the evening of January 15, 1953, preceding the annual meeting, an informal dinner meeting of the Board was held in the main hall of the Smithsonian Institution, with the Chancellor, Chief Justice Vinson, presiding. This followed a custom established in 1949 at the suggestion of Chancellor Vinson, who believed that an evening meeting each year would help the regents by further acquainting them with the scientific and scholarly work of the Institution. Several research workers representing different departments of the Institution were present and gave brief firsthand accounts of their recent studies to the Board members.

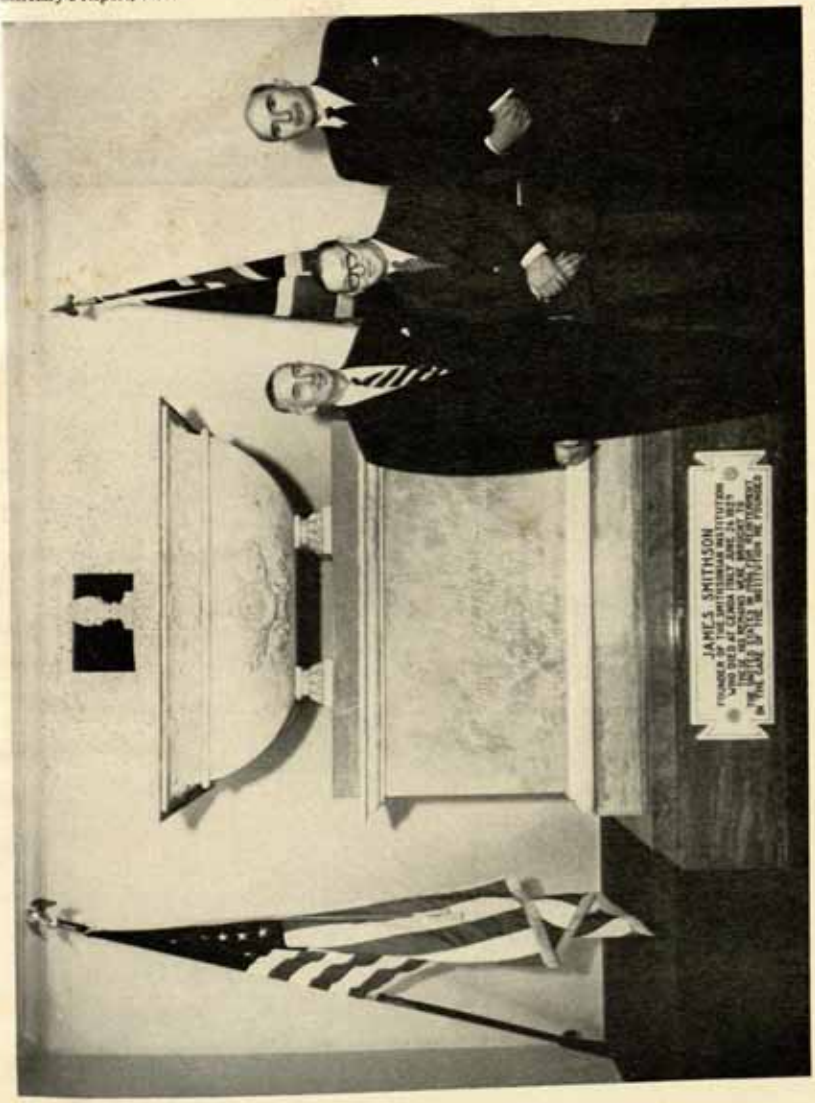
The regular annual meeting of the Board was held on January 16 in the Regents Room. The Secretary gave his annual report covering the activities of the Institution and its bureaus. The financial report of the executive committee was presented for the fiscal year ended June 30, and this was accepted by the Board. The usual resolution was passed authorizing expenditures of the income of the Institution for the fiscal year ending June 30, 1954.

INDUCTION OF NEW SECRETARY

Dr. Leonard Carmichael, psychologist and former president of Tufts College, who had been elected seventh Secretary of the Smithsonian Institution by the Board of Regents at its meeting on April 9, 1952, took office on January 2, 1953. Special induction ceremonies were held in the Regents Room, with the Honorable Harold M. Stephens, chief judge of the United States Court of Appeals, administering the oath of office. Dr. Carmichael succeeded Dr. Alexander Wetmore, biologist, who retired after serving 28 years with the Institution, since 1945 as Secretary. Dr. Wetmore, as research associate, is continuing his scientific work with the Smithsonian.

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 159.



Ceremonies at the Smithsonian Institution, June 24, 1953, when a British Union Jack was presented to be displayed at the tomb of James Smithson, whose bequest 124 years ago founded the Institution "for the increase and diffusion of knowledge among men." Left to right: Dr. Leonard Carmichael, Secretary of the Smithsonian Institution; Sir John Cockcroft, chairman of Britain's Defense Research Policy Committee; and Sir Roger Makins, British Ambassador to the United States.

APPROPRIATIONS

Funds appropriated to the Institution for the fiscal year ended June 30, 1953, total $2,419,500, obligated as follows:

Management	$57,289
United States National Museum	765,514
Bureau of American Ethnology	59,454
Astrophysical Observatory	119,840
National Collection of Fine Arts	43,619
National Air Museum	145,242
Canal Zone Biological Area	7,000
International Exchange Service	65,664
Maintenance and operation of buildings	864,945
Other general services	290,528
Unobligated	405
Total	2,419,500

In addition $1,428,050 (of which $13,825.80 was unobligated) was appropriated to the National Gallery of Art, and $615,000 was provided in the District of Columbia appropriation act for the operation of the National Zoological Park.

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

From the Institute of Inter-American Affairs, $24,287.37 for the operation of the Institute of Social Anthropology through December 31, 1953.

From the National Park Service, Department of the Interior, $122,700 for archeological projects in connection with the River Basin Surveys.

From the National Science Foundation, $6,000 to supplement Smithsonian funds for the transportation of exchange publications through the International Exchange Service.

VISITORS

Visitors to the Smithsonian group of buildings during the year 1952–53 again topped all previous records, totaling 3,429,429, or 3,392 more than the previous year. April 1953 was the month of largest attendance, with 535,832; August 1952 was second, with 475,102. Largest attendance for one day was 44,533 for May 9, 1953. Table 1 gives a summary of the attendance records for the five buildings. These figures, when added to the 3,231,450 estimated visitors at the National Zoological Park and 1,647,470 at the National Gallery of Art, make a total number of visitors at the Smithsonian Institution of 8,308,349.

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TABLE 1.—*Visitors to certain Smithsonian buildings during the year ended June 30, 1953*

Year and month	Smithsonian Building	Arts and Industries Building	Natural History Building	Aircraft Building	Freer Building	Total
1952						
July	73, 580	196, 035	83, 429	29, 122	7, 968	390, 134
August	84, 587	245, 475	100, 092	35, 097	9, 851	475, 102
September	45, 340	107, 327	53, 678	17, 755	6, 283	230, 383
October	37, 107	90, 921	60, 933	14, 494	5, 127	208, 582
November	30, 512	66, 385	45, 746	12, 482	3, 858	158, 983
December	19, 479	42, 224	33, 076	8, 472	2, 623	105, 874
1953						
January	25, 555	59, 076	46, 302	11, 990	3, 182	146, 105
February	29, 885	74, 429	43, 350	12, 386	3, 495	163, 545
March	35, 812	89, 224	53, 442	13, 557	4, 595	196, 630
April	92, 510	289, 714	113, 078	31, 568	8, 962	535, 832
May	80, 047	222, 349	111, 340	25, 756	8, 247	447, 739
June	68, 855	183, 454	86, 309	24, 785	7, 117	370, 520
Total	623, 269	1, 666, 613	830, 775	237, 446	71, 308	3, 429, 429

A special record was kept of groups of school children visiting the Smithsonian. The count showed that 207,420 school children came in 5,041 groups, or about 40 to a group. These are enumerated by month in table 2.

TABLE 2.—*Groups of school children visiting the Smithsonian, 1952–53*

	Groups	Children
1952:		
July	91	2, 188
August	94	2, 337
September	76	2, 066
October	210	6, 292
November	276	7, 947
December	77	1, 723
1953:		
January	178	4, 127
February	225	5, 658
March	426	14, 179
April	1, 393	76, 193
May	1, 414	61, 471
June	581	23, 239
Total	5, 041	207, 420

TWENTIETH ANNUAL JAMES ARTHUR LECTURE ON THE SUN

In 1931 the Institution received a bequest from James Arthur, of New York, a part of the income from which was to be used for an annual lecture on some aspect of the study of the sun. The twentieth Arthur lecture was delivered in the auditorium of the Natural History Building on the evening of May 21, 1953, by Dr. C. E. Kenneth Mees,

director of the research laboratories of the Eastman Kodak Co., Rochester, N. Y. The subject of Dr. Mees's address was "Recent Advances in Astronomical Photography." This lecture will be published in full in the general appendix of the Annual Report of the Board of Regents of the Smithsonian Institution for 1953.

JAMES SMITHSON'S TOMB

Ceremonies were held on the afternoon of June 24, 1953, in connection with the rededication of the tomb of James Smithson, founder of the Smithsonian Institution, which is located in a small chapel near the north entrance of the Smithsonian Building. Speakers for the occasion, which marked the 124th anniversary of Smithson's death in Genoa, Italy, were Sir Roger Makins, British Ambassador to the United States; Sir John Cockcroft, Chairman of the Defense Research Policy Committee of Great Britain; and Dr. Leonard Carmichael, Secretary of the Smithsonian Institution. The Ambassador and Sir John, on behalf of the British people, presented a Union Jack to be displayed with the Stars and Stripes beside the tomb as a "symbol of international understanding."

The next day following the ceremonies William W. Johnson, of the Treasurer's Office, was presented with a certificate of award for his original suggestion that Smithson's crypt be redecorated.

TERMINATION OF THE INSTITUTE OF SOCIAL ANTHROPOLOGY

At the end of the calendar year 1952, the activities of the Institute of Social Anthropology came to an end with the termination of grants from the Institute of Inter-American Affairs, Department of State, under which the Institute had operated. This agency was created in 1943 as an autonomous unit of the Bureau of American Ethnology to carry out cooperative training in anthropological teaching and research with the other American republics as a part of the wartime program of the Interdepartmental Committee for Cooperation with the American Republics. Its first director and founder was Dr. Julian H. Steward, who was succeeded in 1946 by Dr. George M. Foster. Summaries of the work of the Institute have been included each year within the report of the director of the Bureau of American Ethnology. One of the lasting monuments of the agency is the 16 monographs in the Smithsonian series entitled "Publications of the Institute of Social Anthropology," the final number of which appeared in 1953. Several anthropologists remaining on the Institute of Social Anthropology staff on December 31, 1952, were transferred to the Institute of Inter-American Affairs.

RENOVATION OF NATIONAL COLLECTION OF FINE ARTS

A complete rearrangement of the paintings and art objects in the National Collection of Fine Arts was completed in May under the supervision of its director, Thomas M. Beggs. The collection, housed in the Natural History Building, consists of several major bequests to the Nation through the Smithsonian. Terms of the bequests sometimes require that the collections be preserved as entities, although they often consist of paintings quite miscellaneous, both in subject matter and style. Compliance with these terms sometimes has been difficult, especially with the limited space available for exhibition of constantly increasing material. This problem has been solved by the rearrangement in which paintings from the different collections representing various nationalities are grouped in adjacent alcoves without breaking up the integrity of any collection.

Nucleus of the rearrangement is the Harriet Lane Johnston collection, bequeathed to the Nation by the niece of President James Buchanan and First Lady of the White House during his administration. It was this bequest, quite typical of the Civil War period taste in art and containing such relics as the Bible used by President Buchanan at his inauguration, that started the original National Gallery of Art. This collection is maintained in its entirety in the new arrangement. This is also true of the Ralph Cross Johnson, John Gellatly, and Alfred Duane Pell collections. Other large collections are represented by only a few examples. These include the William T. Evans collection, the Henry Ward Ranger bequest, and the A. R. and M. H. Eddy donation.

SUMMARY OF THE YEAR'S ACTIVITIES OF THE BRANCHES OF THE INSTITUTION

National Museum.—The collections of the National Museum increased by more than 1,607,000 specimens during the year, a million more than the previous year, bringing the total catalog entries to 34,764,250. Some of the year's outstanding accessions included: In anthropology, more than 300 chipped-stone artifacts from Dauphin County, Pa.; 2,000 potsherds from Transjordan and Palestine; and a fine collection of ceramic ware representing New England folk pottery; in zoology, more than 1,000 mammals from South West Africa, about 2,400 bird skins and skeletons from Colombia, 14,000 fishes from Bermuda and the Caribbean, 14,000 ladybird beetles, and 3,200 identified polychaete worms; in botany, 45,000 plant specimens from Ecuador and Colombia; in geology, an array of minerals, gems, and meteorites, 500,000 Arctic Foraminifera, and several excellent fossil vertebrate remains; in engineering and industries, about 500 radio and electronic devices and a collection of lithographic materials and equip-

ment; and in history, a fine lot of laces, linens, and jewelry from Mrs. Woodrow Wilson, a dress of Mrs. Harry S. Truman for the First Ladies collection of gowns, and 93 pistols for the modern firearms series.

Members of the staff conducted fieldwork in Panama, British Guiana, South West Africa, Thailand, Tahiti, Mexico, Fiji Islands, and many parts of the United States. The Museum issued 18 publications.

National Gallery of Art.—The Gallery had 1,647,470 visitors during the year, an 8-percent increase over 1951–52. In all, 1,408 accessions were received, by gift, loan, or deposit. Works of art accepted included paintings by A. V. Tack, Manet, Berthe Morisot, Sir William Orpen, Leonid, John Kensett, Cranach, Van Dyck, P. Gertner, A. Benson, and B. Bruyn; a bust of Whistler by Sir Joseph Boehm; and several groups of prints and drawings. Nine special exhibitions were held. Traveling exhibitions of prints from the Rosenwald Collection were circulated to 17 galleries and museums in this country and 1 in Canada. Exhibitions from the "Index of American Design" were given 58 bookings in 21 States and the District of Columbia and also in Germany, Austria, Italy, Greece, Turkey, and Palestine. Over 43,000 persons attended the Gallery's special tours and the "Picture of the Week" talks, and 14,000 attended the 39 auditorium lectures on Sunday afternoons. The Sunday evening concerts in the west garden court were continued.

National Collection of Fine Arts.—The Smithsonian Art Commission met on December 2, 1952, and accepted for the National Collection 3 oil paintings, 1 sculpture, 5 pieces of modern glass, and 4 ceramic pieces. An addition of $5,000 was made to the Barney fund. The Gallery held 13 special exhibitions during the year. The Smithsonian Traveling Exhibition Service circulated 32 exhibitions, 20 in the United States and Canada and 12 abroad.

Freer Gallery of Art.—Purchases for the collections of the Freer Gallery included Chinese painting, bronzes, metalwork, jade, lacquer, and pottery; Persian paintings, pottery, and manuscripts; Indian paintings; and Japanese pottery. More than 71,000 persons visited the Gallery. In May the Gallery adopted a new plan of keeping open to the public on Tuesday evenings, with occasional lectures.

Bureau of American Ethnology.—The anthropologists of the Bureau staff continued their researches, Dr. Stirling on mid-American archeology, Dr. Collins on the Eskimo and Arctic anthropology, Dr. Harrington on Indian linguistics and the California Indians, and Dr. Drucker on the ethnology of Mexico and the northwest coast of North America. Dr. Roberts continued as Director of the River Basin Surveys, and Dr. Foster as Director of the Institute of Social Anthropology (to the time of its termination on December 31).

International Exchange Service.—As the official United States agency for the interchange of governmental, scientific, and literary publications between this country and other nations of the world, the International Exchange Service during the year handled 1,021,938 packages of such publications, weighing 855,102 pounds. This was 20,324 packages and 29,475 pounds more than the previous year. Consignments were made to all countries except China, North Korea, and Rumania. Toward the end of the year, a grant of $6,000 was received from the National Science Foundation to supplement funds for the transportation of exchange publications that otherwise would have been delayed.

National Zoological Park.—The Zoo received 810 accessions during the year, comprising 1,797 individual animals, and 1,731 were removed by death, exchange, et cetera. The net count of animals at the end of the year was 2,741. Noteworthy among the accessions were 2 Barbary apes, a Formosan civet never before exhibited in the Zoo, 3 East Indian monitor lizards, a young flat-tailed otter from Brazil, also the first of its kind to be exhibited here, and 2 of the rare Allen's monkeys. In all, 247 creatures were born or hatched at the Zoo during the year—95 mammals, 119 birds, and 33 reptiles. Visitors totaled approximately 3,231,000.

Astrophysical Observatory.—The manuscript of volume 7 of the Annals of the Astrophysical Observatory was completed and sent to the printer late in the year. Mr. Hoover completed a thorough study of the silver-disk pyrheliometer. Two of these instruments were built in the APO shops for other institutions. Solar-radiation studies were continued at the Observatory's two field stations—at Montezuma, Chile, and Table Mountain, Calif. Research carried on by the Division of Radiation and Organisms concerned mainly physiological and biochemical processes by which light regulates plant growth and the mechanisms of the action of the auxin-type growth hormones, and several scientific papers were published.

National Air Museum.—Providing adequate storage facilities for the space-consuming material awaiting a National Air Museum building continues to be a serious problem. Twenty loads of material were brought from Park Ridge, Ill., to the new storage facility provided at Suitland, Md. The Museum staff has helped in the celebration of the Fiftieth Anniversary of Powered Flight, participated in many special aeronautical events and exhibits, and inspected material for possible accession, besides taking care of the collections. The Museum received 32 accessions (totaling 112 specimens) from 28 sources. Full-sized aircraft received included a Douglas DC–3 transport plane that had traveled 8½ million air miles, the *Excalibur III* in which a series of historic flights were made, the original *Hiller-copter*, and a German Messerschmitt Me 163 rocket interceptor. At the end of the year

manuscript of a new edition of the Handbook of the Aeronautical Collections was nearly completed.

Canal Zone Biological Area.—New diesel generators installed at the station now insure an adequate supply of electric current. A number of other necessary improvements were made. During the year 700 visitors came to the islands, a hundred more than the previous year; 57 of these were scientists who used the facilities of the island to further their various researches, chiefly in biology and photography.

LIBRARY

Accessions to the Smithsonian library totaled more than 68,414 publications during the year, these coming from more than 100 foreign countries. One of the most notable gifts of the year was a large and valuable collection of books and periodicals on philately presented by Eugene N. Costales, of New York. At the close of the year the holdings of the Smithsonian library and all its branches aggregated 941,328 volumes including 584,295 in the Smithsonian Deposit at the Library of Congress but exclusive of incomplete volumes of serials and separates and reprints from serials.

PUBLICATIONS

Eighty-one publications were issued under the Smithsonian imprint during the year. (See Appendix 12 for complete list.) Outstanding among these were: "Primitive Fossil Gastropods and Their Bearing on Gastropod Classification," by J. Brookes Knight; "Structure and Function of the Genitalia in Some American Agelenid Spiders," by Robert L. Gering; "Dresses of the First Ladies of the White House," by Margaret W. Brown; "The Generic Names of the Beetle Family Staphylinidae," by Richard E. Blackwelder; "Life Histories of North American Wood Warblers," by A. C. Bent; "Catalog of the Cycle Collection of the Division of Engineering, U. S. National Museum," by Smith Hempstone Oliver; "The Indian Tribes of North America," by John R. Swanton; "La Venta, Tabasco: A Study of Olmec Ceramics and Art," by Philip Drucker; and "Prehistoric Settlement Patterns in the Virú Valley, Peru," by Gordon R. Willey. In all, 177,675 copies of Smithsonian publications were distributed during the year. The galley proof of the ninth edition of the Smithsonian Physical Tables was being read by the compiler, Dr. W. E. Forsythe, at the end of the year.

APPENDIX 1

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, 1953:

COLLECTIONS

Specimens incorporated into the national collections totaled 1,607,911 (more than twice the number received last year) and were distributed among the six departments as follows: Anthropology, 10,540; zoology, 211,677; botany, 82,984; geology, 1,275,140; engineering and industries, 2,008; and history, 25,562. The unusual increase is attributable chiefly to the accessioning of a large number of small fossils, including 750,000 Permian invertebrates and 500,000 Arctic Foraminifera. Most of the other accessions were acquired as gifts from individuals or as transfers from Government departments and agencies. The Annual Report of the Museum, published as a separate document, contains a detailed list of the year's acquisitions, of which the more important are summarized below. Catalog entries in all departments now total 34,764,250.

Anthropology.—A collection of 315 chipped-stone artifacts, including fluted projectile points and other man-made objects that suggest a Paleo-Indian culture, from the Shoop site, Dauphin County, Pa., is of particular interest. The Carnegie Institution of Washington, in continuation of their generous cooperation, donated a collection of potsherds representing type objects from excavated sites in the Maya area.

Through an exchange with the Denver Art Museum, the division of ethnology acquired two ceremonial bundles that were formerly used by northern Blackfoot Indians in the rites for tobacco planting. A rare and valuable Chinese Lamaist robe, of dark blue silk and embellished with over-all couching of braided silk and embroidery in metallic gilt, was presented by Maj. Lee Hagood who had acquired it in Shanghai in 1918. Objects recovered from historical sites of villages, trading posts, and factories in Virginia, Maryland, Delaware, New York, and Massachusetts and other New England States were received from various donors. Of outstanding interest and usefulness to the collector and student of early American ceramics are 189 pieces of redware, stoneware, and other types of New England folk pottery presented by Mrs. Lura Woodside Watkins. These pottery fragments excavated from sites of New England potteries in existence between

1687 and 1880 were assembled by Mrs. Watkins as a study collection for use and illustration in her "New England Potters and Their Wares." Another important addition, presented by Mrs. Florence Bushee of Newbury, comprises 320 fragments and whole specimens of glass and ceramics excavated by the late Charles H. Danforth at the site of the Boston and Sandwich Glass Co. factory at Sandwich, Mass.

A cast of the Hotu II skull excavated in Iran in 1951 was donated by the Wenner-Gren Foundation for Anthropological Research and the American Institute of Human Paleontology.

Zoology.—More than 1,000 mammals collected by Charles O. Handley, Jr., in the Kalahari Desert region of South West Africa, while serving as a member of the Peabody-Harvard expedition under the leadership of L. K. Marshall, were added to the collection. Nearly 500 small mammals were received from various units and members of the military services stationed in Korea and Japan. As transfers the Museum received 47 mammals of Madagascar from Lt. Vernon J. Tipton, United States Army Medical Service Graduate School; and a series of rodents from the Marshall, Gilbert, Phoenix, and Tahiti Islands from investigators working under the auspices of the United States Geological Survey and the Pacific Science Board of the National Research Council. Dr. Henry W. Setzer, while giving instruction on the preparation of specimens for purposes of documentation to members of a U. S. Army medical unit, obtained 156 mammals in Panama.

On the termination of fieldwork in Colombia by M. A. Carriker, Jr., whose collecting has been financed for several years by the income from the W. L. Abbott bequest, 2,174 skins and 225 skeletons of birds were forwarded to the Museum. The Abbott bequest also provided funds for the purchase of 349 skins of birds from Northern Rhodesia. Dr. Harry M. Smith presented 386 skins of birds taken in northern Burma. As transfers the Museum received 58 Alaskan bird skins from the Public Health Service's Arctic Health Research Center at Anchorage and 49 skins and 20 skeletons of birds from the Office of Naval Research taken in the vicinity of Point Barrow, Alaska.

Collecting on various islands in the Pacific Ocean, chiefly in the Marshall and Gilbert Islands and the Tuamotus, under the auspices of the Pacific Science Board by Joe T. Marshall, Edwin T. Moul, and J. P. E. Morrison, and of the United States Geological Survey by F. R. Fosberg, resulted in the transfer of 365 lizards to the Museum.

More than 14,000 specimens of fishes obtained by Dr. William Beebe in Bermuda and the Caribbean area were presented by the New York Zoological Society. Other important accessions recorded were some 1,500 fishes from the *Blue Dolphin* North Atlantic expeditions under the leadership of Comdr. David C. Nutt; 528 fishes from the Gulf of Mexico and the coast of Washington transferred by the United

States Fish and Wildlife Service; 67 paratypes of Mexican fishes from Dr. José Alvarez; and 582 fishes from the Red Sea collected by Dr. Eugenie Clark. As exchanges there were received 144 fishes, including 32 holotypes and paratypes, from the University of Hawaii, and 161 specimens, representing 100 species of Indian fishes, from the Zoological Survey of India.

The Korschefsky collection of ladybird beetles, comprising over 14,000 specimens and containing 1,445 named species representing 206 genera, was acquired by purchase by the Smithsonian Institution, thus increasing the usefulness of the reference series for this family of beetles. As a result of the gift of 539 termites, comprising 96 species hitherto unrepresented in the collections, of which 65 were represented by type material, by Dr. Alfred Emerson, University of Chicago, the national collections now contain representatives of more than 1,000 of the 1,800 known species.

Over 3,200 identified polychaete worms were presented by Dr. Marian H. Pettibone, of the University of New Hampshire. As transfers from the Pacific Science Board, the Division of Marine Invertebrates received 3,412 forms of marine life found on Raroia Atoll in the Tuamotus; 3,980 invertebrates collected on the northern Marshall and Gilbert Islands from the United States Geological Survey; and more than 10,000 identified peneid shrimps and some 500 miscellaneous crustaceans and other marine invertebrates of the Gulf of Mexico from the Fish and Wildlife Service. About 800 holotypes and paratypes were added to the marine-invertebrate collections by the donors who described the new species.

Mollusks from atolls in the northern Marshall Islands, Onotoa Atoll in the Gilbert Islands, Raroia in the Tuamotus, and localities in the Fiji, Cook, and Society Islands were transferred by the Pacific Science Board and the United States Geological Survey. Approximately 2,000 land, fresh-water, and marine mollusks from Stewart Island, New Zealand, were presented by Miss Olive Allan, A representation of almost all known races and colonies of the colorful tree snails (*Liguus*) of Florida, totaling 1,680 specimens, was received from Ralph H. Humes. Dr. George R. LaRue, University of Michigan, one of the leading American parasitologists, presented 1,200 lots of tapeworms and digenetic trematodes. Nearly 100 echinoderms from Onotoa Atoll collected by Dr. P. E. Cloud, Jr., and 707 from the Marshall Islands collected by F. S. MacNeil were transferred by the United States Geological Survey.

Botany.—An important addition to the South American collections resulted from the transfer to the National Herbarium from the herbarium of the National Arboretum, United States Department of Agriculture, of 45,000 botanical specimens collected in Ecuador and Colombia by the staffs of the Cinchona missions. The Division of

Plant Introduction and Exploration, United States Department of Agriculture, transferred 704 specimens from Turkey and South Africa and 963 specimens from southern Brazil. Australian plants collected by L. R. Specht while participating in the National Geographic Society–Smithsonian Institution–Commonwealth of Australia expedition to Arnhem Land were presented by the Australian Government.

Gifts included 283 plants of the table mountains of Venezuela from the New York Botanical Garden; 1,693 Virginia plants from H. A. Allard; 498 specimens, mostly from the Amazon region, from the Instituto Agronomico do Norte, Belém, Pará, Brazil; and 446 Colombian plants from the Instituto de Ciencias Naturales, Bogotá.

As exchanges, several large collections were received, of which reference may be made to 2,070 specimens, mostly from Cuba, from the Naturhistoriska Riksmuseet, Stockholm; 1,312 specimens from the Komarov Botanical Institute, Academy of Sciences, U. S. S. R.; and 579 specimens from the Belgian Congo from the Jardin Botanique de l'État, Brussels.

E. P. Killip collected 2,281 plants for the Museum on Big Pine Key, Fla., and the Isle of Pines, Cuba. Fieldwork by Dr. Ernest R. Sohns in Guanajuato, Mexico, added 875 specimens to the herbarium.

Geology.—Noteworthy gifts received include an exhibition group of datolite crystals from Joseph S. Rapalus; uranium minerals from Utah from George Dix; and a large polished slab of rhodocrosite of rich rose color obtained in Argentina from Ellis Clarke Soper.

A fine crystal of gadolinite from Norway, an aquamarine (beryl) crystal from Russia, a large specimen of vanadinite from Mexico, several groups of unusual cyrtolite crystals from Colorado, and a milarite crystal from Switzerland were added to the Roebling Collection.

Included among the additions to the Canfield Collection were a large and unusual cruciform twin crystal of quartz from Mexico, a group of quartz crystals from Madagascar, an emerald crystal from Austria, an opal from Australia, and a large green tourmaline crystal from Brazil. The Chamberlain bequest provided funds for the purchase of a 28.8-carat green apatite from Burma and a 17.3-carat pink scapolite cat's-eye from Ceylon. A very unusual golden beryl cat's-eye from Madagascar, weighing 43 carats, was acquired for the gem collection by exchange. Dr. Stuart H. Perry continued his interest in the meteorite collection by donating a sample of the unique Soroti, Uganda, meteorite; other meteorites, mostly from the United States, were acquired by gift or purchase.

As gifts, the Museum received Permian gastropods from the Florida Mountains, N. Mex., Miocene mollusks from Bogachiel River, Wash., Cretaceous and Tertiary Foraminifera from Egypt, Cretaceous invertebrates from Texas, Permian invertebrates from Sicily, Devonian

fossils from Iowa, Tertiary invertebrates from Trinidad, and Foraminifera from the Gulf of Mexico.

Through funds provided by the Springer bequest, the Museum acquired 11 type specimens of Carboniferous and Ordovician crinoids and 45 metatypes of other Ordovician crinoids from Oklahoma. The Museum purchased under the Walcott bequest Mesozoic invertebrates from the Austrian Alps and Tertiary and Mesozoic brachiopods from Sicily. Fieldwork financed by the same bequest resulted in the collection in Mexico of 900 rock samples containing Foraminifera by Dr. A. R. Loeblich, Jr., and Dr. David H. Dunkle, and 10,000 invertebrates by Dr. G. A. Cooper, Arthur L. Bowsher, and William T. Allen in New Mexico, Texas, and Missouri.

Six transfers were received from the United States Geological Survey, among which were specimens sorted out from the deep-sea cores obtained in the North Atlantic. Another transfer, received from the Office of Naval Research, contains the type specimens of fossil woods from the Cretaceous of Alaska described by Dr. C. A. Arnold, of the University of Michigan.

One of the largest accessions, 500,000 Arctic Foraminifera, includes materials obtained during cruises of the U. S. S. *Albatross* vessels under the command of Capt. R. A. Bartlett and Comdr. David C. Nutt, and specimens obtained by Dr. A. R. Loeblich, Jr., under a grant from the Office of Naval Research.

New and interesting specimens have been acquired by exchange, including many genera and species of Foraminifera not hitherto represented in the collections, 158 invertebrates from the Triassic of England and the Tertiary of Germany, 355 Austrian Triassic brachiopods from the Naturhistorisches Museum, and 69 Paleozoic and Cenozoic brachiopods from Japan from the National University, Yokohama.

Transfers from the Smithsonian River Basin Surveys include, among others, a nearly complete skeleton of the fossil reptile *Champsosaurus* from the Paleocene of North Dakota, a plesiosaur skeleton from the Upper Cretaceous of Wyoming, and some 70 specimens of mammals from Oligocene and Miocene strata of the Canyon Ferry Reservoir area in Montana, all collected by Dr. T. E. White. An important assemblage of Paleocene mammalian jaws and teeth from the Bison basin in central Wyoming as well as several small collections of mammals from Eocene beds of the Powder River and Wind River basins in Wyoming and from the Eocene and Oligocene in Montana were transferred by the United States Geological Survey. Lower and Middle Cretaceous fishes were collected in Mexico by Dr. David H. Dunkle under the income of the Walcott bequest. An excellent collection of cetacean and other mammalian remains from the Miocene of the Chesapeake Bay region made by the late Dr. R. Lee Collins was presented to the Museum by his wife.

Engineering and industries.—Nearly 500 electronic and radio devices collected and preserved by the late L. C. F. Horle, radio pioneer and engineer, were presented by Mrs. Susan Horle. Of equal interest is a small planing machine reputed to have been used to plane bamboo for the filaments of early Edison lamps, presented by Dr. Vannevar Bush. Allen Pope presented a gasoline engine made about 1898 by his father, Harry Pope, to power an experimental automobile. An apparatus for taking core samples of the ocean bottom, perfected by Dr. Charles S. Piggot and received from the Carnegie Institution of Washington, has considerable historical significance inasmuch as the subsequent development of this instrument has vastly extended knowledge of the ocean floor.

From Dr. Selman A. Waksman the Museum received the original shaking machine and innoculating needle used by him in the experiments that resulted in the discovery of the antibiotic streptomycin.

Another outstanding accession was the gift by the Lithographers National Association, Inc., of 142 lithographs, plates, and other technical materials which will be used in preparing a display of the history and techniques of offset lithography. José Ortiz Echagüe, a distinguished Spanish pictorial photographer, presented 15 of his carbon fresson process prints. Six prints by the English pictorialist, the late Alexander Keighley, were received from his estate.

A scale model of the Fourdrinier papermaking machine was presented by the Hammermill Paper Co., and one of a modern cotton ginning mill constructed at the United States Cotton Laboratory, Stoneville, Miss., was transferred from the United States Department of Agriculture. A pictorial quilt of Fort Dearborn, made about 1815, was received from Mrs. John H. Snyder.

As exchanges, the Museum acquired 20 specimens of woods of Thailand from the Royal Forest Department, Bangkok. Study sets of the woods of New Zealand, Sarawak, and Iriomote Islands were also added to the collection.

History.—Of particular interest among the accessions was the gift by Mrs. Woodrow Wilson of the laces, embroidered linens, and a large gold, diamond, and lalique glass brooch presented to her when she accompanied President Wilson to Europe in 1919. The collection of dresses of the First Ladies of the White House was augmented by the dress given by Mrs. Harry S. Truman to represent the administration of President Truman, 1945–1953. A black crepe dress worn by Queen Victoria of the United Kingdom about 1880 was given to the costume collection by Mrs. Langley Moore, of the London Museum of Costume.

The Department of Justice transferred 93 pistols needed to complete the series of modern firearms in the division of military history.

Further additions to the Straub collection of gold and silver coins were made by Paul A. Straub.

The Post Office Department transferred to the division of philately 3,198 recently issued stamps which had been distributed by the Universal Postal Union. Gifts of stamps also were received from the Governments of Monaco, Philippines, Netherlands, Nicaragua, Czechoslovakia, Poland, Australia, and Norway, and from the United Nations Postal Administration. Outstanding additions to the philatelic collection were as follows: 12 volumes of stamps of Convention States of India from an anonymous donor; carrier stamps and rare foreign stamps from Philip H. Ward, Jr.; Nesbitt dies and postal fiscal stamps of Austria-Hungary from B. H. Homan; and United States precancels and Bureau print precancel errors from John R. Boker, Jr.

EXPLORATION AND FIELDWORK

At the invitation of Princeton University, Dr. Waldo R. Wedel, curator of archeology, participated from July until September 1952 as the representative of the Smithsonian Institution in the interpretation of the archeological aspects of a site near Cody, Wyo., occupied nearly 7,000 years ago by aboriginal hunters of buffalo. Ninety-five archeological sites located in the Upper Essequibo, the Rupununi savannas, and the coastal area of the northwest district of British Guiana were surveyed and excavated in the interval between October 1952 and April 1953 by Dr. Clifford Evans, associate curator of archeology, under a Fulbright research grant, funds provided by the Smithsonian Institution, and grants from other sources to the coinvestigator, Dr. Betty J. Meggers. At the request of a field party of the United States Geological Survey working in the Monument Valley–Comb Ridge area of northeastern Arizona, Dr. Walter W. Taylor, collaborator in anthropology, visited 41 sites, from 17 of which sherd collections were assembled for subsequent study. At the close of the fiscal year John C. Ewers, associate curator of ethnology, was conducting field investigations of Assiniboin Indian arts and crafts on Fort Peck and Fort Belknap Reservations, Montana.

During the last half of the year 1952, Charles O. Handley, Jr., assistant curator of mammals, observed and collected mammals in the Kalahari Desert region of northeastern South West Africa while assigned to the Peabody-Harvard ethnological expedition. Following arrival at Walvis Bay on July 1, 1953, the party, under the direction of L. K. Marshall, proceeded to Windhoek which served as a base for the 6-months investigation of the primitive Bushmen residing in the desert south of Okavongo River. Maun in Bechuanaland was the easternmost locality visited. In June 1953 Mr. Handley also made a short field trip to the Dismal Swamp of Virginia to obtain additional data for inclusion in a memoir on that swamp sponsored by the Virginia Academy of Sciences. At the request of the Army Medical

Services, Dr. Henry W. Setzer, associate curator of mammals, was given a detail in January and February 1953 to proceed to the Canal Zone of Panama to give instruction to members of the 25th Preventive Medicine Survey Detachment on the collection and preparation of study specimens of mammals involved in the parasitological and epidemiological investigations of tropical diseases, and on the completion of this assignment he devoted a few days to the study of the fauna of Barro Colorado Island.

During May and June, Dr. Alexander Wetmore, research associate, assisted by W. M. Perrygo of the National Museum, carried on field studies on the distribution of bird life in Panama in continuation of a program begun several years ago. The work this year covered an area in the southern part of the Province of Veraguas, extending from the National Highway that crosses western Panama down through the great tracts of swampy forest that lie back of the southern coast. The series of specimens obtained give valuable comparative material from an area that previously had been poorly represented in the National Museum collections. Field observations were highly interesting, since the middle of May marked the beginning of the rains, whereas most of the earlier studies had been made during the dry season of the year. Many of the resident birds exhibit marked difference in habit between the two periods. Though most of the great host of migrant birds from North America that winter here leave for the north by May, numerous records were obtained of several species of which there are groups of younger individuals that have not yet attained breeding status but that remain in these tropical areas through the summer season when the older members are on their northern nesting grounds. Ornithological fieldwork in Thailand by Herbert G. Deignan was made possible by grants from the Guggenheim Foundation and special research funds of the Smithsonian Institution. He arrived at Bangkok on October 8, 1952, and 12 days later departed for the hills west of that city accompanied by Robert E. Elbel, Mutual Security Agency, and three native assistants. Collections were made in Kanchanaburi province during October and November. Fieldwork in Prochnap Khiri Khan province, which is situated in southwestern Thailand between the Gulf of Siam and the Tenasserim Mountain range, was completed on December 31, 1952. The field party worked during January 1953 in the mountainous areas of western Nan and northern Lampang provinces on the Thailand-Laos frontier. On February 9, 1953, Deignan arrived at Chiang Rai, capital of the northernmost province, and from there proceeded to the Mekong River Valley and made collections at Chiang Saen Kao in the region where the boundaries of Burma, Thailand, and Indo-China meet. After returning to Bangkok on March 20, Deignan devoted a week to fieldwork in Ratburi province, which is situated betwen the provinces of Kanchanaburi and

Prochnap Khiri Khan. The field party then proceeded late in March to the forested area near Ban Hua Thanon in Khlong Klung Valley, province of Nakhon Sawan, where fieldwork in Thailand was terminated on May 4, 1953.

Traveling by air from Washington, D. C., Dr. Joseph P. E. Morrison, associate curator of mollusks, arrived at Viti Levu, one of the Fiji Islands, on June 11, 1952, and continued the flight on the same day to Tahiti by way of the Cook Islands. Following 10 days of collecting on Tahiti, the team for the study of coral-atoll ecology organized by the Pacific Science Board was transported, through the courtesy of the French Government, some 450 miles by schooner to Raroia Atoll, where field studies and collections were made from June 26 to September 7, 1952. Members of the field party were brought back to Tahiti by the same French schooner. Following another week of collecting on Tahiti, Dr. Morrison proceeded by air to Aitutaki in the Cook Islands and Viti Levu, the season's work being completed on September 23 at that locality.

Fieldwork by three parties engaged in search for invertebrate and vertebrate fossils was financed by the income from the Walcott bequest. Dr. G. A. Cooper, curator, Arthur L. Bowsher, associate curator, and W. T. Allen, aide, division of invertebrate paleontology and paleobotany, commenced the season's work on July 9, 1952, at Adair, Okla., where they spent 2 days collecting Mississippian fossils while en route to Pine Springs Camp in the Guadalupe Mountains of western Texas. Blocks of invertebrate fossils were quarried from the Permian reef limestone near Guadalupe Peak. On July 18 Cooper's party proceeded to Silver City, N. Mex., to obtain Devonian fossils and thence to other Devonian localities in the vicinity of Kingston, Mud Springs Mountains, Derry, the San Andreas and Sacramento Mountains near Alamogordo, and the Mimbres Mountains. Blocks of silicified upper Pennsylvanian limestone were also collected in the southern part of the Sacramento Mountains. On the return trip stops were made July 29 to August 2, at Ponca City and Tulsa, Okla., to collect Permian invertebrates, and in Missouri for Mississippian fossils.

From the middle of September until mid-December, associate curators Dr. A. R. Loeblich, Jr., and Dr. David H. Dunkle searched for Jurassic and Cretaceous invertebrates and Mesozoic and Tertiary vertebrates in eastern and southern Mexico. They made initial collections in the extensive Cretaceous beds in Coahuila and Tamaulipas and later continued the fieldwork in Puebla, Oaxaca, and Chiapas. In the course of this trip, which traversed the Sierra Madre Oriental from the vicinity of Monterrey to beyond the Isthmus of Tehuantepec, they collected Foraminifera, mollusks, and brachiopods from the Mesozoic deposits and vertebrates from an Upper Cretaceous forma-

tion in Tamaulipas, Lower Cretaceous deposits near Tlaxiaco, Oaxaca, and a Tertiary occurrence near Guanajuato.

The recently discovered occurrence of Paleocene mammals in the Bison Basin near the divide between the Red Desert and the valley of the Sweetwater River in south-central Wyoming by a field party of the United States Geological Survey led Dr. C. L. Gazin, curator of vertebrate paleontology, with the assistance of F. L. Pearce, to commence an intensive search for additional materials.

A grant from the National Science Foundation enabled Dr. A. C. Smith, curator of phanerogams, to proceed from Washington on March 6, 1953, to Fiji, where it is his intention to continue botanical field studies until January 1954 on the upland regions on south-central Viti Levu as well as on Ovalau, Taveuni, and Ngan.

Dr. Ernest R. Sohns, associate curator of grasses, devoted several weeks in October and November 1952 to collecting grasses in Mexico, mostly in the State of Guanajuato.

E. P. Killip, research associate in botany, continued his critical studies of the plants of Big Pine Key, Fla., and was engaged also for several months in collecting plants on the Isle of Pines, Cuba.

Mendel L. Peterson, acting head curator of the department of history, participated in May 1953 in the underwater investigation of the site of a Spanish ship sunk off Plantation Key, Fla. Evidence found on the wreck proved this ship to have been one of a fleet commanded by Admiral de Torres which, according to documents preserved in the Casa Lonja in Seville, Spain, was wrecked on a nearby reef during a hurricane on July 15, 1733. Hand grenades, cannon balls, swords, flintlock muskets, silver coins, and pewter utensils were recovered at the site. This fieldwork is carried on under a grant of funds from E. A. Link, of the Link Aviation Corp.

VISITORS

During the fiscal year 1953 there were 3,120,657 visitors to the Museum buildings, an average daily attendance of 8,549. This is an increase of 17,006 over the total of 3,103,651 visitors in the previous fiscal year. The 207,420 school children included in this total arrived in 5,041 separate groups. Most of them traveled by bus, and some came from localities as far distant as Montana, North and South Dakota, Texas, and Mississippi. Small groups of schoolchildren are not recorded. Almost two-thirds of all the visitors entered the Museum buildings during April to August, inclusive. April 1953 was the month of the largest attendance with 495,302 visitors; August 1952 was the next largest with 430,154; and May 1953 was third with 413,736. Attendance records for the buildings show the following numbers of visitors: Smithsonian Building, 623,269; Arts and Industries Building, 1,666,613; and Natural History Building, 830,775.

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BUILDINGS AND EQUIPMENT

During the year five office rooms assigned to the division of crafts and industries in the Arts and Industries Building were reconditioned, the work involving the construction of concrete floors, the painting of the office rooms, and replastering of one wall. Steel racks were constructed for housing 1,170 drawers, which provided accessibility to 3,860 cubic feet of anthropological materials hitherto located in essentially dead storage.

CHANGES IN ORGANIZATION AND STAFF

The vacancy in the division of medicine and public health was filled on December 8, 1952, by the appointment of George B. Griffenhagen as associate curator.

Respectfully submitted.

REMINGTON KELLOGG, *Director.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

APPENDIX 2

Report on the National Gallery of Art

SIR: I have the honor to submit, on behalf of the Board of Trustees, the Sixteenth Annual Report of the National Gallery of Art, for the fiscal year ended June 30, 1953. This report is made pursuant to the provisions of section 5 (d) of Public Resolution No. 14, 75th Congress, 1st 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, 1953, were Samuel H. Kress, Ferdinand Lammot Belin, Duncan Phillips, Chester Dale, and Paul Mellon. The Board of Trustees held its annual meeting on May 5, 1953. Samuel H. Kress was reelected President and Ferdinand Lammot Belin, Vice President, to serve for the ensuing year. Donald D. Shepard continued to serve during the year as adviser to the Board.

All the executive officers of the Gallery continued in office during the year:

Huntington Cairns, Secretary-Treasurer.
David E. Finley, Director.
Harry A. McBride, Administrator.
Huntington Cairns, General Counsel.
John Walker, Chief Curator.
Macgill James, Assistant Director.

The three standing committees of the Board, as constituted at the annual meeting May 5, 1953, were as follows:

EXECUTIVE COMMITTEE

Chief Justice of the United States, Fred M. Vinson, chairman.
Samuel H. Kress, vice chairman.
Ferdinand Lammot Belin.
Secretary of the Smithsonian Institution, Dr. Leonard Carmichael.
Paul Mellon.

FINANCE COMMITTEE

Secretary of the Treasury, George M. Humphrey, chairman.
Samuel H. Kress, vice chairman.

Ferdinand Lammot Belin.
Chester Dale.
Paul Mellon.

ACQUISITIONS COMMITTEE

Ferdinand Lammot Belin, chairman.
Duncan Phillips.
Chester Dale.
Paul Mellon.
David E. Finley.

PERSONNEL

On June 30, 1953, full-time Government employees on the staff of the National Gallery of Art numbered 304, as compared with 301 employees as of June 30, 1952. The United States Civil Service regulations govern the appointment of employees paid from appropriated public funds.

APPROPRIATIONS

For the fiscal year ended June 30, 1953, the Congress of the United States appropriated for the National Gallery of Art $1,428,050, 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 section 4 (a) of Public Resolution No. 14, 75th Congress, 1st session, approved March 24, 1937 (50 Stat. 51). This sum includes the regular appropriation of $1,240,550 and a supplemental appropration of $187,500 for the replacement and repair of refrigeration equipment used in connection with the air conditioning.

From the regular appropriation the following expenditures and encumbrances were incurred:

Personal services	$1,108,950.00
Printing and reproduction	5,222.31
Electricity, supplies, equipment, etc	126,347.59
Unobligated balance	30.10
Total	1,240,550.00

From the supplemental appropriation the following expenditures and encumbrances were incurred:

Replacement of 3 refrigeration machines	$170,398.00
Repair of motors, etc	3,306.30
Unobligated balance	13,795.70
Total	187,500.00

ATTENDANCE

There were 1,647,470 visitors to the Gallery during the fiscal year 1953, an average daily attendance of about 4,538. This is an increase of 124,874 over the number for 1952. Since March 17, 1941, when the Gallery was opened to the public, to June 30, 1953, there have been 21,931,483 visitors.

ACCESSIONS

There were 1,408 accessions by the National Gallery of Art as gifts, loans, and deposits during the fiscal year 1953. Most of the paintings and a number of the prints were placed on exhibition.

GIFTS

PAINTINGS

The Board of Trustees on July 21, 1952, accepted from Mrs. Augustus Vincent Tack the gift of a portrait of President Truman, painted by her husband, which will be held for a National Portrait Gallery. On October 21 the Gallery received the gift of a painting from Samuel L. Fuller, entitled "Portrait of a Lady," by Salviati, which had been accepted by the Board of Trustees on December 6, 1950. On November 3, the Board accepted the bequest by the late Mrs. Charles S. Carstairs of three paintings: "Head of a Woman," by Manet; "The Sisters," by Berthe Morisot; and a portrait of herself by Sir William Orpen. The gift of a painting by Leonid entitled "Faraduro," from the Avalon Foundation, was accepted by the Board of Trustees on December 3, 1952. On February 9, 1953, the Board accepted from Frederick Sturges, Jr., the painting "Newport Harbor, 1857," by John Kensett. On March 30, 1953, the Board accepted a bequest of the following seven paintings from the late Adolph Caspar Miller:

Artist	*Title*
Cranach	Madonna and Child.
Van Dyck	Portrait of a Young Man.
Peter Gertner	Portrait of a Young Man.
Peter Gertner	Portrait of a Lady.
Ambrosius Benson	Portrait of a Man.
Ambrosius Benson	Portrait of a Lady.
Barthel Bruyn	Portrait of a Man.

SCULPTURE

On October 21, 1952, the Board accepted a bequest by the late Albert E. Gallatin of a bust of Whistler by Sir Joseph Edgar Boehm which will be held for a National Portrait Gallery. On December 3 the Board accepted a gift from the children of the late Mrs. Otto Kahn

of a terra-cotta bust of an old man, Florentine School, second half of fifteenth century.

PRINTS AND DRAWINGS

On October 21, 1952, the Board of Trustees accepted 693 prints and drawings from Lessing J. Rosenwald to be added to his gift to the Gallery. On December 3 the Board approved the addition of 96 prints by Alphonse Legros to the gift of George Matthew Adams. On December 30 the Board accepted a gift from Rush H. Kress of an early sixteenth-century German manuscript choral in two volumes.

EXCHANGE OF WORKS OF ART

On October 21, 1952, the Board of Trustees accepted the offer of Lessing J. Rosenwald to exchange the following five prints by Van Meckenem for superior impressions of the same works: "Christ Before Caiphas," "Scourged," "Pilate Washing His Hands," "Christ Shown to the People," and "Crucifixion." On May 5, 1953, the Board approved Mr. Rosenwald's offer to exchange the following three prints for superior impressions: "The Spinner," by Van Meckenem; "Virgin with the Pear," by Durer; "Madonna and Child Standing on a Crescent Moon," by Altdorfer.

WORKS OF ART ON LOAN

During the fiscal year 1953 the following works of art were received on loan by the National Gallery of Art:

From	*Artist*
Chester Dale, New York, N. Y.:	
Mrs. Chester Dale	Bellows.
Edouard Blau	Bazille.
Le Pont Neuf	Marquet.
The Letter	Bonnard.
Woman in a Chemise	Derain.
Mlle. Dora Maar	Picasso.
Dining in the Garden	Vuillard.
Jacques-Louis David	Rouget.
Nude	De la Fresnaye.
Mme. Kisling	Modigliani.
Morning Haze	Monet.
Woman with a Turban	Matisse.
Putnam Foundation, San Diego, Calif.:	
St. Bartholomew	Rembrandt.
Death of the Virgin	Petrus Christus.
Robert Woods Bliss, Washington, D. C.:	
16 objects of pre-Columbian art.	

LOANED WORKS OF ART RETURNED

The following works of art on loan were returned during the fiscal year 1953:

To	*Artist*
Chester Dale, New York, N. Y.:	
The Hunter	David.
Houses of Parliament	Monet.
Mrs. Chester Dale	Bellows.
Mrs. Thomas Palmer (?)	Feke.
Portrait of a Lady in Red	Theus.
Black Hawk	King.
Portrait of a Boy	Rousseau.
The Windmill	Ryder.
Basque Landscape	Oudot.
Woman with a Turban	Matisse.
The Gourmet	Picasso.
Fernand Stuyck del Bruyère, Belgium:	
Calvary	Henri met de Bles.

WORKS OF ART LENT

During the fiscal year 1953, the Gallery lent the following works of art for exhibition purposes:

To	*Artist*
The Chattanooga Art Association, Chattanooga, Tenn.:	
22 American portraits	Various.
The Mint Museum, Charlotte, N. C.:	
22 American portraits	Various.
Randolph-Macon College, Lynchburg, Va.:	
18 American portraits	Various.
American Federation of Arts, New York, N. Y.:	
Mrs. Yates	Gilbert Stuart.
Virginia Museum, Richmond, Va.:	
Bulls of Bordeaux (series of 4)	Goya.
The White House, Washington, D. C.:	
Arctic Three-Toed Woodpecker	J. J. Audubon.
Orchard Oriole	J. J. Audubon.
Allies Day, May 1917	Childe Hassam.
Portrait of Lincoln	Volk.
Abraham Lincoln	Lambdin.
Newport Harbor, 1857	Kensett.
Landscape	Harpignies.
Nathaniel Hawthorne	Emanuel Leutze.
DeWitt Clinton	John W. Jarvis.
Andrew Jackson	Ralph Earle.
General Washington at Princeton	Charles Polk.
The Flags (San Marco, Venice)	E. Vail.
Blair-Lee House, Washington, D. C.:	
Henry Clay	Healy.
Franklin Pierce	Healy.
William Henry Harrison	Lambdin.
John Marshall	Lambdin.
Allies Day, May 1917	Childe Hassam.

EXHIBITIONS

The following exhibitions were held at the National Gallery of Art during the fiscal year 1953:

Lithographs by Toulouse-Lautrec. Selected from the Rosenwald Collection. Continued from previous fiscal year through August 3, 1952.

American Portraits from the Collection of the National Gallery of Art. August 10 through September 28, 1952.

Demonstration of Techniques. Watercolor renderings from the Index of American Design. October 5 through October 7, 1952.

American Antiques. Watercolor renderings from the Index of American Design. October 9 through October 19, 1952.

French Drawings, Masterpieces from Five Centuries. From the Louvre, other French museums and private collections. Sponsored by Smithsonian Traveling Exhibition Service. November 2 through November 30, 1952.

Twentieth-Century French Paintings From the Chester Dale Collection. Opened November 22, 1952, to continue indefinitely.

Japanese Painting and Sculpture, From the 6th Century A. D. to the 19th Century. Sponsored by the Government of Japan. January 25 through February 25, 1953.

Nuremberg and the German World, 1460–1530. Prints and books from the Kress and Rosenwald Collections. March 15 through July 12, 1953.

19th- and 20th-Century Paintings from the Edward G. Robinson Collection. May 10 through June 24, 1953.

TRAVELING EXHIBITIONS

Rosenwald Collection.—Special exhibitions of prints from the Rosenwald Collection were circulated to the following places during the fiscal year 1953:

Chattanooga Art Association, Chattanooga, Tenn.:
Collection of Master Prints.
July 12–August 4, 1952.

University of Alabama, University, Ala.:
Toulouse-Lautrec Prints.
August 1952.

Detroit Institute of Arts, Detroit, Mich.:
18th-Century Venetian Art.
September–October, 1952.

Walters Art Gallery, Baltimore, Md.:
"The World Encompassed"—4 maps.
October 7–November 23, 1952.

Academy of Music, Philadelphia, Pa.:
3 Blake prints, to accompany premier of Virgil Thompson's themes from Blake's "Songs of Innocence and Experience."
October 10, 1952.

Philadelphia Museum of Art, Philadelphia, Pa.:
"Graphic Art by 20th-Century Sculptors"—12 drawings.
October 11–December 7, 1952.

Society of the Four Arts, Palm Springs, Fla.:
2 Oudry Drawings.
November 15–December 12, 1952.

Religious Art Committee of Student Body, Union Theological Seminary, New York, N. Y.:
4 prints.
November 30–December 16, 1952.
John Herron Art Institute, Indianapolis, Ind.:
18th-Century Venetian Art.
November 1952–January 4, 1953.
Randolph-Macon Woman's College, Lynchburg, Va.:
Collection of Master Prints.
December 1952.
Virginia Museum, Richmond, Va.:
Goya-Tauromachia prints.
January 1953.
Toledo Museum of Art, Toledo, Ohio:
Music Manuscripts.
January 11–March 1, 1953.
Pierpont Morgan Library, New York, N. Y.:
"Landscape Drawings and Water Colors; Breugel to Cezanne"—7 drawings.
January 30–April 11, 1953.
Philadelphia Art Alliance, Philadelphia, Pa.:
Selections from Recent French Acquisitions.
February 9–March 1, 1953.
Denver Art Museum, Denver, Colo.:
"Art Tells the Story"—1 Blake print.
March 1–April 28, 1953.
Vancouver Art Gallery, Vancouver, British Columbia:
French Impressionism, Drawings and Watercolors.
March 23–April 19, 1953.
Tyler School of Art, Elkins Park, Pa.:
Hobby Show for Abington Hospital Benefit.
April 15, 1953.
Minneapolis Institute of Arts, Minneapolis, Minn.:
19th-Century Monotypes—5.
May 5–June 30, 1953.

Index of American Design.—During the fiscal year 1953, 25 traveling exhibitions of original watercolor renderings of this collection, with 58 bookings, were sent to the following States and countries:

State or country	*Number of exhibitions*
Alabama	3
Arkansas	1
Connecticut	1
District of Columbia	9
Illinois	2
Indiana	1
Iowa	6
Kentucky	1
Louisiana	1
Maine	1
Maryland	3
Michigan	1
Mississippi	1
New Jersey	2

State or country	Number of exhibitions
New York	4
North Carolina	5
Ohio	4
Pennsylvania	1
South Carolina	1
Tennessee	2
Virginia	1
Wisconsin	1
Greece	1
Italy	1
Palestine	1
Turkey	1
Western Germany	1
Western Germany and Austria	1

CURATORIAL ACTIVITIES

The Curatorial Department accessioned 927 gifts to the Gallery during the fiscal year 1953. Advice was given regarding 285 works of art brought to the Gallery for opinion, and 60 visits to other collections were made by members of the staff for either expert opinion or in connection with offers of gifts. About 1,200 inquiries requiring research were answered verbally and by letter. On August 10, 1952, John Walker, as representative of the United States Government on the occasion of the Centennial Celebration of the German National Museum of Nüremberg, gave an address before a large audience. Charles M. Richards conducted two courses in art history under the auspices of the Department of Agriculture. Miss Elizabeth Mongan gave a series of lectures on prints at Beaver College, Swarthmore College, and the Tyler School of Art. Mr. Richards served as an "expert on art" and lecturer at the Career Conference held at George Washington University. He also attended the annual meeting of the American Association of Museums at Buffalo, N. Y., and an organizational meeting of the Southern Conference of Museums at Raleigh, N. C. Miss Katharine Shepard was sent as a delegate from the Washington Society to the annual meeting of the Archaeological Institute of America in Cleveland. Perry B. Cott was elected vice president of this Society. Mr. Cott served on the following committees: Fine Arts Committee, Washington Cathedral; Advisory Committee for Fulbright Awards in Fine Arts; Committee for the Inaugural Medal; Committee for the Protection of Cultural Property. Mr. Cott arranged a schedule of tours of United States museums for visiting foreigners under the International Exchange of Persons Division, Department of State. Erwin O. Christensen was one of five judges at the Army-Wide Library Publicity Contest. Mr. Christensen was chairman of the session on "European and American Art" at the Howard University Festival of Fine Arts this spring, and he also made examinations and wrote

reports on the Morosini and Negroli helmets in the Widener Collection. William P. Campbell was one of three judges at the "Neighborhood Art Show" in Fauquier County, Va.

Special installations were prepared for the French drawings exhibition and the exhibition of Japanese paintings and sculpture under the direction of Mr. Cott. He also supervised the installation of new vitrines for the Robert Woods Bliss Collection of pre-Columbian art.

RESTORATION AND REPAIR OF WORKS OF ART

Necessary restoration and repair of paintings and sculpture in the Gallery's collections were made by Francis Sullivan, resident restorer to the Gallery. Thirty-one pieces of furniture in the Widener Collection were shipped to New York for repair and conditioning; these were returned to the Gallery in October.

PUBLICATIONS

During the year Huntington Cairns contributed an article on "Symbolism and the Language of Jurisprudence" to the forthcoming volume "In the Beginning Was the Word: An Inquiry into the Meaning and Function of Language," and reviews of "The Theodosian Code and Novels" and "Law, the Science of Inefficiency," by William Seagle, to the Library of Congress United States Quarterly Book Review; "The Note-Books of Matthew Arnold," edited by Lowry, Young, and Dunn, to Poetry Magazine; and "Feeling and Form," by Susanne Langer, to the Virginia Quarterly Review. He also delivered a series of lectures at the Johns Hopkins University on "The Theory of Criticism."

In November a new book, "Great Paintings from the National Gallery of Art," by Huntington Cairns and John Walker, was published by the Macmillan Co.

Nine articles by John Walker on paintings in the Chester Dale Collection appeared in the Ladies Home Journal.

Mr. Christensen contributed an article, "A Page from the Sketchbook of Martin Van Heemkerck" for the Gazette des Beaux-Arts.

Other publications by the staff during the fiscal year 1953 include the following:

"Objects of Medieval Art," Handbook No. 3 in the National Gallery of Art series by Erwin O. Christensen.

A catalog entitled "Twentieth-Century French Paintings from the Chester Dale Collection" was prepared by William P. Campbell.

A book for hobbyists entitled "Early American Design: Toleware" was written by Mr. Christensen. He also wrote the book "Early American Wood Carving."

A monograph on Giovanni Bellini's "Feast of the Gods" is being revised by Mr. Walker and a sixth edition of the catalog, "French

Paintings from the Chester Dale Collection," is being prepared by Mr. Campbell.

During the fiscal year 1953 the Publications Fund added four new color postcards and a new 11- by 14-inch color reproduction to the list available and 6 additional new 11- by 14-inch color prints were on order. Nineteen new monotone postcards and four new Christmas-card color plates were produced. At the time of the opening of the exhibition of Twentieth-Century French Paintings from the Chester Dale Collection a stock of 18 color and monotone postcard subjects was also acquired from the Art Institute of Chicago and distributed here. Eleven more large collotype reproductions of paintings at the Gallery distributed by a New York publisher were placed on sale, and this company also produced the first 6 of a new series of 11- by 14-inch plate-size color reproductions of our works of art.

A new set of playing cards, Wedgwood plates bearing a picture of the Gallery building, a stock of "Famous Paintings" calendars including many Gallery paintings, and the book, "Italian Painters of the Renaissance," by Bernard Berenson, illustrated with numerous Gallery paintings, were also made available. The 1952 A. W. Mellon lectures of Jacques Maritain in published form were placed on sale as well as four other books by National Gallery of Art staff members.

Exhibition catalogs of the French drawings, Robinson, and Japanese shows were distributed, and over 20,000 postcards of Japanese works of art were sold here during the latter exhibition.

EDUCATIONAL PROGRAM

The attendance for the general, congressional, and special tours and the "Picture of the Week" totaled 43,544, while the attendance at 39 auditorium lectures on Sunday afternoons was approximately 13,068 during the fiscal year 1953.

Tours, lectures, and conferences arranged by appointment were given 202 groups and individuals. The total number of people served in this manner was 4,701. These special appointments were made for such groups as representatives from leading universities and museums, groups from other governmental departments, high schools, college students, women's clubs, Sunday-school classes, and a number of foreign visitors. This service also included the training of Junior League volunteers who thereafter conducted tours for art students in the Washington high schools and a training program for members of the Arlington American Association of University Women who served as volunteer docents and conducted tours in the Gallery for all the Arlington public-school children in grades 2 through 6.

The staff of the Education Office delivered 17 lectures; 22 lectures were delivered by guest speakers. During March and April Sir Kenneth Clark delivered the second annual series of the A. W. Mellon

Lectures in the Fine Arts on the theme, "The Nude: A Study of Ideal Form."

During the past year, 113 persons borrowed 3,327 slides from the lending collection. Seven copies of the National Gallery film were circulated on itinerary with 106 bookings completed. In the coming year, 18 copies of the film will be placed in audiovisual libraries in as many different States so that they may have the maximum distribution with guaranteed good treatment.

Eight more sets of the "Christmas Story," a mimeographed lecture illustrated by 34 slides, were made up and circulated with approximately 1,882 people viewing the slides.

The printed Calendar of Events, announcing all Gallery activities and publications, is distributed monthly to a mailing list of 5,100 names.

LIBRARY

Books, pamphlets, periodicals, photographs, and subscriptions purchased out of the fund presented to the National Gallery of Art by Paul Mellon totaled 306 during the fiscal year 1953; 33 were purchased out of the fund given by Harold K. Hochschild. Gifts included 270 books and pamphlets, while 713 books, pamphlets, periodicals, and bulletins were received from other institutions. Outstanding among these gifts were 50 books presented by Lessing J. Rosenwald.

Although the Library is not open to the public, it is possible for students of art and persons with art questions to use the services of the Library. During this fiscal year the Library staff handled 1,430 reference questions, and there were 635 readers other than the Gallery staff who used the Library.

The Library is the depository for photographs of the works of art in the collections of the National Gallery of Art. During the year 425 persons other than the Gallery staff came to purchase prints, and 215 mail orders were filled.

INDEX OF AMERICAN DESIGN

During the fiscal year 1953, a total of 7 new exhibits containing 304 renderings were completed. Index material was studied during the year by 572 persons representing special research interests, designers, groups interested in the material for publications, exhibitions, and slides, and to get a general idea of the collection as a whole.

A total of 859 photographs of Index renderings were sent out of the Gallery on loan, for publicity, and purchase. A gift of seventy 2-x-2″ slides of Index material was made by Dr. Konrad Prothmann. Twenty-two sets (consisting of 1,435 slides) of 2-x-2″ slides were circulated in 26 States, Italy, and England.

MAINTENANCE OF THE BUILDING AND GROUNDS

The usual work in connection with the care and maintenance of the building and its mechanical equipment and the grounds was continued throughout the year. Flowering and foliage plants grown in the moats were used in the garden courts.

In order to provide additional storage space for the Publications Office, a new concrete floor was laid in an unfinished area at the west end of the ground floor.

A partition, stainless steel sink, and print washer were installed in one of the darkrooms of the photographers' laboratory in order to increase the efficiency of that department.

The elevators were inspected by a representative of the District government, and also by a representative of the Hartford Accident & Indemnity Co., and found to be in good mechanical condition.

The high-tension switchgear, together with the safety relays and protective devices, was examined and tested by the Potomac Electric Power Co.

Refrigeration machine No. 4 was thoroughly checked and the necessary adjustments made in order that it would be in first-class operating condition when the heavy summer load of air-conditioning would be placed upon it.

With funds appropriated for the purpose, a contract was entered into with the Worthington Corp. for the replacement of three refrigeration machines. Two of the machines were in operation by June 23, 1953, and the work of installing the third machine is now under way.

OTHER ACTIVITIES

A total of 38 Sunday evening concerts were given during the fiscal year 1953 in the West Garden Court. The National Gallery Orchestra, conducted by Richard Bales, played nine concerts at the Gallery with additional performances at the United States Naval Academy at Annapolis, Md., and in the Corcoran Gallery of Art. Two of the orchestral concerts at the National Gallery were made possible by the Music Performance Trust Fund of the American Federation of Musicians. During April, May, and June, seven Sunday evenings were devoted to the Gallery's Tenth American Music Festival. Thirty-two compositions by thirty-one American composers were played. Most of the concerts were broadcast in their entirety by Station WCFM, Washington, and the Continental Network. A new feature of the series was the addition of the Church of the Reformation Cantata Choir to the National Gallery Orchestra at two concerts which presented both classical and contemporary composers.

The photographic laboratory of the Gallery produced 14,013 prints, 402 black-and-white slides, 1,156 color slides, and 127 color trans-

parencies, in addition to 2,130 negatives, X-rays, infrared and ultraviolet photographs.

During the fiscal year, 2,358 press releases were issued in connection with Gallery activities, while 142 permits to copy paintings, and 224 permits to photograph in the Gallery were issued.

OTHER GIFTS

Gifts of books on works of art and related material were made to the Gallery by Paul Mellon and others. Gifts of money were made during the fiscal year 1953 by the Old Dominion Foundation, the Avalon Foundation, and Harold K. Hochschild.

AUDIT OF PRIVATE FUNDS OF THE GALLERY

An audit of the private funds of the Gallery has been made for the fiscal year ended June 30, 1953, 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.

APPENDIX 3

Report on the National Collection of Fine Arts

SIR: 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, 1953:

THE SMITHSONIAN ART COMMISSION

The 30th annual meeting of the Smithsonian Art Commission was held in the Regents Room of the Smithsonian Building on Tuesday, December 2, 1952. The members present were: Paul Manship, chairman; Alexander Wetmore, secretary (member, ex officio); John Taylor Arms, Robert Woods Bliss, Gilmore D. Clarke, David E. Finley, Lloyd Goodrich, Walker Hancock, George Hewitt Myers, Archibald Wenley, Lawrence Grant White, Andrew Wyeth, and Mahonri Young. Thomas M. Beggs, Director, and Paul V. Gardner, curator of ceramics, National Collection of Fine Arts, were also present.

The Commission recommended to the Board of Regents the reelection of David E. Finley, Paul Manship, Eugene E. Speicher, and Archibald Wenley for the ensuing 4-year period.

The following officers were elected for the ensuing year: Paul Manship, chairman; Robert Woods Bliss, vice chairman; and Leonard Carmichael, secretary. The following were elected members of the executive committee for the ensuing year: David E. Finley, chairman, Robert Woods Bliss, Gilmore D. Clarke, and George Hewitt Myers. Paul Manship, as chairman of the Commission, and Leonard Carmichael, as secretary of the Commission, are ex officio members of the executive committee. Dr. Alexander Wetmore, retiring Smithsonian Secretary, was added to the list of emeritus members of the Commission.

Dr. Wetmore reported to the Commission that a bill (H. R. 8216) had been introduced in the House of Representatives "to establish as a branch of the Smithsonian Institution an American Academy of Music, Drama, and Ballet, for the education of selected pupils in all the various phases of these arts, and for other purposes, as part of a National War Memorial (to include a theater and opera house)." A similar bill was introduced in the Senate (S. J. 105).

Mr. Beggs presented his annual report to the Commission, and said that special emphasis had been given to exhibitions during the year. He reported the completion of the renovation of the first-floor galleries,

the reorganization of the permanent exhibition of the Harriet Lane Johnston, Ralph Cross Johnson, John Gellatly, and Pell Collections, and the preparation in progress of a new catalog and handbooks of the collections. Responsibility for scheduling the monthly foyer exhibitions in the Natural History Building, including those of scientific materials, was transferred by the Secretary to the National Collection of Fine Arts.

Mr. Beggs also described other activities of the National Collection of Fine Arts: The Third Annual Exhibit of the Kiln Club of Washington, representing accomplishment by local craftsmen under Paul V. Gardner's direction; the exhibits of paintings by Edwin Scott and Alice Pike Barney, indicating new uses of the Barney Fund; the Art and Magic in Arnhem Land Exhibit, shown first in the Natural History Building and now being circulated by the Smithsonian Traveling Exhibition Service; the exhibition of "French Drawings of Five Centuries," lent by the French Government, first shown at the National Gallery of Art by the Smithsonian Traveling Exhibition Service, followed by showings at the Cleveland Museum of Art, the City Art Museum of St. Louis, the William Hayes Fogg Art Museum, and the Metropolitan Museum of Art, before its return to France. Mr. Beggs reported that the contract with the Department of State for funds for the preparation of exhibitions to be sent abroad in 1953 and 1954 had been renewed.

The following objects were accepted by the Commission for the National Collection of Fine Arts:

Oil, The Stephen Children (Theodore Brower, Cornelia, John, and Esther Amelia), attributed to a brother of President Madison. Gift of Amelia R. Lowther.

Oil, Man in White (Dr. Henry Sturgis Drinker), by Cecilia Beaux, N. A. (1863–1942). Henry Ward Ranger bequest.

Oil, Portrait of Dr. George F. Becker (1847–1919), geologist, by Fedor Encke (1851–?). Gift of Mrs. George F. Becker. Accepted for the National Portrait Gallery.

Marble, General Philip H. Sheridan (1831–1888), by Thomas Buchanan Read (1822–1872). Gift of Benjamin Bell. Accepted for the National Portrait Gallery.

Five pieces of modern glass: Gazelle bowl and base (crystal glass designed by Sidney Waugh and made by Steuben Glass, Inc., Corning, New York); vase (8 inches high), ashtray (smoke crystal glass with cut flutings), globular vase (6¼ inches high with crystal glass engraved fish decoration), all designed by Gerda Stromberg and made at Strombergshyttan, Sweden. Gift of Mr. and Mrs. Hugh J. Smith, Jr.

Ceramic, bottle, 14 inches high, St. Ives pottery, stoneware, Tenmoku glaze, designed by Bernard Howell Leach. Gift of the artist.

Ceramic, bottle, 16 inches high, stoneware, Sgraffito decoration, designed by Paul D. Holleman, Roxbury, Mass. Gift of the Kiln Club.

Two award-winning pieces from the Third Annual Exhibition of Ceramic Art, 1952: bottle, hand-modeled, ivory matt glaze, by Alta C. Fuller, winner

of the B. F. Drakenfeld award; and bowl, wine-red glaze, by Lisle Pursel, winner of Winthrop Ceramic Supply Company award. Gift of the Kiln Club.

STUDY COLLECTION

A ceramic sculpture, Toad, designed by Ollie Palmore Long, gift of the Kiln Club, was added to the study collection.

TRANSFERS ACCEPTED

Four watercolors were transferred from the division of birds on March 13, 1953: Cardinal, Towhee Bunting, and Purple Grackle, by John James Audubon; and Rose-breasted Grosbeak, by Joseph B. Kidd, after Audubon.

Three oils were transferred from the division of graphic arts on March 25, 1953: Indian Summer, by Jaspar F. Cropsey, N. A.; October, by Robert C. Minor; and November, by Jervis McEntee, N. A.

LOANS ACCEPTED

Miniature, James D. Simons, attributed to James Peale, was lent by Miss Henrietta Simons, Charleston, S. C., on July 19, 1952 (withdrawn by owner on September 5, 1952).

Seventeen miniatures were lent by Mr. and Mrs. Ruel P. Tolman, Washington, D. C., as follows:

Man with Red Hair, by Alvan Clark (1804–87).
Unknown Gentleman, by Robert Field (c. 1769–1819).
Unknown Gentleman, by Thomas Flatman (1633/7–88).
Unknown Gentleman, by Sarah Goodridge (1788–1853).
John (or Uriah) Vaughan, by Christopher Greiner (fl. 1837–64).
Robert Parker, attributed to Henry Inman (1801–46).
Unknown Young Lady, attributed to Henry Inman (1801–46).
J. B., by Raphaelle Peale (1774–1825).
Self Portrait, by Sarah Peale (1800–85).
Unknown Lady, by John Ramage (1748–1802).
Self Portrait, by Edward Savage (1761–1817).
Unknown Man, by Richard M. Staigg (1820–81).
Nancy de Villers, by Carolyn D. Tyler.
Miss Mary Angell, by Carolyn D. Tyler.
Elizabeth Moore, by Carolyn D. Tyler.
Mr. W., by an undetermined artist.
Unknown Man, by an undetermined artist.

Six pieces of modern glass were lent by Mr. and Mrs. Hugh J. Smith, Jr., Scarsdale, N. Y., on April 11, 1953.

LOANS TO OTHER MUSEUMS AND ORGANIZATIONS

Table, French, 18th century (P. 220), was lent to the American Federation of Arts, Washington, D. C., on July 10, 1952, for an indefinite period.

Venetian plate, of the Cozzi period, c. 1780 (P. 497), and a soup

tureen, dated Turin, c. 1775 (P. 801), were lent to the Detroit Institute of Arts for an exhibition of Arts of Venice in the 18th century, from September 28 to November 1, 1952. (Returned November 14, 1952.)

Two portraits, by Charles Hopkinson—Nikola P. Pashitch and Prince Kimmochi Saionji—were lent to the Century Association, New York City, for an exhibition of work by Charles Hopkinson, from December 3, 1952, to January 4, 1953. (Returned January 22, 1953.)

Oil, Caresse Enfantine, by Mary Cassatt, was lent to the Munson-Williams-Proctor Institute Art Gallery, Utica, N. Y., for an exhibition of expatriates, Whistler, Cassatt, and Sargent, from January 4 through 25, 1953. (Returned January 30, 1953.)

Oil, The Storm, by Ludwick Backhuysen (with seven oils by Edwin Scott from the Smithsonian Lending Collection), was lent to the United States District Court of the District of Columbia on December 15, 1952, for a period of 4 years.

Two oils, Cliffs of the Upper Colorado River, Wyoming Territory, by Thomas Moran, and Moonlight, by Albert P. Ryder, were lent to the American Federation of Arts on January 12, 1953, for an exhibition of 19th-century American paintings to be circulated in Germany.

Two oils, An Abandoned Farm, by Ernest Lawson, and Laguna, New Mexico, by Albert L. Groll, were lent to The White House on February 6, 1953, for an indefinite period.

Oil, Westward the Course of Empire Takes its Way, by Emanuel Leutze, was lent to the Denver Art Museum for an exhibition, "Art Tells the Story," from March 1 through April 26, 1953. (Returned May 6, 1953.)

Oil, At Nature's Mirror, by Ralph Blakelock, was lent to the American Federation of Arts on February 13, 1953, for their traveling show "American Tradition 1800–1900," through May 1953. (Returned May 29, 1953.)

Two oils, Roses, by Walter Shirlaw, and The Signing of the Treaty of Ghent, Christmas Eve, 1814, by Sir Amedee Forestier (with 4 pastels by Alice Pike Barney, and 5 oils by Edwin Scott, from the Smithsonian Lending Collection), were lent to the United States District Court of the District of Columbia on February 18, 1953, for a period of 4 years.

Oil, Portrait of Wyatt Eaton, by J. Alden Weir (with 5 oils by Edwin Scott, from the Smithsonian Lending Collection), was lent to the Department of Justice on March 12, 1953, for a period of 4 years.

Bronze, Bust of Hon. Elihu Root, by James Earle Fraser, was lent to the National War College on March 13, 1953, for a period of 4 years.

Oil, Portrait of Dr. George F. Becker, by Fedor Encke, was lent to the National Academy of Sciences on April 17, 1953, for a period of 4 years.

Four oils, Sea and Rain, by George H. Bogert; Evening Glow, Mount McIntyre, by James Henry Moser; The Vintage, by Alexander Rene Veron; and Conway Hills, by Frederick B. Williams (with a watercolor, Hill and Lake, by James Henry Moser, from the Smithsonian Lending Collection), were lent to the Department of State on April 23, 1953, for a period not to exceed 4 years.

Oil, Portrait of Rear Admiral Richard E. Byrd, by Seymour M. Stone (with 4 oils by Edwin Scott from the Smithsonian Lending Collection), was lent to the Bureau of the Budget on May 13, 1953, for a period not to exceed 4 years.

Three oils, Col. William Shakespeare King, by George Catlin; Hon. Salmon P. Chase, by James Reid Lambdin; Rustic Dance, by Jean Antoine Watteau; and two marble busts, Hon. Charles Evans Hughes, by Moses W. Dykaar, and Gen. Philip H. Sheridan, by Thomas Buchanan Read, were lent to the United States Court of Military Appeals on June 11, 1953, for a period not to exceed 4 years.

Four watercolors by William H. Holmes, My Old Mill, Holmescroft, Near Rockville, Maryland; A Maryland Wheat Field; Over the Maryland Fields; and the Normal Rock Creek about 1910 (with 1 oil by Edwin Scott, from the Smithsonian Lending Collection), were lent to the Bureau of the Budget on June 25, 1953, for a period not to exceed 4 years.

LOANS RETURNED

Two oils, Portrait of George Washington, attributed to William Winstanley, after Gilbert Stuart, and The Signing of the Treaty of Ghent, Christmas Eve, 1814, by Sir Amedee Forestier, lent March 22, 1949, to the Department of State, were returned January 19, 1953.

Three oils, Conway Hills, by Frederick Ballard Williams; The Meadow Brook, by Charles P. Gruppe; and Sea and Rain, by George H. Bogert, lent March 14, 1946, to the Department of the Treasury, were returned February 12, 1953.

Oil, December Uplands, by Bruce Crane, lent June 27, 1950, to the Executive Office, Council of Economic Advisers, was returned February 26, 1953.

SMITHSONIAN LENDING COLLECTION

One oil painting, Paris, 1910, by Edwin Scott (1863–1929), was added to the Alice Pike Barney Memorial Collection on April 11, 1953.

The following paintings were lent for varying periods:

Tuskegee Institute, Tuskegee Institute, Ala.:
August 15, 1952:
Old Man with Pipe, by O. W. Roederstein.
Soldiers of the Empire, by Indoni.
Tangier, by L. Garcia.

Ballerine, by Alice Pike Barney.
Captain Wheeler, by Alice Pike Barney.
Laura Alice in Big Hat, by Alice Pike Barney.
Laura in Fichu, by Alice Pike Barney.
Laura with Blue Scarf, by Alice Pike Barney.
Marie Huet, the Painter, by Alice Pike Barney
Martha, by Alice Pike Barney.
Matsu and Puss, by Alice Pike Barney.
Self Portrait in 1924, by Alice Pike Barney.
Self Portrait with Palette, by Alice Pike Barney.
The Brass Kettle, by Alice Pike Barney.
Woodsprite, by Alice Pike Barney.
Young Girl with Fichu, by Alice Pike Barney.

Department of Justice, Washington, D. C.:

September 25, 1952:

Marie Huet, by Alice Pike Barney.
R. D. Shepherd, by Alice Pike Barney.
White Paradise, by Alice Pike Barney.
Chambre des Députés No. 3, by Edwin Scott.
Femmes près des Escaliers No. 1, by Edwin Scott.
Place de la Madeleine, by Edwin Scott.
Quai de la Seine, Église St. Gervais, by Edwin Scott.
Scene Italienne près de la Fontaine, by Edwin Scott.

March 12, 1953:

La Madeleine No. 2, by Edwin Scott.
Maison de Millet, by Edwin Scott.
Notre Dame, by Edwin Scott.
Place St. Germain-des-Près, by Edwin Scott.
Porte St. Martin No. 2, by Edwin Scott.

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

December 15, 1952:

Bateau de Pêche, by Edwin Scott.
Église de Ville, by Edwin Scott.
Homme au Chapeau Rouge, by Edwin Scott.
Honfleur Fishing Boats No. 1, by Edwin Scott.
Saint Roche, Rue St. Honore, by Edwin Scott.
Tête de Femme, by Edwin Scott.
The Seine at Paris (L'Institute), by Edwin Scott.

February 18, 1953:

Ali Kuli Kahn, by Alice Pike Barney.
Camille Gorde, by Alice Pike Barney.
Jimmy Davis, by Alice Pike Barney.
Old Actor, by Alice Pike Barney.
Côte aux Environs de Cherbourg, by Edwin Scott.
Porte de Cherbourg, by Edwin Scott.
Porte St. Martin et Enterrement, by Edwin Scott.
Ships at Anchor, Cherbourg, No. 1, by Edwin Scott.
Ship at Anchor, Cherbourg, No. 2, by Edwin Scott.

Lehigh University, Bethlehem, Pa.:

March 3, 1953:

Chambre des Députés in a Mist, by Edwin Scott.
Saint Roche Church, by Edwin Scott.
The Madeleine at Dawn, by Edwin Scott.

Department of State, Washington, D. C.:
April 23, 1953:
Hill and Lake, by James Henry Moser.
Bureau of the Budget, Washington, D. C.:
May 13, 1953:
Boulevard St. Germain (Près St. Germain-des-Près), by Edwin Scott.
Chambre des Députés No. 1, by Edwin Scott.
Place de la Concorde No. 1, by Edwin Scott.
Saint Germaine des Près No. 3, by Edwin Scott.
June 25, 1953:
Saint Germaine des Près No. 2, by Edwin Scott.

ALICE PIKE BARNEY MEMORIAL FUND

An addition of $5,000 to the fund established in 1951 by Miss Natalie Clifford Barney and Mrs. Laura Dreyfus-Barney, in memory of their mother, for the purpose of encouraging the appreciation and creation of art in the United States, was received in January 1953.

THE HENRY WARD RANGER FUND

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, 2 paintings were recalled for action of the Smithsonian Art Commission at its meeting on December 2, 1952.

No. 62. Man in White (Dr. Henry Sturgis Drinker), by Cecilia Beaux, N. A. (1863–1942), was accepted by the Commission to become a permanent accession.

No. 5. The Orange Bowl, by Anna S. Fisher, N. A. (–1942), was returned to the Rhode Island School of Design, Providence, R. I., where it was originally assigned in 1921.

The following paintings, purchased by the Council of the National Academy of Design in 1952, have been assigned as follows:

Title and Artist	*Assignment*
137. Yorktown Heights (watercolor), by Warren Baumgartner, N. A. (1895–).	Suffolk Museum, Stone Brook, Long Island, N. Y.
138. Pirates Alley, New Orleans, by Guy Pene Du Bois, N. A. (1884–).	Philbrook Art Center, Tulsa, Okla.
139. Night Fair, by Martin Jackson (1871–).	Mead Memorial Museum, Amherst College, Amherst, Mass.
140. Tide Water Creek, Oreg. (watercolor), by Theodore Kautzky, N. A.	William A. Farnsworth Library and Art Museum, Rockland, Maine.
141. My Studio, by John Koch (1910–).	Society of Liberal Arts, Joslyn Art Museum, Omaha, Nebr.
142. Still Life with Leaves, by Roger Kuntz.	Berkshire Museum, Pittsfield, Mass.

SMITHSONIAN TRAVELING EXHIBITION SERVICE

Thirty-two exhibitions were circulated during the past season, 20 in the United States and Canada and 12 abroad, as follows:

UNITED STATES AND CANADA

Painting and Drawing

Title	*Source*
Contemporary Swiss Paintings	Eidgenoessische Kunstkommission of Switzerland; Dr. Heinz Keller, Curator of Kunstmuseum in Winterthur.
Finnish Paintings and Sculpture	Fine Arts Academy and Finnish-American Society in Helsinki; Finnish Legation (Heikki Reenpaa).
French Drawings, Masterpieces from Five Centuries.	Mme. Jacqueline Bouchot-Saupique; M. Georges Salles; French Embassy.
German Drawings and Watercolors	Dr. Charlotte Weidler.
Seven Cuban Painters	Institute of Contemporary Art in Boston; Pan American Union (José Gomez Sicre).

Graphic Arts

Children's Books from Fifty Countries I.	U. S. Office of Education and State Department.
Children's Books from Fifty Countries II.	U. S. Office of Education and State Department.
Modern Swedish Bookbindings	Swedish Association of Master Bookbinders; Swedish Institute in Stockholm; Swedish Embassy.
Woodcuts by Antonio Frasconi	Print Club of Cleveland; Cleveland Museum of Art; Weyne Gallery.

Design

Furniture, Costume, and Textiles	Index of American Design, National Gallery of Art.
Design from Britain	Council of Industrial Design; Dollar Exports Council; British Embassy.

Architecture

New Libraries	American Institute of Architects.
The Re-union of Architecture and Engineering.	American Institute of Architects.

Textiles

Swedish Textiles	Swedish Embassy; Swedish Homecraft League; Friends of Textile Art.

Ceramics

Artists and Potters of Vallauris I	Rene Batigne, Director, Museum of Vallauris, France.
Artists and Potters of Vallauris II	Rene Batigne, Director, Museum of Vallauris, France.

Folk Art

Norwegian Decorative Painting	Norwegian Artists Guild; Norwegian Embassy.
Our Wide Land Pennsylvania German Arts and Crafts.	Index of American Design, National Gallery of Art.

Ethnology

Art and Magic in Arnhem Land	Smithsonian Institution, Department of Anthropology.

ABROAD

Influences on American Architecture (Gropius).
American Wallpaper.
Contemporary American Textiles.
Containers and Packaging.
The World of Paul Revere.
The City of New York.
Aspects of the American Film—Fourteen Directors.
Mississippi Panorama.
Fashion and Color Photography.
Carl Schurz.

These displays were scheduled as an integral part of the programs of 77 museums and galleries, located in 29 States, the District of Columbia, and Canada. Catalogs were published for each, including the exhibit of the "French Drawings of Five Centuries," lent by the Government of France. This exhibit was first shown at the National Gallery of Art, Washington, D. C., and then sent to Cleveland, St. Louis, Boston, and New York City, before its return to France. The catalog, prepared by Mme. Bouchot-Saupique, curator of drawings at the Louvre, was privately printed, with an introduction by Mrs. Annemarie H. Pope, chief of the Smithsonian Traveling Exhibition Service.

INFORMATION SERVICE

In addition to the many requests for information received by mail and telephone, inquiries made in person at the office numbered 1,432. Examination was made of 773 works of art submitted for identification.

Washington art groups and local chapters of national civic organizations were served during the year by National Collection of Fine Arts staff members who judged art exhibitions and competitions, and addressed meetings on subjects in their special fields.

Introductions also were written to catalogs of exhibitions published by organizations showing in the foyer gallery.

SPECIAL EXHIBITIONS

Thirteen special exhibitions were held during the year:

July 2 through 30, 1952.—An exhibition of Swedish textiles, arranged in cooperation with the Swedish Embassy by the Potomac Craftsmen, consisting of 195 ceramics, rugs, textiles, books, and paintings.

August 7 through 27, 1952.—An exhibition of 55 oil paintings, "Reveries of Paris," by Edwin Scott, from the Alice Pike Barney Memorial Collection. An illustrated catalog was printed with private funds.

August 7 through 27, 1952.—An exhibition of 14 portraits in oil, "Citizens of Japan," by Marguerite S. Hardesty. An illustrated catalog was privately printed.

September 5 through 28, 1952.—The Third Annual Exhibition of Ceramic Art, sponsored by the Kiln Club of Washington, consisting of 225 pieces (117 by local artists, 39 by invited American artists, and 69 loaned by various Washington Embassies and Legations as representative of the work of their national artists). Demonstrations on the potter's wheel were given twice a day four times a week. A catalog was privately printed.

September 5 through 28, 1952.—The Second Regional Exhibition of the Washington Sculptors Group, consisting of 50 pieces of sculpture. A catalog was privately printed.

October 9 through 29, 1952.—Norwegian Decorative Painting through One Thousand Years, held under the patronage of His Excellency, the Ambassador from Norway, Wilhelm Munthe de Morgenstierne, consisting of 96 large mounted photographs, and 55 pieces of ceramics. A catalog was privately printed.

November 9 through 27, 1952.—The Fifteenth Metropolitan State Art Contest, held under the auspices of the D. C. Chapter, American Artists Professional League, assisted by the Entre Nous Club, consisting of 308 paintings, sculpture, prints, ceramics, and metalcraft. A catalog was privately printed.

December 7, 1952, through January 4, 1953.—The Tenth Annual Exhibition of the Artists' Guild of Washington, consisting of 50 paintings and 9 pieces of sculpture.

January 11 through 28, 1953.—Contemporary Indian Art and Crafts, sponsored by the Government of India, organized by the Academy of Fine Art, Calcutta, and the All-India Association of Fine Art, Bombay, consisting of 363 items. A catalog was privately printed.

March 5 through 29, 1953.—The Sixty-first Annual Exhibition of the Society of Washington Artists, consisting of 83 paintings and 16 pieces of sculpture. A catalog was privately printed.

May 10 through 31, 1953.—The Twentieth Annual Exhibition of the Miniature Painters, Sculptors, and Gravers Society of Washington, D. C., consisting of 221 examples. A catalog was privately printed.

May 22, 1953.—At the request of Representative Charles R. Howell, of New Jersey, the model of the 1939 prize-winning design for the Smithsonian Gallery of Art, by Eliel Saarinen, was placed on exhibition in the lobby of the Natural History Building.

June 7 through 28, 1953.—The Fifty-sixth Annual Exhibition of the Washington Water Color Club, consisting of 135 watercolors, etchings, and drawings. A catalog was privately printed.

Respectfully submitted.

THOMAS M. BEGGS, *Director.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

APPENDIX 4

Report on the Freer Gallery of Art

SIR: I have the honor to submit the Thirty-third Annual Report on the Freer Gallery of Art for the year ended June 30, 1953.

THE COLLECTIONS

Additions to the collections by purchase were as follows:

BRONZE

52.28. Chinese, Northern Wei dynasty (A. D. 386–535). Standing Buddha image of gilt bronze on a low four-legged platform; removable mandorla decorated with flames and floral patterns cast in low relief. 0.359 x 0.144. (Illustrated.)

53.62. Chinese, Shang dynasty (ca. 1525–1028 B. C.). Cast socketed dagger-ax of the type *ch'ü ko*. Decorations in relief and intaglio; patination malachite with spots of cuprite. 0.236 x 0.068.

JADE

53.9. Chinese, Shang dynasty (ca. 1525–1028 B. C.). Very light, translucent, greenish nephrite ornament mask. Carved in relief and incised. Rear side pierced with six holes for fastening, and a central hole running from top to bottom. 0.046 x 0.041 x 0.006.

LACQUER

53.8. Chinese, Chou dynasty (ca. 3d century B. C.). Brown lacquer bowl with decorations overlaid in red and flat lacquer. 0.055 x 0.271.

53.63. Chinese, Ming dynasty, Wan-li period (A. D. 1573–1619). Red lacquer box with cover; decorations carved in relief and countersunk decoration carved in black and tan intaglio. 0.132 x 0.323.

53.64. Chinese, Ming dynasty, Yung-lo period (A. D. 1403–1425). Red lacquer box with cover; decorations carved in relief and countersunk intaglio. 0.079 x 0.266.

53.69. Chinese, Ming dynasty, Hsüan-tê period (A. D. 1426–1435). Red lacquer box with cover; decorations carved in relief and countersunk intaglio. 0.045 x 0.098.

MANUSCRIPT

53.71. Persian, mid-16th century (A. D. 1557). A leaf from *Yûsuf-u-Zulaikhâ* by Jâmî. Persian text in black *nasta'liq* in two columns. Text inlaid in larger leaf of rose color with designs in gold (ibexes, deer, birds). 0.254 x 0.151.

53.72. Persian, mid-16th century (A. D. 1557). A leaf from *Yûsuf-u-Zulaikhâ* by Jâmî. Persian text in black *nasta'liq* in two columns with two-line caption in red. Text inlaid in larger leaf of rose color with arabesques and animal designs in gold. 0.253 x 0.151.

53.73. Persian, mid-16th century (A. D. 1557). A leaf from *Yûsuf-u-Zulaikhâ* by Jâmî. Persian text in black *nasta'liq* in two columns with two-line caption in red. Text inlaid in larger leaf of rose color with animals in landscape and birds in floral rinceaux, respectively. 0.254 x 0.150.

53.74. Persian, mid-16th century (A. D. 1557). A leaf from *Yūsuf-u-Zulaikhā* by Jāmī. Persian text in black *nasta'līq* in two columns with two-line caption in red. Text inlaid in larger leaf of rose color with animals in landscape and floral and arabesque rinceaux, respectively. 0.254 x 0.151.

METALWORK

52.29. Chinese, Ming dynasty, 15th century. Gold jar with cover; studded with 21 settings for semiprecious stones of which 7 are empty; both jar and cover decorated with incised pattern of dragons among clouds. 0.092 x 0.091.

PAINTING

52.25 Chinese, Yüan dynasty. Ch'ien Hsüan (A. D. 1235–1290). Handscroll entitled "K'o fang t'u." Ink and faint colors on paper. Artist's signature and 8 seals on painting; 1 inscription and 12 seals on mount. 0.251 x 1.034.

52.27. Chinese, dated in correspondence with A. D. 1464, Ming dynasty, Hsi Ch'ang (A. D. 1388–1470). Handscroll entitled "Hsiao-hsiang-kuo-yü." Bamboos in ink on paper. Two inscriptions and seven seals on painting; title, two inscriptions and nine seals on mount. 0.290 x 7.800.

52.31. Indian, second half of 16th century, Mughal, school of Akbar (A. D. 1555–1605). Illustration from a dictionary (unidentified): "Ruler holding court in a tent encampment and investing retainer with gold kaftan." Color and gold. On verso: 35 lines of black *nasta'līq* writing, captions in red. Wide border with birds and plants in gold. 0.238 x 0.123.

52.32. Indian, second half of 16th century, Mughal, school of Akbar (A. D. 1555–1605). Illustration from a dictionary (unidentified): "River scene—Ruler and attendants in main boat and smaller boat in foreground from which a man is being drowned." Color and gold. On verso: 35 lines of black *nasta'līq* with captions in red. Wide gold-painted border with Indian figures in floral setting. 0.231 x 0.125.

52.33. Indian, second half of 16th century, Mughal, school of Akbar (A. D. 1555–1605). "Audience scene in a palace pavilion during which an old courtier kisses the hand of an enthroned young prince." Colors and gold. Wide border with crude animal scenes to fit painting into an album. 0.242 x 0.129.

52.34. Indian, second half of 16th century, Mughal, school of Akbar (A. D. 1555–1605). Illustration from a dictionary (unidentified): "Preparation for the hunt in the palace courtyard." One line of *nasta'līq* writing on top. Delicate color tints and gold. On verso: 35 lines of *nasta'līq* writing in black, captions in red. Wide gold-painted border with Indian figures in stylized landscape. 0.216 x 0.122.

52.35. Persian, 14th century (A. D. 1341), Mongol (Īl-Khān period), Inju school (Shīrāz). Page from a *Shāh-nāma* manuscript showing "Rustam lifting Afrāsiyāb from the saddle." Painted with colors and gold, writing in black proto-*nasta'līq* in six columns between red columnar lines. 0.086 x 0.171.

53.12–53.60. Persian, first half of 17th century (between 1598 and 1643). Period of Shah 'Abbās, school of Isfahan. By Riza Abbasi (Riẓāye 'Abbāsī), and other artists. Album of 60 drawings.

53.61. Persian, early 17th century. Period of Shah 'Abbās, school of Isfahan. "Lamentation over the dead body of Christ." By 'Alī Rizā ('Abbāsī) after Perugino. Color and gold. Three gold-painted borders, the last and widest one with animals in rinceaux on blue ground. 0.210 x 0.152.

POTTERY

52.12. Chinese, T'ang dynasty (A. D. 618–906). Figurine, mortuary, of a man on horseback; fine, whitish-buff clay, fired medium hard; transparent glaze, with fine crackle, over areas of brown and green on white surface; man's head, hands, boots, and saddle blanket unglazed and painted. 0.935 x 0.340 x 0.117.

52.13. Chinese, T'ang dynasty (A. D. 618–906). Figurine, mortuary, of a woman on horseback; fine, whitish-buff clay, fired medium hard; transparent glaze, with fine crackle, over areas of brown and green on white surface; woman's head unglazed and painted, also other small areas. 0.431 x 0.376 x 0.148.

52.14. Chinese, T'ang dynasty (A. D. 618–906). Figurine, mortuary, of a Negro groom, left hand restored; fine, whitish-buff clay, fired medium hard; transparent glaze, with fine crackle, over green robe with brown lapels and brown boots, hand white; head and neck unglazed and painted. 0.207 x 0.067.

52.16. Chinese, Ming dynasty, Hsüan-tê period (A. D. 1426–1435). Bowl with conical sides and foliate rim; fine white porcelain; transparent glaze, high-fired; decoration in underglaze cobalt blue, fruit and floral sprays inside and out; six-character Hsüan-tê mark on base. (Pair with 52.17.) 0.079 x 0.227.

52.17. Chinese, Ming dynasty, Hsüan-tê period (A. D. 1426–1435). Bowl with conical sides and foliate rim; fine white porcelain; transparent glaze, high-fired; decoration in underglaze cobalt blue, fruit and floral sprays inside and out; six-character Hsüan-tê mark on base. (Pair with 52.16.) 0.078 x 0.227.

52.18. Chinese, Ming dynasty, Ch'eng-hua period (A. D. 1465–1487). Bowl with plain, slightly flaring rim; fine white porcelain; transparent glaze, high-fired; decoration in underglaze cobalt blue, large lotus sprays inside and out; six-character Ch'eng-hua mark on base. 0.070 x 0.151.

52.19. Chinese, Ming dynasty, Hung-chih period (A. D. 1488–1505). Dish with plain straight rim; fine white porcelain; transparent glaze, high-fired; decoration of dragons amid clouds incised in the paste and covered with brilliant green enamel which shows a fine crackle; six-character Hung-chih mark on base. (Pair with 52.20.) 0.044 x 0.215.

52.20. Chinese, Ming dynasty, Hung-chih period (A. D. 1488–1505). Dish with plain, straight rim; fine white porcelain; transparent glaze, high-fired; decoration of dragons amid clouds incised in the paste and covered with brilliant green enamel which shows a fine crackle; six-character Hung-chih mark on base. (Pair with 52.19.) 0.044 x 0.215.

52.21. Chinese, Ming dynasty, Chêng-tê period (A. D. 1506–1521). Jar of the type *cha-tou;* fine white porcelain; transparent glaze, high-fired, inside and on base; decoration of dragons amid clouds incised in paste and covered with green enamel on a ground of yellow enamel; four-character Chêng-tê mark on base which is perforated by four symmetrically placed drilled holes. 0.113 x 0.146.

52.22. Chinese, Sung dynasty (A. D. 690–1279), Ying-ch'ing type. Vase with broad rounded shoulder and cylindrical neck; coarse-grained white porcelain with earth adhesions; transparent glaze with faint bluish tone and fine crackle; decoration, in relief under glaze, carved lotus pattern below a row of stamped patterns on shoulder, horizontal fluting on body. 0.202 x 0.127.

52.23. Chinese, Han dynasty (207 B. C.–A. D. 220). Vase, small, of *hu* shape with flaring flanged rim; reddish-buff clay with sand tempering, fired medium hard; green glaze with pale iridescence and fine crackle, all over; decoration of horizontal lines in relief and intaglio, three triangular spurs on flat base. 0.131 x 0.107.

52.24. Chinese, Han dynasty (207 B. C.–A. D. 220). Vase, small, with broad shoulder, contracted mouth and low, thick rim; reddish clay with sand tempering, fired medium hard; green glaze with pale iridescence and fine crackle, all over; decoration, none. Two triangular spurs and remains of a third on flat base. 0.113 x 0.149.

52.26. Chinese, Han dynasty (207 B. C.–A. D. 220), Yüeh ware. Basin with rounded sides and horizontal flaring rim; clay not visible, but probably fine gray stoneware; thin, transparent, mat glaze, with slight greenish tinge, all over; decoration stamped and incised in clay; four animal masks with rings applied in relief outside. 0.086 x 0.356.

52.30. Chinese, Shang dynasty (ca. 1525–1028 B. C.). Gray pottery vessel of the type *huo*, decoration incised and in relief. Replica of 42.1, a bronze *huo*. 0.193 x 0.213.

53.1. Chinese, Ming dynasty, Hsüan-tê period (A. D. 1426–1435). Bowl with plain, straight rim; fine white porcelain, brownish mottling on footrim; plain, transparent glaze; decoration in underglaze blue; garden scene with figures outside; plain white inside; six-character Hsüan-tê mark. 0.070 x 0.191.

53.2. Chinese, Ming dynasty, Hsüan-tê period (A. D. 1426–1435). Bowl with plain straight rim and convex center; fine white porcelain, fired pale orange on footrim; plain, transparent glaze; decoration in underglaze blue; floral border and lotus panels outside, scroll border, floral wreath, and interlocking festoons with arabesques; six-character Hsüan-tê mark. 0.060 x 0.152.

53.3. Chinese, Ming dynasty, second half 15th century. Vase of *mei-p'ing* shape with straight neck; fine white porcelain, scattered black flecks on base; plain, transparent glaze; decoration in underglaze blue, clouds on neck; overlapping petals and pendent leaves on shoulder; landscape garden with figures, stylized lotus panels. 0.228 x 0.144.

53.4. Chinese, Ming dynasty, late 15th century. Bowl, shallow with plain, slightly flaring rim; fine white porcelain; plain glaze, faintly gray, transparent inside; decoration in colored glazes, turquoise five-claw dragons on deep blue ground with white flecks, plain inside. 0.038 x 0.148.

53.5. Chinese, Ming dynasty, second half 15th century. Bowl with plain, straight rim; fine white porcelain; plain, transparent glaze; decoration in underglaze blue; cash diaper band at rim, nine dragons amid waves outside; one dragon in waves inside. (Pair with 53.6.) 0.073 x 0.132.

53.6. Chinese, Ming dynasty, second half 15th century. Bowl with plain, straight rim; fine white porcelain; plain, transparent glaze; decoration in underglaze blue; cash diaper band at rim, nine dragons amid waves outside; one dragon in waves inside. (Pair with 53.5.) 0.075 x 0.132.

53.7. Chinese, Ming dynasty, Chêng-tê period (A. D. 1506–1521). Dish with plain, straight rim; fine white porcelain; plain, transparent glaze; decoration in underglaze blue and overglaze yellow enamel; blue flowers on yellow ground; six-character Chêng-tê mark. 0.045 x 0.213.

53.65. Chinese, Ming dynasty, Yung-lo period (A. D. 1403–1424). Bowl of thin white porcelain with floral decorations traced in the white body under the glaze and scarcely visible except as a transparency. 0.100 x 0.201.

53.66. Chinese, Ch'ing dynasty, K'ang Hsi period (A. D. 1662–1722). Porcelain bowl of solid aubergine color, with cloud and dragon decorations carved in body under the glaze; six-character mark of the K'ang Hsi period incised on unglazed foot. 0.091 x 0.128.

53.67. Chinese, Ch'ing dynasty, K'ang Hsi period (A. D. 1662–1722). White bottle-shaped porcelain vase decorated with lotus-leaf design in relief around base; six-character mark of the K'ang Hsi period in underglaze blue on base. 0.200 x 0.069.

53.68. Chinese, Ch'ing dynasty, Ch'ien Lung period (A. D. 1736–1795). Bottle-shaped *famille rose* vase decorated with enamels in the *mille fleur* design; six-character mark of the Ch'ien Lung period in red on base. 0.128 x 0.067.

53.10. Japanese, late 17th century, Kakiemon. A chrysanthemum-shaped deep porcelain plate decorated with vitrifiable enamels. 0.282 x 0.054. (Illustrated.)

53.11. Japanese, late 17th century, Kakiemon. An oval-shaped porcelain bowl decorated with vitrifiable enamels; black lacquer cover. 0.089 x 0.193 x 0.150.

52.11. Persian, 10th century. Platter, shallow, wide-rimmed, on low ring-foot. Two Kufic inscriptions in black-brown on white slip. The clear glaze shows a fine crackle in places. Inside of foot unglazed, revealing the light reddish clay. Broken and put together in ancient times (three bronze rivets) and again recently. Greater part of outer edge and small area on wide margin made of plaster. 0.468 x 0.060. (Illustrated.)

53.70. Persian, 10th century. Bowl, shallow, on solid foot. Knot design in center and festooned edge are in deep brown slip on white glaze pitted in parts and occasionally chipped off along edge. Broken and put together, but only very small pieces missing. 0.324 x 0.067.

STONE SCULPTURE

52.15. Chinese, Northern Ch'i dynasty. Standing figure of a Bodhisattva in high relief against a flat background; right hand holds a lotus bud, left hand a flask. Traces of color. 1.034 x 0.417.

Total number of accessions to date (including above) 10,794

REPAIRS TO THE COLLECTIONS

Cleaning and restoration of 24 American paintings were completed by John and Richard Finlayson, of Boston. The Gallery has obtained the services of Takashi Sugiura as picture mounter, assigned to the oriental collections.

CHANGES IN EXHIBITIONS

Changes in exhibitions totaled 141 as follows:

American art:	
Etchings	2
Oil paintings	19
Watercolor paintings	9

Chinese art:	
Bronze	2
Gold	1
Kossū	1
Lacquer	2
Paintings	17
Pottery and porcelain	30
Wood sculpture	2
Japanese art:	
Bronze sculpture	1
Paintings	42
Pottery	10
Sassanian art:	
Silver	2
Venito-Islamic art:	
Brass	1

LIBRARY

Accessions of books, pamphlets, periodicals, and study materials totaled 835 pieces, making a total of 31,905 books and pamphlets, of which 18,303 are in Chinese, 6,682 in Japanese, and others in Arabic, Armenian, Hindi, Sanskrit, Tibetan, and Turkish, as well as in the Western languages. The above total does not include study material. One of the year's outstanding gifts to the library was the *Hōryūji Kondō hekiga shū* reproductions from the Tokyo National Museum.

In addition to the work of expanding the card catalog and revision of the oriental books catalog, 976 publications and scrolls were cataloged, 229 parts of serial publications were entered, 3,522 cards were added to the catalogs and shelf lists. A total of 509 items were bound, labeled, repaired, or mounted.

Bibliographic references of the American paintings owned by the Gallery were coordinated with the catalog cards and the Gallery folder sheets. Work on indexing of both the English and Japanese editions of the Japanese periodical *Kokka* continued, and the project is more than half complete. The compilation of abstracted material in the field of art and archeology in cooperation with the associate in technical research has consumed a great deal of time. This publication is intended to be the principal guide to all recent literature on technical abstracts of art and archeology, beginning with published sources for 1943, through December 1952. It is intended that the completed abstracts will be published in the near future as one of the series of Occasional Papers of the Freer Gallery of Art.

PUBLICATIONS

Three publications of the Gallery were issued during the year:

Pope, John Alexander: Fourteenth-century blue-and-white. A group of Chinese porcelains in the Topkapu Sarayı Müzesi, Istanbul, 1952. Occasional Papers, vol. 2, No. 1. (Smithsonian Publ. 4089.)

Pope, John Alexander: Ming porcelains in the Freer Gallery of Art. May 1953.
Gallery Book I: A selection of etchings, drypoints, lithographs and lithotints by James McNeill Whistler (1834–1903).

Papers by staff members appeared in outside publications as follows:

Wenley, A. G.: A *hsi tsun* from the Avery Brundage Collection. Archives, Chinese Art Society of America, vol. 6, 1952.
———. Exhibition of Japanese painting and sculpture. Bulletin, Vereeniging van Vrienden der Aziatische Kunst, Derde Serie, No. 1, June 1953.
Ettinghausen, Richard (contributor): Bibliography of periodical literature on the Near and Middle East, vols. 19–22. The Middle East Journal, 1951–52.
Gettens, R. J.: Science in the art museum. Scientific American, vol. 187, No. 1, pp. 22–27, July 1952.
———. The bleaching of stained and discoloured pictures on paper with sodium chloride and chlorine dioxide (with French translation). Museum, vol. 5, No. 2, pp. 116–130, 1952.
———. La technique des "Primitifs Flamands." Studies in Conservation, vol. 1, No. 1, pp. 1–29, October 1952. (With P. Coremans and J. Thissen.)

REPRODUCTIONS

During the year the photographic laboratory made 3,814 prints, 242 glass negatives, and 1,125 lantern slides. Total number of negatives on hand, 10,044; lantern slides, 7,067.

BUILDING

The general condition of the Freer building is good, and the maintenance and operation have been satisfactory, but the galleries and much mechanical equipment need renovation.

The major projects of the cabinet shop have been the completing and putting in service of eight new exhibition cases and the overhauling of the shop for the oriental picture mounter. Miscellaneous odd jobs in connection with the maintenance of office and Gallery equipment, crating, etc., continue as usual.

ATTENDANCE

The Gallery was open to the public from 9 to 4:30 every day except Christmas Day, until May 25, 1953. Since that date the hours on Tuesdays have been from 2 to 10. The total number of visitors to come in the main entrance was 71,308. The highest monthly attendance was in August, 9,851, and the lowest was in December, 2,623.

There were 1,703 visitors to the office during the year.

HERZFELD ARCHIVE

The Herzfeld material continues to be used by experts in Near Eastern archeology throughout the world.

Recent Addition to the Collection of the Freer Gallery of Art.

52.11

53.10

Recent Additions to the Collection of the Freer Gallery of Art.

AUDITORIUM

On May 26, 1953, Mr. Pope gave the initial lecture in the 1953–54 series at 8:30 p. m. in the auditorium on "The Ming Dynasty and Its Porcelains" (illustrated). Attendance, 521. In addition, the auditorium was used by four outside agencies.

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 or written, and exclusive of those made by the technical laboratory on specimens (listed below), were made upon 4,925 objects as follows: Belonging to private individuals, 2,040; belonging to dealers, 1,142; belonging to other museums, 1,743. In all, 503 photographs of objects were examined and 790 oriental language inscriptions were translated for outside individuals and institutions. By request, 8 groups totaling 343 persons met in the exhibition galleries for docent service by staff members; and 1 group of 9 persons was given docent service in the study-storage rooms. There were 25 distinguished foreign visitors who studied the collections.

Work done in the technical laboratory included the characterization of an organic red pigment found on a number of Chinese objects within and without the Freer Collection, and the analysis of a copper-corrosion product in ancient Egyptian bronzes which is to be described as a new mineral. Examinations were made of 29 objects from the Freer Collection, and 56 from outside sources. Many of these bore on the two problems mentioned above. Also work was continued on the collection of material for Abstracts of Technical Studies in Art and Archeology. The laboratory equipment was augmented by the installation of a comparison microscope, a chemical balance, and an X-ray viewer.

By invitation the following lectures were given outside the Gallery by staff members:

1952

Oct. 15. Mr. Pope addressed members of the Oriental Ceramic Society, in London, on "Some Blue-and-White in Istanbul." (Illustrated with photographs.) Attendance, 100.

Oct. 24. Mr. Pope addressed a joint meeting of the members of the Svenska Orientsällskapet and the Föreningen Keramikens Vänner, in the Nationalmuseum, Stockholm, on "Chinese Porcelains from the Ardebil Shrine." (Illustrated with photographs.) Attendance, 90.

1952

Oct. 29. Dr. Ettinghausen addressed a joint meeting of the members of the Middle East Institute, the Oriental Club, and the Washington Society, Archaeological Institute of America, at Dumbarton Oaks, on "Islamic Miniatures and the West." (Illustrated.) Attendance, 120.

Oct. 30. Mr. Pope gave a public lecture in the Kunstindustriemuseum, Copenhagen, on "Chinese Porcelains from the Ardebil Shrine." (Illustrated with photographs.) Attendance, 40.

Nov. 6. Mr. Pope addressed members of the Association Française des Amis de l'Orient (in French), in the Musée Guimet, Paris, on "Chinese Porcelains from the Ardebil Shrine." (Illustrated with photographs.) Attendance, 100.

While in London, Mr. Pope gave the following lectures at the University of London under the auspices of the Percival David Foundation of Chinese Art and the School of Oriental and African Studies, as follows:

Nov. 12. "The Introduction of Chinese Porcelain into Europe." (Illustrated with photographs.) Attendance, 70.

Nov. 18. "Chinese Porcelains from the Ardebil Shrine." (Illustrated with photographs.) Attendance, 50.

Nov. 25. "Chinese Porcelains from the Ardebil Shrine." (Illustrated with photographs.) Attendance, 55.

Dec. 11. Dr. Ettinghausen addressed members of the Middle East Institute, Washington, D. C., on "Islamic Art." (Illustrated.) Attendance, 20.

Dec. 16. Dr. Ettinghausen lectured at the University of Michigan, in Ann Arbor, on "Great Art Monuments in Iran, Afghanistan, and India." (Illustrated.) Attendance, 101.

1953

Jan. 5. Dr. Ettinghausen lectured at Dumbarton Oaks, Washington, D. C., on "Iran and Her Historical Monuments." (Illustrated.) Attendance, 170.

Jan. 15. Mr. Wenley addressed the annual dinner of the Smithsonian Board of Regents, giving a brief account of his trip to Japan as chairman of the committee for the Japanese Loan Exhibition. (Illustrated.) Attendance, 26.

Jan. 16. Dr. Ettinghausen gave a lecture at the Iranian Embassy in Washington, D. C., on "Iranian Architecture." (Illustrated with Dr. Ettinghausen's own slides.) Attendance, 85.

Feb. 6. Dr. Ettinghausen gave a lecture at the Foreign Service Institute, State Department, Washington, D. C., on "Islamic Art." (Illustrated.) Attendance, 24.

Feb. 8. Mr. Stern gave a public lecture at the National Gallery of Art, Washington, D. C., on "The Exhibition of Japanese Art." (Illustrated with borrowed slides.) Attendance, 350.

Feb. 8. Mr. Stern gave a lecture to the District of Columbia Library Association at the National Gallery of Art, Washington, D. C., on "The Exhibition of Japanese Art." (Illustrated with borrowed slides.) Attendance, 175.

1955

Feb. 13. Mr. Pope gave a lecture at the John Herron Art Institute, Indianapolis, Ind., on "The Introduction of Chinese Porcelain into Europe." (Illustrated.) Attendance, 110.

Feb. 24. Dr. Ettinghausen gave a lecture at The Mosque, Washington, D. C., on "Near Eastern Art and Facilities for Its Study in Washington, D. C." (Illustrated with borrowed slides.) Attendance, 220.

Feb. 24. Mr. Pope gave a lecture at the Chinese Art Society, China House, New York City, on "Chinese Porcelains from the Ardebil Shrine." (Illustrated.) Attendance, 60.

Mar. 23. Mr. Gettens gave a lecture at the Chemistry Club, Trinity College (Catholic University), Washington, D. C., on "Artificial Coloring Materials of the Ancients." (Illustrated.) Attendance, 25.

Mar. 24. Mr. Stern gave a lecture at the Center for Japanese Studies, Rackham Amphitheatre, University of Michigan, Ann Arbor, on "The Traveling Exhibition of Japanese Art Treasures." (Illustrated.) Attendance, 220.

Mar. 25. Dr. Ettinghausen gave a lecture at the Science Society, Dartmouth College, Hanover, N. H., on "Archaeological Travels in Afghanistan and India." (Illustrated.) Attendance, 100.

Mar. 28. Dr. Ettinghausen gave a lecture at the Frick Collection, New York City, on "Islamic Miniatures and the West." (Illustrated.) Attendance, 185.

Apr. 8. Mr. Pope gave a lecture at the American Oriental Society, Catholic University, Washington, D. C., on "Tentative Identification of Certain Early Persian Collectors of Chinese Porcelain." Attendance, 40.

Apr. 8. Mr. Stern gave a lecture at the American Oriental Society, Catholic University, Washington, D. C., on "Hokusai's *Hyakunin-isshu Ubaga Etoki*, or Poems of a Hundred Poets Explained by a Wet Nurse." (Illustrated.) Attendance, 40.

Apr. 9. Mr. Stern gave a lecture at the American Oriental Society, Hotel Washington, Washington, D. C., on "The Exhibition of Japanese Painting and Sculpture Currently Touring the United States." (Illustrated.) Attendance, 60.

Apr. 10. Dr. Ettinghausen gave a lecture at the Cleveland Museum of Art, Cleveland, Ohio, on "Archaeological Travels in Iran, Afghanistan and India." (Illustrated.) Attendance, 250.

Apr. 16. Dr. Ettinghausen gave a lecture at the Walters Art Gallery, Baltimore, Md., on "Archaeological Travels in Iran and Afghanistan." (Illustrated.) Attendance, 90.

June 17 Mrs. Usilton gave a lecture at the 48th annual meeting of the American Association of Museums (Librarians' Section), Buffalo, N. Y., on "Selling Your Museum Library to Your Board of Directors." (Illustrated.) Attendance, 20.

June 18. Mr. Gettens gave a lecture at the 48th annual meeting of the American Association of Museums, Buffalo, N. Y., on "Current Art Technical Literature: An Abstracts Project." (Illustrated.) Attendance, 85.

June 23. Dr. Ettinghausen gave a lecture at The Cultural Attachés' Group, United Nations Club, Washington, D. C., on "Art and Nature in the Near East." (Illustrated.) Attendance, 38.

Members of the staff traveled outside of Washington on official business as follows:

1952

July 7–Sept. 23. Mr. Wenley went to Japan to serve as chairman of the committee representing five American Museums in which the Japanese Loan Exhibition is being held. This committee was sent to advise with the Japanese Government concerning the contents of the exhibition.

Sept. 23–Dec. 22. Mr. Pope, in Europe, carried out further research on problems related to the Chinese porcelains from the Ardebil Shrine; visited museums and collections and consulted with scholars and connoisseurs in London, Glasgow, Stockholm, Copenhagen, and Paris.

In addition, 5 members of the staff made a total of 18 trips outside of Washington on official business.

Members of the staff held honorary posts and undertook additional duties outside the Gallery as follows:

Mr. Wenley:
- Research Professor of Oriental Art, University of Michigan.
- Member, Board of United States Civil Service Examiners at Washington, D. C., for the Smithsonian Institution.
- Member, Board of Trustees, Textile Museum, Washington, D. C.
- Member, Council of the Far Eastern Ceramic Group.
- Member, Board of Trustees of the Hermitage Foundation, Norfolk, Va.
- Member, Visiting Committee, Dumbarton Oaks Research Library and Collection.
- Member, Smithsonian Art Commission.
- Member, Consultative Committee, Ars Orientalis.
- Chairman, Louise Wallace Hackney Scholarship Committee of the American Oriental Society.

Mr. Pope:
- Member, Board of Governors of the Washington Society of the Archaeological Institute of America; the Board met at the Freer Gallery of Art, on July 23, 1952, and on May 13, 1953.
- President, Far Eastern Ceramic Group.
- Art Editor, Far Eastern Quarterly.
- Member, Editorial Board of the Archives of the Chinese Art Society of America.
- President, Southern Association of Exeter Alumni in Washington.
- Accompanied 5 students and 1 teacher from the Garrison-Forest School, Baltimore, Md., through the Japanese exhibition at the National Gallery of Art, Washington, D. C., February 12, 1953.

Dr. Ettinghausen:
- Research Professor of Islamic Art, University of Michigan.
- Near Eastern editor of Ars Orientalis.
- Member, Editorial Board, The Art Bulletin.
- Trustee, American Research Center in Egypt.
- Member, Comitato Internazionale di Patronato, Museo Internazionale delle Ceramiche, Faenza, Italy.
- Member, Editorial Advisory Committee, Studies in Art and Literature in Honor of Belle DaCosta Greene.

Dr. Ettinghausen: Editor, A Selected and Annotated Bibliography of Books and Periodicals in Western Languages Dealing with the Near and Middle East with Special Emphasis on Medieval and Modern Times; published by the Middle East Institute, 1952.

Went to the Georgetown Branch of the District of Columbia Public Library to examine and advise about the exhibition of 30 Egyptian paintings by Youssef Sida; wrote the Foreword in the Catalogue of the Exhibition of Modern Paintings by Youssef Sida under the Patronage of H. E. the Egyptian Ambassador, July 17–19, 1952.

Mr. Gettens: Associate Editor, Studies in Conservation, published for the International Institute for the Conservation of Museum Objects.

Abstractor for Chemical Abstracts, American Chemical Society.

Mr. Stern: Assisted in the preparation of the catalog of the Japanese Loan Exhibition; also in the installation of the objects in the Exhibition, National Gallery of Art, Washington, D. C., November 1952–January 1953.

Respectfully submitted.

A. G. Wenley, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

APPENDIX 5

Report on the Bureau of American Ethnology

SIR: I have the h nor 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, 1953, conducted in accordance with the act of Congress of April 10, 1928, as amended August 22, 1949, which provides ". . . 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

On January 28 Dr. M. W. Stirling, Director of the Bureau, left for Panama on the fourth National Geographic Society–Smithsonian Institution archeological expedition to Panama. From February 13 to March 1 the expedition was in Darién where 2 weeks were spent on the Sambu River studying the little-known Choco Indians. The fact that their territory was opened for settlement only 2 years ago offered unusual opportunity to study the beginnings of the acculturation process. Following this, Dr. Stirling spent a month in archeological work on the islands of the Gulf of Panama, with headquarters on Taboga Island. Excavations in shell-midden sites were conducted on Taboga and Taboguilla Islands and a large burial site in a rock shelter on Urabá was investigated. He spent the first half of April on Almirante Bay in the Province of Bocas del Toro where he examined midden and cave sites and made test excavations. He returned to Washington on April 20.

Dr. Frank H. H. Roberts, Jr., Associate Director of the Bureau, was occupied most of the year with the management of the River Basin Surveys, of which he is Director. In August he went to Lincoln, Nebr., to inspect the headquarters of the Missouri Basin project, whence, accompanied by Ralph D. Brown, chief of the Missouri Basin project, and Dr. Gordon C. Baldwin, archeologist from the Region 2 office of the National Park Service at Omaha, Nebr., he proceeded to the Harlan County Reservoir project in south-central Nebraska where he visited the excavating party from the Laboratory of Anthropology of the University of Nebraska, under the direction of Dr. John L. Champe. The work at the Harlan County Reservoir was

a cooperative undertaking between the Laboratory of Anthropology and the Inter-Agency Archeological Salvage Program. While there the party examined several sites which had been excavated during the summer or were then being dug. From Dr. Champe's camp the party proceeded to Medicine Creek Reservoir, near Cambridge, Nebr., where E. Mott Davis of the Nebraska State Museum, University of Nebraska, was carrying on another cooperative project, excavating a site containing material belonging in the Early Man category. From Medicine Creek Dr. Roberts and his associates went to Denver, Colo., where they conferred with officials in the regional office of the Bureau of Reclamation. From Denver they went to Laramie, Wyo., where they examined and studied a collection of specimens from excavations carried on by Dr. William Mulloy of the University of Wyoming at the Keyhole Reservoir. The latter work was also a cooperative project. From Laramie the party went to Cody, Wyo., where it spent 2 days at the Horner site where a joint party from the Smithsonian Institution and Princeton University, under the leadership of Dr. Waldo R. Wedel and Dr. Glenn L. Jepsen, was collecting interesting new evidence on one of the early hunting groups in the Plains area. From Cody, Dr. Roberts and his companions went to Billings, Mont., to confer with regional officials of the Bureau of Reclamation about the various projects underway or contemplated in that portion of the Missouri Basin. At Billings the party was joined by John L. Cotter from the Washington office of the National Park Service. From Billings, they went to the Garrison Reservoir in North Dakota where they inspected the excavations being conducted by River Basin Surveys parties at the site of Fort Berthold II and an early historic Indian village on the top of a small butte near Elbowoods, N. Dak. The group then went on to Bismarck, N. Dak., where it examined and studied materials which had been collected by a party from the North Dakota State Historical Society at the site of the Indian village which was adjacent to Fort Berthold II. From Bismarck the party proceeded to Jamestown where the River Basin Surveys were excavating a village site and some mounds in the area to be flooded by the Jamestown Reservoir. It then proceeded to the Oahe Dam of the Oahe Reservoir near Pierre, S. Dak., where two River Basin Surveys groups were digging. One of the latter was at work in the remains of a fortified village a short distance above the dam while the other was occupied at an earlier site some miles upstream. From Pierre, Dr. Roberts and his associates went to the Fort Randall Reservoir where another River Basin Surveys party was digging in two sites. En route they stopped and inspected a site where the University of Kansas had carried on a cooperative excavation project during the earlier part of the season. From Fort Randall the group returned to the headquarters at Lincoln where

several days were spent in examining and studying collections coming in from the various field parties. At that time Dr. Roberts assisted Mr. Brown in preparing plans for the termination of the various field parties and for the fall and winter work at the laboratory in Lincoln.

Dr. Roberts returned to the field office at Lincoln in September following the accidental death of Mr. Brown, and for a period of 2 weeks took charge of the operations there, supervising the termination of the field projects and the return of personnel and equipment to the field headquarters. At that time he also reviewed and edited a number of preliminary reports on reconnaissance surveys, and approved them for mimeographing and distribution.

In December Dr. Roberts went to St. Louis to attend the annual meetings of the American Association for the Advancement of Science and gave the retiring address as chairman of Section H, speaking on the subject "Progress in the Inter-Agency Archeological and Anthropological Salvage Program in the United States." In May he attended the meetings of the Society for American Archeology at Urbana, Ill., taking part in a number of discussions pertaining to the work in the Plains area. Later in the month he went to Lincoln, Nebr., to take part in a meeting of the Missouri Basin Inter-Agency Field Committee. In January he completed a manuscript, "Earliest Men in America, Their Arrival and Spread in Late Pleistocene and Post Pleistocene Times," for the International Commission for a Scientific and Cultural History of Mankind. During the year Dr. Roberts received an alumni award from the University of Denver for distinguished service in the field of American archeology.

Dr. Henry B. Collins, anthropologist, continued his Eskimo studies and other Arctic activities. He continued to serve as a member of the National Research Council's Committee on International Relations in Anthropology and was appointed a member of the Permanent Council of the International Congress of Anthropological and Ethnological Sciences, to participate in planning for the next session of the Congress, to be held in Philadelphia in 1954.

As a member of the Board of Governors of the Arctic Institute of North America Dr. Collins attended several meetings of the Board and of the executive committee held in Montreal, Ottawa, and Washington. As chairman of the directing committee of the Arctic Bibliography, he continued to supervise the operation of this project and made arrangements with the Department of the Air Force for support of the work during the present and coming fiscal years and for the publication of the material assembled in 1952 and 1953. The Arctic Bibliography is being prepared for the Department of Defense by the Arctic Institute under contract with the Office of Naval Research. It describes, and indexes by topic and region, the contents of 24,000 publications in all fields of science relating to the Arctic and sub-

Arctic regions of America, Siberia, and Europe. About 40 percent of the material is in English, 30 percent in Russian, and the rest mainly in Scandinavian, Finnish, German, and French. The first 3 volumes of the Bibliography, of approximately 1,500 pages each, will be issued as a publication of the Department of the Army in July 1953. A fourth volume of the same size, representing the work of the past 2 years, was turned over to the printer at the end of the present fiscal year.

Dr. Collins participated in the preparation of a Program of History of America, which the Comisión de Historia of Mexico is organizing under the sponsorship of the Rockefeller Foundation. In January he attended a meeting in Havana at which plans for the program were discussed, and prepared a paper on the subject assigned to him—the Arctic Area—which summarized existing knowledge of the archeology, ethnology, physical anthropology, and history of the Eskimo and Indian tribes of the American Arctic.

On June 23 Dr. Collins and his assistant, William E. Taylor, were flown by the R. C. A. F. from Montreal to Cornwallis Island in the Canadian Arctic Archipelago to conduct further archeological excavations for the National Museum of Canada and the Smithsonian Institution. The principal objective of the work is to obtain additional information on the prehistoric Dorset culture, traces of which were found there, with Thule culture remains, by Dr. Collins and Mr. Taylor in 1950 and 1951.

The beginning of the fiscal year found Dr. John P. Harrington, ethnologist, engaged in the preparation of a study of the Abenaki Indians of Maine, Quebec, and formerly also of Vermont, who speak the nearest related living language to the extinct tongue of the Massachusetts Indians, in whose language the Eliot Bible was written. The two tongues were so closely akin that an Indian speaking one could with a little practice have understood the other. A complete treatise on the Abenaki has been assembled, including unique lists of the terms referring to their culture, and the material awaits completion of the typing to make it ready for the printer.

On December 20 Dr. Harrington proceeded to Santa Barbara, Calif., where he continued his studies of the Chumash Indians of the Santa Barbara Channel region. In 1542 the Cabrillo Expedition visited these shores, and, contrary to the custom of the time, put on record about 42 place names, nearly all of which can be identified. All the sites along the coast were visited. The coming of Cabrillo antedated that of the Pilgrim Fathers to what is now Massachusetts by nearly 80 years, and the Indian words written down are far older than any others recorded in California. During the four centuries which have elapsed since Cabrillo came, the language has evidently changed but little. Through good fortune Dr. Harrington was able to locate the

long-looked-for chapel of Saxpilil and to identify the site of the village of Coloc. On April 20, 1953, he returned to Washington.

At the beginning of the fiscal year Dr. Philip Drucker, anthropologist, was in Washington continuing his studies of Meso-American archeology. During the latter part of the summer he began preparations for an acculturational study in southeast Alaska. On September 30 he left Washington for Juneau, Alaska, where he began his investigation of the development and function of the highly interesting intertribal organization of Alaskan Indians known as the Alaska Native Brotherhood. In November he had the good fortune to be invited to attend the annual convention of this organization at Hoonah, Alaska, in the role of an observer. On the first of December he returned to Washington and began preparation of a report on the study just completed.

Shortly after the first of the year Dr. Drucker went to Mexico, D. F., where he conferred with officials of the Mexican Government and obtained the necessary permits to enable him to carry out a program of archeological reconnaissance in the Olmec area of western Tabasco and southern Veracruz. This research project was sponsored jointly by the Smithsonian Institution and the Wenner-Gren Foundation for Anthropological Research. At the end of January he departed for the field where he continued his investigations until the middle of May. He returned to Mexico City to make arrangements for the exportation of the ceramic samples collected in the course of the survey, the study of which should make it possible to identify as to culture affiliation each of the 70-some-odd archeological sites discovered and tested in the course of the trip. On June 10 he left for Washington, D. C.

RIVER BASIN SURVEYS[1]

(Report prepared by FRANK H. H. ROBERTS, Jr.)

As in previous years the investigations of the River Basin Surveys were carried on 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. During the fiscal year 1952–53 the work was financed by a transfer of $122,700 from the National Park Service to the Smithsonian Institution. Included were $111,065 for investigations in the Missouri Basin and $11,635 for all other areas where projects were underway. An additional $50,294 in carryover of previous funds was also available for the Missouri Basin, making a total of $161,359 for that area. The over-all total for the fiscal year, including an unexpended balance of $3,390, was $172,994. That amount was approxi-

[1] See article by Dr. Roberts in 1951 Smithsonian Report, pp. 351–383, for a 5-year summary of the River Basin Surveys work.

mately 26 percent less than for the preceding year and necessitated a corresponding reduction in operations.

Field investigations consisted of reconnaissance or surveys for locating archeological sites and paleontological deposits that will be affected by construction work, or are located in areas that will be flooded, and the excavation of sites that previous survey parties had observed and recorded. Following the trend of the preceding year there was much greater emphasis on excavation because the survey parties had in large measure caught up with the general program and there were fewer proposed reservoir areas requiring preliminary study. Reconnaissance parties visited 6 new reservoir basins located in 3 States. Further surveys were made in 7 reservoir areas where some preliminary studies had previously been carried on. They were in 5 different States. At the end of the fiscal year excavations were completed or were underway in 6 reservoir basins in 4 States. During the course of the year there were nine excavating parties in the field. Four of them were in areas where there had been no digging previously. The other five continued investigations at reservoir projects where work was started during prior field seasons. A paleontological party collected materials and made geologic studies in 4 reservoir basins in 3 States. By June 30, 1953, reservoir areas where archeological surveys had been made or excavations carried on since the start of the program in 1946 totaled 241 in 27 States. One lock project and four canal areas were also investigated. The survey parties have located and recorded 3,469 archeological sites, and of that number 852 have been recommended for excavation or limited testing. Preliminary appraisal reports were completed for all the reservoirs surveyed, and where additional reconnaissance has resulted in the discovery of further sites supplemental reports have been prepared. Some of those finished during the fiscal year, together with others completed toward the end of the previous year, were mimeographed for limited distribution to the cooperating agencies. In the course of the year 23 such reports were issued. The total number distributed since the start of the program is 172. The variance between that figure and the total number of reservoirs investigated is partially attributable to the fact that in a number of cases a whole series of reservoirs occurring in a basin or subbasin has been included in a single report. Other completed manuscripts had not yet been mimeographed at the end of the year. Excavations carried on during the year brought the total for reservoir projects where such investigations have been made to 42 located in 17 different States. The results of certain phases of some of that work have appeared in various scientific journals, and Bulletin 154 of the Bureau of American Ethnology, River Basin Surveys Papers, containing 6 reports, was ready for release on June 30, 1953. Detailed technical reports on 10 additional excavation projects have

been completed and are ready for publication. Paleontological surveys have been made in 121 reservoir areas. Archeological work has also been done in 88 of them and the remaining 33 will eventually be visited by archeological parties. The total of all reservoir basins surveyed, including those where archeological studies are still to be made, is 273.

The reservoir projects that had been surveyed for archeological remains, as of June 30, 1953, were distributed by States as follows: Alabama, 1; California, 20; Colorado, 24; Georgia, 4; Idaho, 11; Illinois, 2; Kansas, 10; Kentucky, 1; Louisiana, 1; Minnesota, 1; Mississippi, 1; Montana, 15; Nebraska, 28; New Mexico, 1; North Dakota, 13; Ohio, 2; Oklahoma, 7; Oregon, 27; Pennsylvania, 2; South Dakota, 9; Tennessee, 3; Texas, 19; Virginia, 2; Washington, 11; West Virginia, 2; Wyoming, 21. Excavations have been made or were being made in reservoir basins in: California, 5; Colorado, 1; Georgia, 4; Kansas, 3; Montana, 1; Nebraska, 1; New Mexico, 1; North Dakota, 4; Oklahoma, 2; Oregon, 2; South Carolina, 1; South Dakota, 3; Texas, 7; Virginia, 1; Washington, 3; West Virginia, 1; Wyoming, 2. Only the work of the River Basin Surveys or that in which there was direct cooperation with local institutions is included in the foregoing figures. Projects that were in direct cooperation with the National Park Service or were carried on by local institutions alone are not included because complete information about them was not available.

The River Basin Surveys continued to receive extensive and helpful cooperation during the year from the National Park Service, the Bureau of Reclamation, the Corps of Engineers, and various State and local institutions. Detailed maps of the reservoirs under investigation were supplied by the agency concerned and at a number of projects temporary office and laboratory rooms, as well as dwelling facilities, were provided. For survey work in Tennessee guides and transportation were furnished by the Corps of Engineers and the same source made transportation available at a series of excavations in Georgia. The work of the River Basin Surveys men was made much easier by the assistance of the field personnel of the other agencies and their accomplishments were much greater than they would have been without that help. As in other years, the National Park Service functioned as the liaison between the various agencies both in Washington and in the field. Through its several regional offices it secured information about the locations for dams and reservoirs and data on their construction priorities. The National Park Service also was mainly responsible for the preparation of estimates and justifications and procurement of funds for carrying on the program. The enthusiastic cooperation of Park Service personnel was a definite aid in all phases of the operations.

The main office in Washington directed and supervised the work in the east and south, while that in the Missouri Basin was under the supervision of a field headquarters and laboratory at Lincoln, Nebr. The materials collected by survey and excavating parties in the east and south were processed in Washington. Those from the Missouri Basin were handled at the Lincoln laboratory.

Washington office.—The main headquarters of the River Basin Surveys continued under the direction of Dr. Frank H. H. Roberts, Jr., throughout the year. Carl F. Miller and Ralph S. Solecki, archeologists, were based on that office, although Solecki was transferred to the Missouri Basin Project early in July and continued there until October when he returned to Washington. Late in November he was granted leave of absence to accept a Fulbright Scholarship for archeological investigations in Iraq. He was appointed a collaborator of the Smithsonian Institution and from March until the end of June conducted excavations financed jointly by the Iraq Government and the Smithsonian Institution.

At the start of the fiscal year Mr. Miller was in the office working on material obtained the latter part of the previous year at the John H. Kerr Reservoir (Buggs Island) on the Roanoke River in southern Virginia. During July he spent several days inspecting a site near Cambridge, Md., where a large mound attributable to the Adena culture was being destroyed by a housing development. In August he made a brief survey of the Demopolis Reservoir basin on the Warrior River in Alabama and checked on several sites in the Grenada Reservoir on the Yalobusha River in Mississippi. In October he took part in the Southeastern Archeological Conference held at Macon, Ga., and in November made all arrangements for the annual meeting of the Eastern States Archeological Federation which met in Washington. During the autumn months he completed his technical report on the excavations that he made at the Fort Lookout Trading Post site in the Fort Randall Reservoir basin in South Dakota while on loan to the Missouri Basin Project the previous year. He also finished certain revisions in the completed technical report on work at the Allatoona Reservoir on the Etowah River in Georgia. He revised a paper on Indian pottery types of Pissaseck, Va., for publication in the Journal of the Washington Academy of Sciences. Late in December Mr. Miller visited the Bluestone Reservoir on New River near Hinton, W. Va., to ascertain the exact status of the reservoir pool and what the situation was with respect to sites that had been recommended for excavation and testing when a survey was made of the area in 1948. During January and February he studied materials from his excavations at the John H. Kerr Reservoir and worked on his technical report for that project. From March 9 to June 6 he conducted excavations at four sites in the Jim Woodruff Reservoir area on the Flint

River in southern Georgia, and gave a number of talks on the River Basin Surveys program before local groups both in Georgia and northern Florida.

Dr. Theodore E. White, geologist, divided his time between the Washington office and the Missouri Basin. From November 12, 1952, to March 30, 1953, he was in Washington, cleaning, cataloging, and identifying the small mammals he had collected during the field season. In addition he identified three lots of bone from archeological sites in the Columbia Basin and one lot from a site excavated by a cooperating agency in the Missouri Basin. He completed a series of five papers on "Observations on the Butchering Technique of Some Aboriginal People" and was a joint author, with C. M. Barber, of a sixth. All have been submitted for publication in American Antiquity. He also finished a manuscript, "Endocrine Glands and Evolution, No. 3," for the journal Evolution. Two other papers, "Lithology, Distribution and Correlation of the Alachua Formation of Florida" and "Lithology, Distribution and Correlation of the Bone Valley Formation of Florida," were submitted to the Committee on the Nomenclature and Correlation of North American Continential Tertiary. Three papers by Dr. White were published during the year. They were: "A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples," American Antiquity, vol. 18, No. 4, pp. 396–98; "Collecting Osteological Material," Plains Archeological Conference News Letter, vol. 6, No. 1, pp. 3–7; and "Studying Osteological Material," ibid., pp. 8–15.

Alabama.—An archeological reconnaissance of the Demopolis Reservoir basin on the Warrior River made August 5–7, 1952, showed that although archeological remains are present in the area they would be little affected by flooding in the bottomlands. No excavations were recommended for the project.

Georgia.—During the period from March 9 to June 6, 1953, surveys and excavations were carried on along the Flint River, in southern Georgia, in a portion of the area that will be flooded by the Jim Woodruff Dam situated in the Apalachicola River, just below the junction of the Flint and Chattahoochee Rivers, in northern Florida. Carl F. Miller completely excavated 2 sites, partially excavated 2 others, and located 25 sites not previously listed by the University of Georgia when it made the preliminary survey there. One of the excavated sites, Montgomery Fields (9Dr10), was basically Weeden Island in its relationships but contained a number of traits not previously reported for that culture. The floor pattern of a fairly large rectangular structure that had been formed by individual posts, each set in its own hole, was uncovered, and outlines of a number of small circular structures suggesting the same type of construction were found. The large feature probably was a dwelling, while the smaller ones were either

sweat houses or menstrual huts. There were some 30 midden or roasting pits associated with the house remains. One dog burial was found but no human remains. Underlying the Weeden Island material was a nonceramic level characterized by stone artifacts in which projectile points were the predominant form. The latter differ from previously known types from preceramic levels in the area and may indicate a separate culture. A slightly different variant of Weeden Island culture was found at the Lusk Springs site (9Dr21), which was thoroughly tested but not completely excavated.

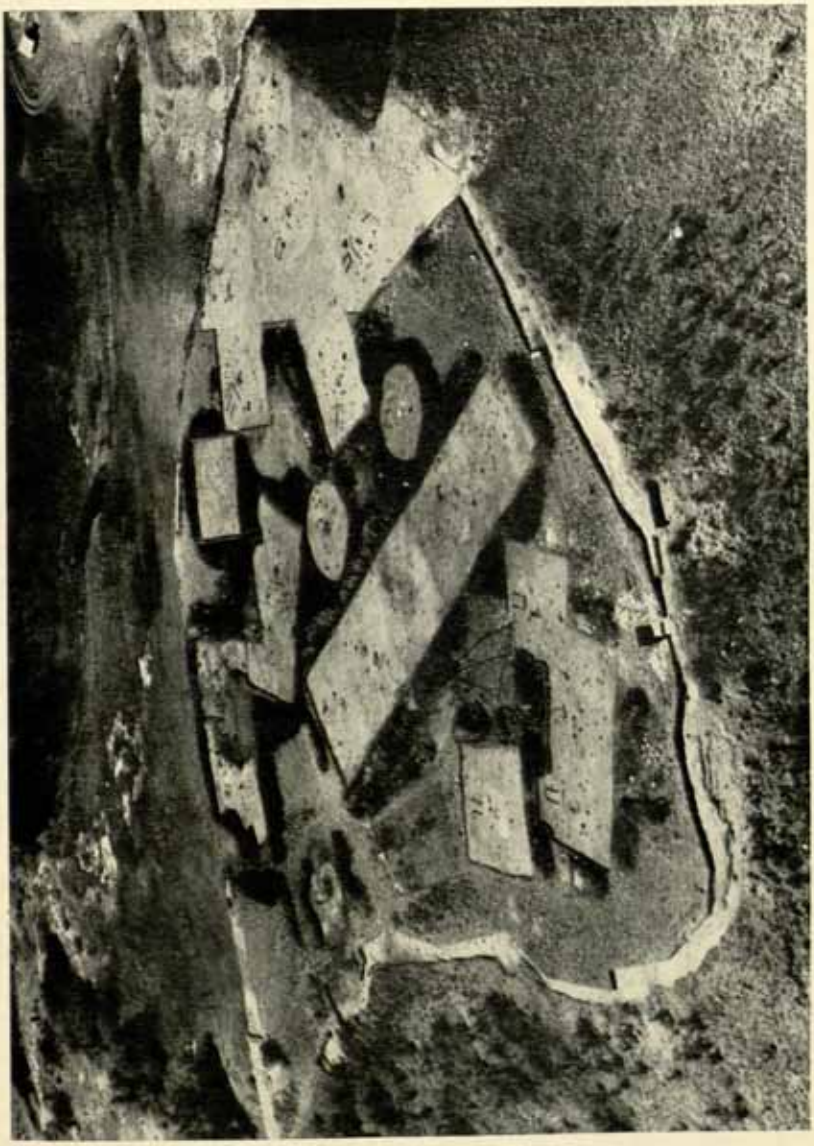
The second site was on the south bank of the Flint River 2½ miles east of Hutchinson's Ferry Landing. An extensive deposit of shells located there had been recorded as a single site (9Dr29) but actually proved to be two (designated A and B). Unit A was found to contain a straight Weeden Island II component, while Unit B represented a Weeden Island I component with an underlying deposit of Santa Rosa–Swift Creek materials. About 150 yards east of 9Dr29 early spring floodwaters in the Flint River exposed another small site (9Dr37). The deposits at that location were widely scattered and had very little depth. From various eroded pits and subsequent test digging, however, a series of Deptford, Swift Creek, and Weeden Island I potsherds were recovered, which makes possible the placing of the site in the cultural sequence for the area. During the course of his surveys Mr. Miller joined in the search for the historically significant location of Apalachicola Fort or Cherokeeleechee's Fort at the junction of the Chattahoochee and Flint Rivers. That town was established in 1716 by the Apalachicola when, as a result of the Yamasee war, they moved back from the Savannah River in South Carolina to the territory they had formerly occupied in southern Georgia. Their chief at that time was named Cherokeeleechee or "Cherokee Killer," and his town frequently goes by the same designation. Not many years later the group withdrew to a new location farther up the Chattahoochee. Mr. Miller tested one site tentatively identified as that of the fort but did not find evidence to support such a possibility.

During the period that Mr. Miller was working in the Jim Woodruff area Joseph R. Caldwell, archeologist of the National Park Service, was digging at a productive site on the Chattahoochee River known as Fairchild's Landing. Considerable new material was found there in a series of stratified shell deposits. Several phases of the Weeden Island culture are represented, and at one end of the site were some early historic remains. Caldwell's data and those of Miller should serve as cross checks and definitely establish all Weeden Island characteristics for the area. In the region adjacent to Fairchild's Landing Mr. Caldwell observed evidence of a possible historic Indian site which may represent one of the several "Fowl Towns" mentioned in various documents. Mr. Caldwell also took part in the search for Apalachi-

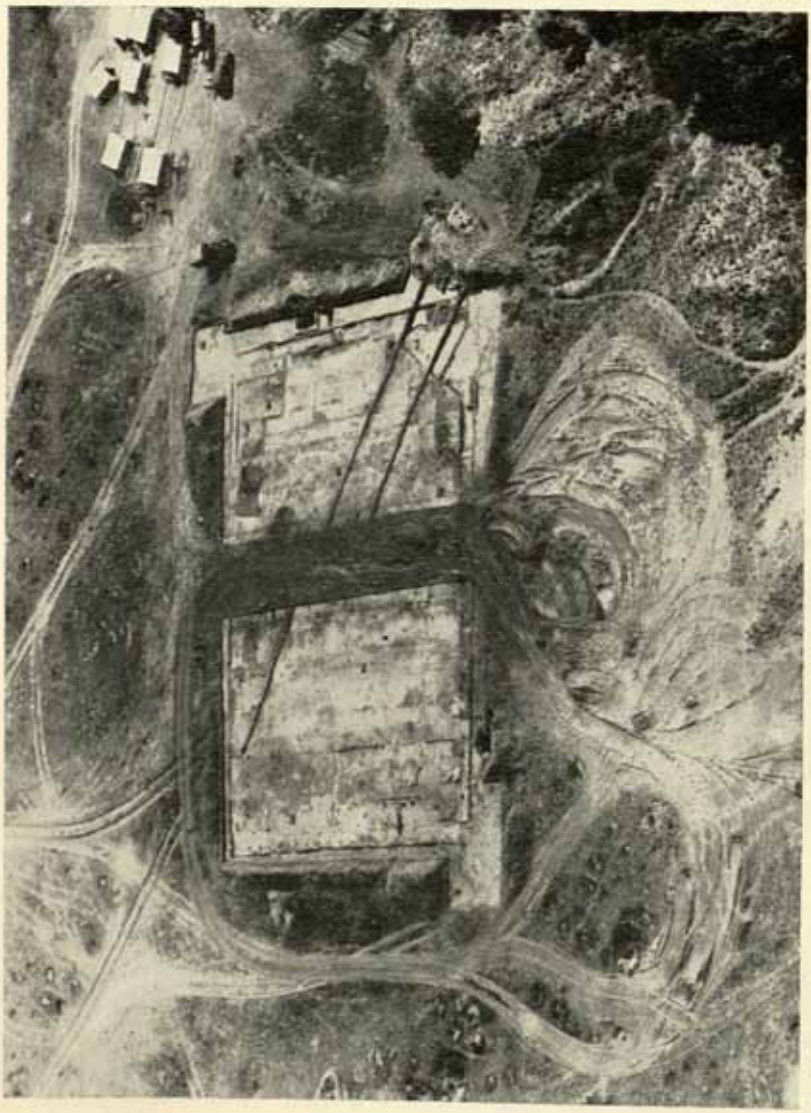
cola. Dr. Mark F. Boyd, of the Florida Historical Society, through an agreement between the National Park Service and the Society, made a historic-site survey of the whole reservoir basin, working in conjunction with Miller and Caldwell in a number of instances. Dr. Arthur Kelly, of the University of Georgia, cooperated in all the recent activities, giving Caldwell and Miller the benefit of the knowledge he obtained while making a general survey of the Jim Woodruff area in previous years. He also helped Dr. Boyd with his historic-sites investigations.

During June excavations were carried on by Ripley P. Bullen in the small portion of the Jim Woodruff Reservoir lying in Florida, under a cooperative agreement between the National Park Service and the Florida State Museum of the University of Florida. Mr. Bullen and his party dug one site near the dam, finding four superimposed occupation levels separated by sterile zones. The bottom level yielded quantities of lithic materials and definitely represented a preceramic culture. The next higher cultural layer contained sherds from fiber-tempered pottery, fragments from steatite vessels, and numerous stone artifacts. The latter, Mr. Bullen reported, constitute many times the number of previously documented worked-stone specimens from the fiber-tempered period in all Florida. The third occupation level was found to belong to the Deptford cultural horizon. The upper layer contained village remains of the Fort Walton period. Associated with that occupation were four "specialized" pits containing charred kernels of corn. The evidence from the site will be extremely important to Florida archeology because it is the first place that a fiber-tempered complex has been found in situ in west Florida and is only the second place where undisturbed Fort Walton village material has been available for extensive study. Investigations at three other sites produced materials that will help in filling the gap between the Deptford and Fort Walton periods at the large site. One of the three indicated a Weeden Island period and another a Kolomoki complex. That is the first time "pure" Kolomoki remains have been found in Florida.

Mississippi.—The Grenada Reservoir area on the Yalobusha River in Mississippi had been surveyed for archeological remains during a previous fiscal year by the University of Mississippi operating under a cooperative agreement with the National Park Service. Upon the completion of that survey 4 of the 51 sites found were recommended for excavation. To determine whether digging there was more essential than in some other areas, several of the sites were examined during August 25–27, 1952. It was finally decided that the meager funds available for digging might be used to better advantage in districts where less was known about the cultural manifestations, particularly so since there is a considerable number of sites in the Grenada basin that will not be affected and can be investigated at some future date.



Remains of Indian village on top of Night-Walker's Butte in the Garrison Reservoir Area, N. Dak. Traces of 27 earth lodges and surrounding palisade were uncovered at that location by River Basin Surveys operations.



Aerial view of the excavations of the River Basin Surveys at the site of Fort Berthold II. Locations of bastions at two diagonally opposite corners of the palisade are clearly shown. Dark strip across center of enclosure indicates area still to be excavated when photograph was made. Field party camp in upper right corner of picture.

Missouri Basin.—The Missouri Basin Project continued to operate throughout fiscal 1953 from the field headquarters at Lincoln, Nebr. Ralph D. Brown served as chief of the project from July 1 to September 7, when he died as the result of an accident. On September 22, Robert L. Stephenson, who had been on leave from the River Basin Surveys' staff, returned to active duty and was assigned to the supervision of the project, serving as acting chief throughout the remainder of the year. In the interval from September 7 to 22, Dr. Frank H. H. Roberts, Jr., was in direct charge of the Lincoln office. Activities during the year were concerned with all four phases of the salvage program. There were preliminary surveys; excavations; processing of the collections obtained from the digging, analyses and study of the materials, and the preparation of general and technical manuscripts on the results; and the publication and dissemination of scientific and popular reports. Most of the work was in the second and third phases. Much of phase 1 was finished in previous years and phase 4 will not get into full swing until more of phase 3 is completed. At the start of the year there was a permanent staff for the Missouri Basin Project of 20 persons. In addition there were 4 temporary part-time employees assisting in the laboratory. Through July and August and part of September 6 temporary assistant archeologists, 60 temporary student laborers, and 25 local nonstudent laborers were employed in the field. During the summer season 11 of the regular staff were also engaged in fieldwork. As the surveys and excavations were brought to a close the temporary employees were gradually laid off and by the first of November only the permanent staff of 20 and a temporary draftsman-illustrator were on the rolls. In May it became evident that a much more limited budget would be available for 1954 and that a reduction in force would be necessary. Consequently by the close of the day's work on June 30 the staff had been reduced to 11 persons.

On May 18 and 19 the Interior Missouri Basin Field Committee, consisting of representatives from all the agencies of the Department of the Interior concerned with the over-all Missouri Basin program, held its 61st regular meeting at the River Basin Surveys' headquarters on the campus of the University of Nebraska, at the invitation of the Missouri Basin Project and the Laboratory of Anthropology of the University. The first session was devoted to routine business, but during the evening of May 18 the members visited the Surveys' laboratory located in the business section of Lincoln and heard Mr. Stephenson explain in detail the mechanics of the field and laboratory work of the salvage program. A series of exhibits of fossil specimens, objects from historic sites, Indian-site artifacts, and methods of pottery reconstruction was used to illustrate portions of Mr. Stephenson's talk. The visitors were also shown the entire process of han-

dling materials from the time they arrive from the field until their analysis and study have been completed and the covering report has been written. Most of the session on May 19 was devoted to a presentation of the work and results of the Inter-Agency Archeological and Paleontological Program. Howard W. Baker, regional director of the National Park Service, Region 2, at Omaha, Nebr., served as chairman. Frederick H. Johnson, secretary of the independent-advisory Committee for the Recovery of Archeological Remains, sketched briefly the general background and importance of the recovery program and explained the activities and purpose of his committee. Dr. Frank H. H. Roberts, Jr., then discussed the Smithsonian Institution's part in the program as a whole, both from the standpoint of the Missouri Basin and other areas throughout the country. Dr. Gordon C. Baldwin, archeologist, Region 2, National Park Service, explained the part his organization has played, told what had been accomplished as of that date, and outlined the needs for the future in a 6-year program. Robert L. Stephenson told about the plans for the remainder of the fiscal year in the Missouri Basin and explained the reasons for the proposed projects. Dr. C. Bertrand Schultz, director of the Nebraska State Museum of the University of Nebraska, summarized the work that his institution had been carrying on as a cooperative effort in the paleontological phase of the investigations and stressed the need for such studies in a proper understanding of the Missouri Basin. Dr. John L. Champe, director of the Laboratory of Anthropology, University of Nebraska, commented on the status of archeology in the Plains area before the salvage program was started and spoke about the current activities from the viewpoint of the cooperating institutions. The historical aspects of the program were presented by Merrill Mattes, regional historian of the Region 2 office, National Park Service. He outlined the historical background for the area, described the current activities and the methods used in making the studies, and made clear the relationship between that subject and those discussed by the other speakers. As a result of the session the members of the Committee undoubtedly left Lincoln with a much better understanding of the salvage program and its aims.

During the year 10 field parties operated in the Missouri Basin. One of them made a series of extensive tests in 4 archeological sites, while 7 were primarily occupied in conducting full-scale excavations in 19 sites. In connection with that work, however, some reconnaissance was carried on in the areas where their investigations were underway. One of the parties was concerned mainly with archeological surveys and another with paleontological studies. The excavations were in 2 reservoir areas in North Dakota, 2 in South Dakota, and 2 in Kansas. The survey party operated in 5 reservoir areas in Kansas, 3 of them being covered for the first time and 2 being revisited

for further checking. The paleontological party worked in 1 reservoir area in Montana, 1 in North Dakota, and 1 in South Dakota. It also visited another project in North Dakota to examine a specimen reported from the Upper Cretaceous deposits there. During July and August 1952, 3 aerial photographic missions were flown over 12 reservoir areas. In all, 5,000 air miles were flown and 62 objectives were photographed. The latter included excavated archeological sites, sites to be excavated, dams and reservoir construction features, and the general topography of the areas to be covered by the ground surveys. The plane used was the personal property of one of the staff archeologists and the pictures were taken by the staff photographer.

The reservoir basins where reconnaissance work was carried on were: The Kirwin, on the north fork of the Solomon River, where 4 additional archeological sites were located and recorded; the Webster, on the south fork of the Solomon, where 3 were found; Tuttle Creek, on the Big Blue River, with 118; Glen Elder, on the Solomon River, with 17; and Wilson, on the Saline River, with 18. On the basis of the evidence obtained, it is apparent that no additional studies will be needed in the Kirwin and Webster areas. At Tuttle Creek, however, there is important material and 10 of the sites have been recommended for future excavation. Included in the 10 are 4 historic sites which are of special significance with respect to the early exploration and settlement of that section of the West. Of the 17 sites recorded for the Glen Elder, 6 small ones gave evidence of being extremely important because they contain materials thus far not observed in the area and they have been recommended for complete excavation. At the Wilson Reservoir 6 of the 18 sites were found to be significant from the standpoint of their relationship to one of the pre-Columbian cultures which thus far is imperfectly known. Two of the sites are caves, probably containing dry materials, and should yield types of artifacts rarely preserved in open sites. One of the recommended sites may prove to be of considerable importance because materials there are eroding from a terrace bank and appear to belong to one of the early occupations in the Plains area. Parties working in the Fort Randall Reservoir basin in South Dakota located 2 new sites, while those operating in the Oahe basin in the same State found 180. At the Jamestown Reservoir in North Dakota 3 new sites were found. The total of new sites observed and recorded in the Missouri Basin during the fiscal year was 339.

In the Garrison Reservoir basin on the main stem of the Missouri River above Bismarck, N. Dak., 2 field parties conducted archeological excavations in 3 of the 147 known there. During July and August and part of September one party dug in the remains of Fort Berthold II. The work at that location falls into the historic category, but it

is important because the fort was established in connection with the large Mandan-Hidatsa-Arikara village, called Like-a-Fishhook, which was occupied from about 1845 to 1890. The remains of the Indian village were studied by parties from the North Dakota State Historical Society under a cooperative agreement with the National Park Service, but much information was needed with respect to the fort and the evidence it might contain bearing on the relationships between the Indians and the Whites. Fort Berthold was originally built in 1858 as a trading post and was known as Fort Atkinson. Its name was changed in 1862, and from 1863 to 1867 it served as a military post. Later it became the agency for the three tribes living in the adjacent village. While there is fairly extensive documentary evidence about the military and trading post, there are many gaps in the record and the archeological excavations contributed information which will help to complete the story of the activities there. About 75 percent of the fort, including the stockade line and two bastions, was excavated. Plans call for further work there during fiscal 1954.

In July and August one party excavated the site of a fortified village on the top of a small butte on the north bank of the Missouri about 10 miles above Fort Berthold. The site is known by the name Night-Walker's Butte in the Bull Pasture because there is an Indian tradition to the effect that a Hidatsa chief by the name of Night-Walker broke away from the main tribe and led his band to the top of a butte where he built a village. Two other sites in the area are also in somewhat similar locations, and which of the three actually was the Night-Walker village is open to question. Nothing found during the excavations throws any light on the problem. The floor areas of 27 earth lodges were uncovered; 29 fire pits, 26 cache pits, 10 roasting pits, and 2 sweat lodges were dug; and approximately three-fourths of the stockade which encircled the edge of the butte was traced. Materials found there suggest that the village was built about or shortly before 1800. The excavations were completed and the detailed technical report on the results was well in progress at the end of the year.

In September the party that worked on the butte investigated the remains of an earth lodge across the river from the village site. It was called Grandmother's Lodge and was the traditional dwelling place of one of the Mandan or Hidatsa supernatural beings who was believed to be the patroness of gardens and crops. The ceremonial lodge, which was only partially excavated, appears to have been rectangular in floor plan and may be older than any other lodge thus far reported for that area. At least one additional lodge and probably several others are present at the site and further work is planned for it during fiscal 1954. That particular location provides an excellent opportunity for comparing evidence obtained through archeo-

logical investigations with the legendary story which is a part of the myths of the Indians in that district.

At the Jamestown Reservoir on the James River in eastern North Dakota one field party continued excavations started toward the close of the previous year. By the end of the season in September it had dug in 5 of the 28 known archeological sites which will be flooded by that reservoir. Two of the sites were burial mounds attributable to the Woodland culture, one was a campsite consisting of a series of boulder-lined depressions strung along the crest of a low bluff, one was a burial pit exposed by a power shovel in the borrow area directly west of the dam, and the other comprised the remains of an Indian village. The floors of four circular houses and a small sweat lodge were uncovered at the latter location. The site covers more than 2 acres and only about 10 percent of it was investigated. A few metal objects and the potsherds found there suggest that the village had Mandan affiliations or at least trade relations with that group and that it was occupied during the first half of the eighteenth century.

In the Oahe Reservoir Basin in South Dakota two parties continued investigations started toward the end of the preceding fiscal year. Excavations were carried on in 4 of the known 318 sites in the basin. At the Black Widow site (39ST3), the location of an extensive earthlodge village of many scattered houses, about 30 miles upstream from the dam on the west side of the Missouri, evidence of two occupations was found. One period was prior to contact with the whites and the other was during the eighteenth century. During July, August, and September numerous cache pits, a refuse mound, and extensive areas of village surface were dug and four house floors were cleared. Three of the houses belonged to the early period, while the other was of the later occupation. The fourth house was superimposed upon cache pits of the early occupation. All four houses were circular in outline but there were conspicuous architectural differences between the three older examples and the one late form. Materials from the site suggest that the older level had its closest affiliations with the Myers site (39ST10), where the South Dakota Archeological Commission did some excavating in 1949, and with one of the three components in the Cheyenne River site (39ST1), which was partially excavated by a Missouri Basin Project party in the summer of 1951. The later period of occupation appears to be Arikara, although historic documentation for the site seemingly is not known. The same party exhumed a single flexed burial which was about to be destroyed by erosion at a multicomponent site (39ST23) not far from the Black Widow site. Part of the skeleton was missing and there were no mortuary offerings accompanying it.

The second excavating party concentrated its efforts in the immediate vicinity of the dam. It completed excavations started at the

Indian Creek site (39ST15) the previous year, made a series of tests at the Mathison site (39ST16), and did extensive digging at the Buffalo Pasture site (39ST6). At the Indian Creek site, which lies on the line of the proposed discharge channel for the Oahe Reservoir, two house floors were cleared. One, probably a ceremonial structure, was 50 feet in diameter. It contained a raised earthen platform or altar, covered with mud plaster, along the wall opposite the entryway. Beside the altar was a buffalo-skull shrine. Only about 1 percent of that site was excavated, but since it was evident that there would be some delay in the construction of the discharge channel, further efforts were deferred until a later field season. The Mathison site, also on the line of the discharge channel, is stratified and the tests showed it contains data on several different Indian periods. In addition it probably was the location of Fort Galpin, one of the frontier posts. Most of the activity during July, August, and early September was at the Buffalo Pasture site 1 mile upstream from the right wing of the dam on the west bank of the river. A large fortified earth-lodge village had been located there. Four earth lodges, the cross section of the defensive ditch or moat, and over 210 linear feet of the palisade wall inside the moat were excavated. One of the lodges proved to be a ceremonial house and contained an excellent example of an altar with bison-skull offerings. Although only about 8 percent of the site was excavated there was an unusually large yield of artifacts. Included in the materials are over 100 restorable pottery vessels, which is a rare find so far as the Plains area is concerned. The material and information from Buffalo Pasture rounds out and helps to clarify that obtained from two sites, Dodd (39ST30) and Phillips Ranch (39ST14), between it and the dam which were dug during previous seasons.

While the River Basin Surveys parties were working in the Oahe area in the summer of 1952 the South Dakota Archeological Commission and the W. H. Over Museum of the University of South Dakota carried on excavations at the Thomas Riggs site (39HU1) under a cooperative agreement with the National Park Service. On two previous occasions the W. H. Over Museum had worked there but had not completed its investigations. During the 1952 season its party, under the leadership of Dr. Wesley R. Hurt, Jr., excavated the remains of five houses and dug a long trench through the village area. Evidence found there indicates that the village was occupied at about A. D. 1500 and that it probably did not have more than 200 inhabitants at any one time. Just what the relationship between it and later Arikara or Mandan communities may have been is still to be determined.

The two parties, one for Indian and one for historical sites, working in the Fort Randall Reservoir basin continued the operations started toward the end of the preceding year. During the field season excava-

tions were carried on in 6 of the 53 known sites which will be inundated. At the start of the year the Indian-site party was centering its activities in village remains where considerable digging had been done the previous field season. At that location, the Oldham site (39CH7), there was evidence for three periods of occupation. The latest was an earth-lodge village with palisade and moat where most of the digging was done during the 1951 season, the middle period was an earth-lodge village with a palisade but no moat, and the earliest was an occupation level underlying both of the others. At the start of the 1952 field season, in May, activities were centered on the portion of the site representing the middle period. Beginning with the new fiscal year attention was turned to the area where there was some overlap between the remains of the last two periods. During the course of the digging 2 earth lodges, 3 drying racks, 2 infant burials, 270 feet of stockade, including 1 bastion, 76 pits, most of which were cache pits, and numerous fire pits were uncovered. Tubular copper beads were found in one of the infant burials. The specimen yield from the site was great and study of the material shows that when the results are completely tabulated there will be much new information about the material culture of the people who inhabited that area. The middle period apparently correlates with what is known as the Great Oasis Aspect in Minnesota. Although less than half of the site was excavated, sufficient data were obtained to warrant stopping the work in August and moving the laborers to a new location. The latter, the Hitchell site (39CH45), consisted of the remains of a semipermanent village characterized by circular, hutlike, pole-framed structures which probably were covered with skins or brush. The site was stratified and preliminary analysis of the materials from it indicates that it was related to the latest and the earliest periods at the Oldham site. While work was underway at the Hitchell site some of the laborers, under the supervision of a field assistant, dug 1,698 feet of test trenches at the Pease Creek site (39CH5) several miles downstream. The evidence revealed by the trenches shows that there were two occupations. The latest was by a group using the location mainly as a camping area, while the earlier presumably had a more permanent type of settlement. Pottery found there suggests Upper Republican and Nebraska cultural influences. The artifact complex as a whole is unique in the Fort Randall area. During the summer season additional testing was carried on at a campsite (39CH51) where some digging had been done during a previous year. Those investigations completed the studies at that location. The activities of the Fort Randall Indian party were brought to a close in late September.

During July the historic-site party completed the excavation of the Fort Whetstone site (39GR4) on the west bank of the Missouri River near the mouth of Whetstone Creek. The palisade was traced

and the outlines of the buildings that stood inside the fortification were followed. Exact dimensions of the fort and buildings were obtained, as were some of the constructional features of the interior of the buildings. All wooden structures had been burned, and evidence indicates that the post was destroyed shortly after abandonment in 1872. About 90 percent of the site was excavated and no additional work will be required there. A number of discrepancies found between the various features revealed by the digging and a plan of the fort drawn in 1871 raised a number of puzzling historical problems. About 500 yards northwest of the fort the remains of a "Missouri Dugout" were found and excavated. At the end of July the party moved to the Fort Randall site (39GR15) on the west bank of the Missouri River half a mile southeast of the Fort Randall military post. Work there showed that the remains were those of a brick kiln, which probably belonged to the period of Fort Randall I. The remains of the kiln and features associated with it were completely excavated and the party left the Fort Randall Reservoir area at the end of August, proceeding to the Kirwin Reservoir in Kansas.

During the 1952 field season work was also carried on in the Fort Randall area by the Nebraska State Historical Society and the University of Kansas under cooperative agreements with the National Park Service. The Historical Society party under the direction of Marvin F. Kivett continued excavations in two sites (39LM26 and 39LM27) located along the highway a short distance east of Oacoma and about 2 miles west of Chamberlain, S. Dak. Some digging was also done at a site (39LM81) 10½ miles upriver from Chamberlain. The work at the first two locations, which was completed, showed evidence of a historic Siouan occupation underlain by an earth-lodge village belonging to what has been called the Fort Thompson focus. The third site was found to have three components, historic Siouan, a level producing a simple-stamped type of pottery which has not yet been culturally correlated, and an earlier Woodland occupation. The University of Kansas party under Dr. Carlyle S. Smith spent a third season at the Talking Crow site (39BF3) about 3½ miles below Fort Thompson, S. Dak. During the three seasons at the site 9 houses were completely excavated, 4 were partially excavated, and 14 were tested to obtain their dimensions and samples of materials from them. Stratigraphic tests were made in three refuse mounds, trenches were dug across the surrounding fortification on four sides of the site, two long trenches were cut through areas between the houses, and numerous other test pits and trenches were dug. From the data obtained it appears that the site had four components. The latest was Siouan dating from shortly after the Civil War. Prior to that was the last occupation by earth-lodge-building people, probably the Arikara, during the period when European trade goods were beginning to

appear in the area. Preceding that was an occupation which just antedated the introduction of trade goods. The earliest occupation was definitely prehistoric in age and its cultural affinities seem to have been widespread. The latest component appears to correlate with one phase of Kivett's Oacoma sites and with the Indian Creek site in the Oahe area. The one just preceding seems to equate with an older phase at Kivett's sites and with the latest component at the Oldham site. The next to the oldest component correlates with the older level at the Black Widow site in the Oahe area, but there is still some question as to the relationship of the first occupation at Talking Crow.

In the Kirwin Reservoir basin in Kansas the historic-sites party, which had moved from the Fort Randall area, spent the period from September 2 to 20 excavating the remains of Camp Kirwan, an old frontier post located on the right bank of the Solomon River in Phillips County. The site (14PH6) was completely excavated and the palisade line was traced as an intrusive trench in the soil.

An archeological party spent 3 weeks in June 1953 testing sites at the Tuttle Creek Reservoir in Kansas. During that period work was carried on at four sites; three of them were in the spillway construction area, and one in the general construction area for the dam. Two of them had been severely damaged by the cut for the spillway, while the others were in immediate danger of destruction by further activities. One of the sites in the spillway line (14PO14) was an earth and stone mound approximately 26 feet in diameter with a maximum height of 1½ feet. The mound contained a burial pit with skeletal remains occurring at two levels. The original interment of at least three bodies apparently had been dug into to make room for subsequent burial of three, possibly four, more bodies. In both levels there was one articulated skeleton in a semiflexed position. Stone implements, copper beads, and fragmentary bits of copper sheeting were found with the bones. At some distance from the pit the remains of an extended burial without a skull were found. It had no accompanying mortuary offering. Indications were that the skull had been removed by some earlier digger and also that the interment was a later intrusion in the mound. In general appearance the mound suggested relationship to others in the Tuttle Creek, Glen Elder, and Wilson Reservoir basins. They have not as yet been assigned to any culture but may well have Woodland affiliations. The extended burial possibly is attributable to the Kansa, as it had certain similarities to others found elsewhere which presumably were made by that tribe. Furthermore, materials collected from two occupation areas nearby indicate a late occupancy, and since a historic Kansa village is known to have existed in the immediate area it seems likely that they may also have lived at those locations. As a matter of fact, the two sites (14PO12 and 14PO13)

may represent parts of a single large occupational area as one is on the eastern edge of the spillway and one is on the western edge of it and both have been extensively damaged by construction activities. Materials collected during the digging there consist of buff-colored potsherds with gray shell-tempered paste and punctated decorations, small triangular-unnotched projectile points, an abundance of stone scrapers, a conical copper bangle, and some bits of sheet metal. The fourth site tested (14RY10) is on the west side of the Blue River. It was buried under considerable flood-borne silt but the exploratory trenches indicated the former presence of an earth lodge and other village features. Potsherds from the house area suggest that a cultural transition was underway at that location. It was not possible to do any extensive digging there, but at the end of the fiscal year plans were being made by one of the local institutions to continue the investigations as a cooperative effort. It was necessary for the River Basin Surveys party to close down its work on June 26 and return to the headquarters at Lincoln.

The paleontological field party completed its activities at the Keyhole Reservoir in Wyoming on July 1, 1952, and left the following day for the Canyon Ferry Reservoir in Montana. En route, at the request of the National Park Service, it visited the South Unit of the Theodore Roosevelt National Monument to examine some paleontological material found in that area. From July 5 to August 3 the party explored exposures of the Oligocene and Miocene deposits in the Canyon Ferry Basin. Some 75 specimens of small mammals were collected, adding greatly to the knowledge of certain groups, particularly the rabbits and small dogs of the Miocene. During the period the paleontologist also identified the Tertiary sediments in a number of localities in the Toston Basin for a mapping party of the United States Geological Survey. From August 9 to 30 the party explored the exposures of the Paleocene Fort Union formation in the Garrison Reservoir near Elbowoods, N. Dak. Specimens are exceedingly rare in that formation, and because of the uncertain correlation of the deposits the value of those found is materially increased. During that period the nearly complete skeleton of *Champsosaurus*, an alligatorlike aquatic reptile, was collected. Exposures of the Oacoma member of the Upper Cretaceous Pierre shale in the vicinity of the Oahe Dam were explored from September 2 to 10. A number of specimens of marine reptiles were found but they had been exposed too long to be worth collecting.

The paleontological party returned to the field in June, and from June 1 to 7, 1953, at the request of the National Park Service made a paleontological survey of certain areas in the Badlands National Monument. From the 9th to the 27th it continued explorations of the Oligocene and Miocene deposits of the Canyon Ferry Reservoir area.

Initial flooding of the reservoir made it necessary to visit several localities by boat. About 100 specimens of small mammals, rabbits, rodents, and marsupials were obtained. Of special interest is a very small rabbit, details of the teeth of which suggest that it may be ancestral to the cony or pika, the tiny rock rabbit which lives high in the mountains. If such should prove to be true these are the earliest known specimens of that group of rabbits found anywhere in the world. The Canyon Ferry Reservoir basin, which will not be available for study another season because of the impounded water, has been the most productive, both in the number and variety of species, of any locality in the area and is the only one thus far that has produced a sizable Middle Oligocene fauna in the Intermountain Basins. On June 27 the party moved to the Fort Peck Reservoir in Montana for the purpose of examining a plesiosaur (marine reptile) skeleton found in the Upper Cretaceous Bear Paw shale by a member of the Fish and Wildlife Service. At the end of the year the party was at Fort Peck.

During the year 18 preliminary appraisal reports were completed, mimeographed, and distributed to the cooperating agencies. One supplemental report, on the Fort Randall Reservoir, was completed and ready to mimeograph. Fourteen short articles on specific subjects in Plains archeology were completed and printed in various publications. Six appeared in the Plains Archeological Conference News Letter; four in the Proceedings of the Nebraska Academy of Sciences, 63d annual meeting; one in American Antiquity; one in the Americana Annual; and two in the Missouri Basin Progress Report, issued monthly by the Interior Missouri Basin Field Committee. Thirteen additional articles were completed and had been accepted for publication by various journals. Nine reports were completed and were ready to submit for publication. They included three technical papers on excavations in the Garrison Reservoir area, one on an excavated site in the Oahe area, one on historic sites dug in the Fort Randall basin, one on excavations in the Kirwin Reservoir, one general paper on the subject of articles of white manufacture as exemplified by the materials from various sites in the Missouri Basin, and two on work in the Northwest done by a member of the staff prior to his joining the Missouri Basin Project.

The laboratory at Lincoln processed 161,036 specimens from 339 sites in 9 reservoir areas and 1 unassignable site. A total of 22,570 catalog numbers was assigned to the series of specimens. The work in the laboratory also included: Reflex copies of record sheets, both negatives and prints, 12,629; photographic negatives, 2,281; photographic contact prints, 11,474; enlargements, 5″ x 7″ to 20″ x 24″, 4,082; photographs mounted for files, 6,374; transparencies mounted in glass, 1,132; drawings, tracings, and maps, 126; specimens drawn for

illustration, 504; completion of restoration of pottery vessels, 32; vessels or rim sections restored, 84.

Temporary interpretative displays showing the scope and results of archeological investigations in the Missouri Basin were installed in the windows of the laboratory in the business section of Lincoln in November 1952, and in the windows of a large Lincoln department store in February 1953. A special display illustrating and interpreting the archeology of the Oahe Reservoir area was installed for the Corps of Engineers by the Missouri Basin Project in the registration building for visitors at the Oahe Dam observation point. Special archeological and paleontological displays were prepared for the meetings of the Interior Missouri Basin Field Committee held at the headquarters and laboratory in May.

Paul L. Cooper, consulting archeologist, was in charge of one excavating and survey party in the Oahe Reservoir basin from July 1 until October 16. He supervised the digging at the Black Widow site and toward the end of the season participated in the reconnaissance work. During the fall and winter months in the laboratory he correlated the records of the Oahe reconnaissance with previous records, summarized information from published and unpublished sources of varied nature, made use of data obtained from excavations by the Missouri Basin Project and other agencies, and prepared "An Appraisal of the Archeology of the Oahe Reservoir." He also worked on a summary report of the activities of the Missouri Basin Project during the calendar years 1950 and 1951. This is concerned with investigations in 42 reservoir areas, the work of 2 full-season survey parties and other shorter-term parties, the activities of a paleontological party during 2 field seasons, and the excavations carried on by 12 full-season parties in Indian and historic sites in 6 different reservoir basins. The specimens obtained from the Black Widow site received preliminary study and a provisional classification was made of the pottery found there. Mr. Cooper participated in the Tenth Conference for Plains Archeology at Lincoln in November and attended the sessions of the Society for American Archeology at Urbana, Ill., in May.

Robert B. Cumming, Jr., archeologist, was in charge of the Indian-site excavations and survey in the Fort Randall Reservoir area in South Dakota from July 1 to September 26. He supervised the digging at the Oldham, Hitchell, and Pease Creek sites. During the months at the laboratory in Lincoln he made analyses of the material and data obtained during the 1951 and 1952 seasons at the Oldham site and prepared a technical report on the results of his investigations at that location. In addition he completed a supplementary report for the previously issued "Appraisal of the Archeological and Paleontological Resources of the Lower Platte Basin," and finished the first

draft, with an accompanying map showing the location of all sites found to that date in the reservoir area, of a supplementary report on the Fort Randall basin. From June 10 through 17, 1953, he supervised the work of the excavating party in the Tuttle Creek Dam area in Kansas. Mr. Cumming presented a résumé of the 1952 field work at the Tenth Conference for Plains Archeology in November.

From July 1 to September 15 Franklin Fenenga, archeologist, was in charge of an excavating party in the Oahe Reservoir area and also took part in additional surveys in the general vicinity of the dam. He directed the digging at the Buffalo Pasture, Mathison, and Indian Creek sites. In August he installed a special display to interpret the archeology of the Oahe Dam area in the observation building maintained by the Corps of Engineers at a spot overlooking the east wing of the dam. During the remainder of the year, at the Lincoln headquarters, he completed appraisal reports on the archeology of the Gavins Point Reservoir in Nebraska and South Dakota and for the Middle Fork Reservoir in Wyoming. He also completed a detailed technical report on the results obtained at the Indian Creek site and had finished approximately 75 percent of the report on the Buffalo Pasture Village by the end of the fiscal year. He presented three papers on archeological field methods before the Seminar on Plains Archeology at the Laboratory of Anthropology of the University of Nebraska. He took part in the Tenth Conference for Plains Archeology and was reelected to a third term as editor of the Plains Archeological Conference News Letter by that group. He presided as president at the anthropological section of the 63d annual meeting of the Nebraska Academy of Sciences and presented a paper, "The Ice-Glider Game, an 18th-Century Innovation in Northern Plains Culture." He also prepared an article, "The Weights of Chipped-Stone Projectile Points, a Clue to Their Functions," for publication in the Southwestern Journal for Anthropology. While in the field he addressed several organizations, telling about the work of the River Basin Surveys, and during the months in Lincoln acted as preceptor of the Indian Project of two groups of Campfire Girls. Because of the curtailment of funds for the Missouri Basin Project it was necessary to terminate Mr. Fenenga's appointment in a reduction-in-force action on June 30, 1953.

During July, August, and early September Donald D. Hartle, archeologist, was in charge of the excavations at the Night-Walker's Butte site and Grandmother's Lodge in the Garrison Reservoir area. In September he also measured and photographed a modern dance lodge in the Santee Bottoms. Throughout the remainder of the year he was at the Lincoln headquarters where he completed the detailed technical report on the excavations, carried on during 2 previous years at the Rock Village site (32ME15). He completed a series

of notes on the work at Night-Walker's Butte, the Grandmother's Lodge, and the dance lodge, and presented a summary report on his summer's work at one of the sessions of the Tenth Conference for Plains Archeology. As a result of the reduction in force, made necessary by curtailed funds, Mr. Hartle's employment was terminated on June 30, 1953.

George Metcalf, field and laboratory assistant, was a member of the Fort Berthold excavating party in the Garrison Reservoir area from July 1 to September 26, 1952. In addition to taking an active part in the digging at the fort he spent several days guiding the paleontological party to exposures noted during the previous year's surveys and in checking on the location of archeological sites reported by local residents. Mr. Metcalf also assisted in the investigations at the Grandmother's Lodge site. After returning to the Lincoln headquarters he prepared the material from Fort Berthold II for cataloging, made an analysis of the artifacts from the Night-Walker's Butte excavations, studied and prepared descriptions of specimens from the Star Village site (32ME16) dug the preceding year, and started work on a description of the remains of the last Arikara earth lodge, a task at which he was engaged until the end of the fiscal year. During the winter he also prepared book reviews for the North Dakota Historical Quarterly and for Nebraska History. Mr. Metcalf's employment was terminated on June 30 through the reduction-in-force program, but on July 1 he was to take a position as a museum aide in the division of archeology, United States National Museum.

On July 1, 1952, John E. Mills, archeologist, was occupied with an excavating party at the site of the Whetstone Army post in the Fort Randall Reservoir area in South Dakota. He completed that work on July 25 and moved his party to the Fort Randall brick-kiln site where he dug until August 29. During August he also made a reconnaissance, visiting the sites of the Lower Brule Indian Agency, Fort Lower Brule, and Fort Hale for the purpose of planning possible future excavations at those locations. In September he took his party to the Kirwin Reservoir area in Kansas and dug the site of Camp Kirwan. From October through June Mr. Mills was engaged at headquarters analyzing materials and preparing reports on the results of his investigations. He completed technical papers on "Historic-Sites Archeology in Fort Randall Reservoir, South Dakota," and "Excavation at Camp Kirwan, Kansas." In addition he completed manuscripts on the results of work which he did before joining the staff of the Missouri Basin Project. They were: "Quantitative Analysis of a Columbia River Shell Mound," and "Cultural Continuity at Nootka Sound, Vancouver Island." In September he addressed the Kirwin High School on the subject "Smithsonian Institution River Basin Surveys" and in May presented a paper, "Ethnohistory," before

the Nebraska Academy of Sciences. Mr. Mills requested leave of absence in May to return to the University of Washington to complete his studies for an advanced degree in anthropology. Such was granted, but in the reduction-in-force program it was necessary to remove his name from the rolls as of June 30.

At the start of the fiscal year J. M. Shippee, field and laboratory assistant, was at the headquarters in Lincoln. He spent several days assembling data for use in making an aerial survey and on July 15 and 16 flew with Ralph S. Solecki over five reservoir areas in Kansas. On July 23, under the general direction of Mr. Solecki, he started a ground survey of the Tuttle Creek Reservoir and was in that area until September 8. From that date until October 4 he assisted in the survey of the Glen Elder, Kirwin, Webster, and Wilson Reservoir basins. On his return to the laboratory he helped to complete the survey sheets and maps for the 156 new sites found, aided in the analysis of specimens, the identification of photographs, and the preparation of exhibits. He wrote an outline summary of the results of Solecki's work for presentation at the Tenth Conference for Plains Archeology. In November he also gave an illustrated talk before the Kansas City Chapter of the Missouri Archeological Society. On June 10, 1953, Shippee went to the Tuttle Creek Reservoir as assistant to Mr. Cumming and after the latter's return to Lincoln on June 17, was in charge of the excavating party for the remainder of the project. Mr. Shippee's employment was terminated by the reduction in force on June 30.

G. H. Smith, acheologist, was in charge of the party digging at the site of Fort Berthold II on July 1 and continued to supervise those excavations until the end of the season on September 23. Returning to the headquarters at Lincoln he spent the time from September 26 to June 30 working over materials and writing reports on his fieldwork. He completed the detailed technical paper on the results of the investigations made during a previous year at Fort Stevenson in the Garrison area. He also finished a brief report on the excavation of Fort Berthold II intended primarily to indicate progress at the site as of the end of the fiscal year. A manuscript consisting of a descriptive account of glass beads, some 8,000 in number, recovered at Fort Berthold was written and accepted for publication by the Central Texas Archeologist. A summary account of the history of the Niobrara River Basin was prepared for submission to the Bureau of Reclamation for use in the revision of the Niobrara Basin report of that Bureau's Region 7 office. At the Tenth Conference for Plains Archeology Mr. Smith reported on the work at Fort Berthold II and also presided as chairman at a session devoted to Plains Ethnohistory. Mr. Smith resigned, effective June 19, to attend the American School of Research, Athens, Greece.

Ralph S. Solecki, archeologist, was transferred to the Missouri Basin Project early in July. During the period from then until October 4 he was in charge of the surveys of the five Kansas reservoirs and in July and August flew three aerial photographic missions over other Missouri Basin areas. After completing the aerial missions Mr. Solecki prepared an article, "Photographing the Past," which appeared in the September issue of the Missouri River Basin Progress Report. While at the Lincoln office during the latter part of October and early November appraisal reports on the five Kansas Reservoir surveys were completed by Mr. Solecki.

Robert L. Stephenson, acting chief of the Missouri Basin Project, devoted a major portion of his time to managing the operations of the project. However, he was able to prepare a series of summary statements on the past 7 years of Missouri Basin Project activities in detail, reservoir by reservoir. He also did extensive work on a technical report of the excavations he supervised during previous years at the Whitney Reservoir on the Brazos River, Hill County, Tex., and made some analysis of notes and materials from the Accokeek site in Maryland. He served as chairman of one section of the Tenth Conference for Plains Archeology in November, attended the annual meeting of the Society for American Archeology at Urbana, Ill., where he presented a paper, "Accokeek: A Middle-Atlantic Culture Sequence," and acted as a discussant for two other papers. He served as chairman for an informal conference of Plains archeologists held at the Lincoln headquarters in April, and was host for the meeting of the Interior Missouri Basin Field Committee meeting in May. At the end of the fiscal year he was on a tour of inspection of the Missouri Basin. While in the field he visited White's paleontological party at Canyon Ferry Reservoir in Montana.

At the start of the fiscal year Richard Page Wheeler, archeologist, was in charge of the survey and excavation party at the Jamestown Reservoir in North Dakota. He continued his investigations there until September 26 when he returned to the headquarters at Lincoln, Nebr. Throughout the remainder of the year he worked on a major technical report summarizing the results of excavations and surveys made by himself and others in the Angostura Reservoir, S. Dak., and in the Boysen and Keyhole Reservoirs in Wyoming, between 1946 and 1951. That report was virtually completed at the close of the year. In addition he prepared a paper, "Plains Ceramic Analysis: A Check-List of Features and Descriptive Terms," which was published in the Plains Archeological Conference News Letter, vol. 5, No. 2. He also wrote an interim report, "Appraisal of the Archeological and Paleontological Resources of the Jamestown Reservoir, North Dakota: Supplement," which was mimeographed and distributed to the cooperating agencies. At the Tenth Conference for

Plains Archeology in November he gave a résumé of the Jamestown investigations and read a paper on the preceramic subsistence patterns in the Great Plains. On May 1 he presented a paper on Dakota mounds and earthworks at the 63d annual meeting of the Nebraska Academy of Sciences. In the late spring he collaborated with Dr. Donald J. Lehmer on a paper, "Time Horizons in the Northern Plains."

Dr. Theodore E. White, geologist, was in charge of the paleontological field party during all its operations. As previously noted, work during the 1952 season was in the Canyon Ferry, Garrison, and Oahe reservoir areas, and in June 1953 the party returned to the Canyon Ferry Reservoir in Montana for additional collecting. From September 15 to November 6, 1952, and from April 2 to May 30, 1953, Dr. White was in the laboratory at Lincoln. During those periods he was occupied in identifying osteological material collected by the various archeological excavating parties. Dr. White's other activities were discussed in connection with the operations of the Washington office.

Cooperating institutions.—Various State and local institutions cooperated in the Inter-Agency Salvage Program during the year. Most of those activities were on the basis of agreements between the agencies and the National Park Service, but in a few cases State groups carried on independently, although correlating their efforts closely with the over-all operations. The Ohio State Archeological and Historical Society continued to assume responsibility for all reservoir areas in that State. The Indiana Historical Society included surveys of potential reservoir areas in its general program for archeological research in Indiana and made periodical reports on the results of the investigations. Institutions working under agreements with the Service and the projects undertaken were: California Archeological Survey, University of California, Berkeley, made surveys of the proposed Trinity, Lewiston, Mooney Gulch, Red Bank, Oroville, Nimbus, Ice House, Union Valley, Pilot Creek, San Luis, and San Lucas Reservoirs of California and the Humboldt River and tributaries in Nevada, and started excavations in sites in the Nimbus and Red Bank areas; the Carnegie Museum of Pittsburgh excavated in the Conemaugh Reservoir area on the Conemaugh River in Pennsylvania; the Florida State Museum of the University of Florida dug a number of sites in the portion of the Jim Woodruff Reservoir basin located in Florida; the University of Kansas continued excavations at a site in the Fort Randall Reservoir basin in South Dakota; the University of Missouri excavated in the Pomme de Terre Reservoir on the river of the same name and at the Table Rock Reservoir on the White River in Missouri; Montana State University dug several small sites in the Garrison Reservoir area in North Dakota; the Nebraska

State Historical Society worked at three sites in the Fort Randall basin, South Dakota; the University of Nebraska Laboratory of Anthropology continued excavations in the Harlan County Reservoir on the Republican River, Nebr.; the University of Nebraska State Museum made archeological excavations in the Medicine Creek Reservoir in western Nebraska, and on a volunteer basis did paleontological work in several Missouri Basin projects; the State Historical Society of North Dakota continued excavations in the Garrison area; the University of Oklahoma worked at the Tenkiller Ferry Reservoir on the Illinois River and at the Keystone Reservoir on the Arkansas River in Oklahoma; the University of Oregon excavated in sites near The Dalles Dam on the Oregon side of the Columbia River; the University of South Dakota worked in the Oahe Reservoir basin in South Dakota; the State College of Washington investigated an early site in the Lind Coulee, Wash.; the University of Washington excavated at the Wakemap Mound site on the Washington side of the Columbia in The Dalles Reservoir basin; and the University of Wyoming continued its digging at the Keyhole Reservoir on the Belle Fourche River in Wyoming.

INSTITUTE OF SOCIAL ANTHROPOLOGY

In the spring of 1952 the Institute of Inter-American Affairs, Department of State, which had made a grant to the Institute of Social Anthropology to enable it to carry on its functions from January 1, 1952, to the end of the fiscal year with the understanding that the Smithsonian anthropologists would be available for program analyses of technical aid projects, decided to utilize anthropologists on a permanent basis. A request was made that plans be prepared to transfer ISA personnel to the Institute of Inter-American Affairs on July 1 and bring to a close the ISA activities as such. Late in June 1952, however, the Institute of Inter-American Affairs extended its grant to the Smithsonian Institution for an additional 3 months, so that there could be an orderly transfer of personnel, and provided $15,725 to finance the ISA until September 30, 1952. Before that date it became apparent that further time would be needed, and the grant was extended to December 31, 1952, and an additional $15,725 made available. The total funds for the 6-month period were $31,450. The activities of the Institute of Social Anthropology ended on December 31, 1952.

The period from July 1 to December 31, 1952, was one of retrenchment and the closing down of projects. In Washington Dr. Foster was occupied in terminating the work of the Institute, in the planning of anthropological aspects of the program in the Institute of Inter-American Affairs, and in the preparation of four article-length manuscripts on contemporary cultures in Latin America for publication

in anthropological journals. Dr. Kalervo Oberg, who had returned to the Washington office in June, prepared reports on the cultural problems encountered by technical aid programs in Brazil, and read and commented on Institute of Inter-American Affairs reports, as requested. He described Servicio programs in Brazil at the annual meeting of the American Association for the Advancement of Science at St. Louis, Mo., in December.

In Mexico all former Institute of Social Anthropology programs were terminated and the activities of Dr. Isabel T. Kelly were integrated with those of the Mexico City offices of the Institute of Inter-American Affairs. Her assignments, all made from that office, included trips to Monterey and Veracruz. In Colombia, beginning July 1, the work of Charles J. Erasmus was directly integrated with the Bogotá office of the Institute of Inter-American Affairs and all assignments, including program planning, routine office work, and field work in fisheries and agriculture were made by that office. Dr. Ozzie Simmons was in Peru on July 1 awaiting transfer to Chile by the Institute of Inter-American Affairs. There was unexected delay in the shift, however, and as he had not been assigned to an Institute program in Peru he made use of the time in terminating basic field studies in the Cañete Valley which, when published, will add to the knowledge of contemporary Latin American culture and will be a useful adjunct to program planning in the Institute of Inter-American Affairs. Dr. Donald Pierson resigned his position in Brazil on June 30, 1952, and subsequently returned to the United States.

Mrs. Eloise B. Edelen, of the Smithsonian Institution editorial staff, continued to edit Institute of Social Anthropology manuscripts. Publication No. 13, "The Tajín Totonac," by Isabel T. Kelly and Angel Palerm, was released on September 22, 1952. Publications No. 15, "Indian Tribes of Northern Mato Grosso, Brazil," by Kalervo Oberg, and No. 16, "Penny Capitalism: A Guatemalan Indian Economy," by Sol Tax, were released for distribution on April 2 and June 16, 1953, respectively.

On December 31, 1952, the employment of Dr. George M. Foster, Director, was terminated through a reduction-in-force action; and anthropologists Isabel T. Kelly, Charles J. Erasmus, Ozzie Simmons, and Kalervo Oberg were transferred to the Institute of Inter-American Affairs.

ARCHIVES

An apparent increase in public interest concerning American Indians, particularly those of the West, has resulted in greater demands on the large photographic collections. For the period from March 1 to June 30, 1953, 288 prints, together with data concerning them, were furnished in response to 104 requests.

During this same period 77 manuscripts were consulted, and 12 orders for microfilm and photostatic copies were filled.

Numerous gifts of photographs and manuscripts were received during the year. New linguistic materials accessioned included a portion of a Ponca-English vocabulary and a number of hymns translated in the Omaha language. This material, prepared in 1872 by J. O. Dorsey, was presented to the Bureau by Mrs. Virginia Dorsey Lightfoot. A portion of an English-Choctaw vocabulary prepared by Cyrus Byington about 1860 was presented by Donald D. McKay. The Historical and Philosophical Society of Ohio presented a newspaper of 1874 in the Creek language.

ILLUSTRATIONS

The time of the illustrator was spent in preparing and executing illustrations and maps for Bureau and River Basin Surveys publications and for research associates, and making posters, graphs, charts, diagrams, and maps, and repairing and altering illustrations for the editorial division and other departments of the Institution. Floor plans and front elevations also were executed for the Smithsonian planning committee.

EDITORIAL WORK AND PUBLICATIONS

There were issued 1 Annual Report, 5 Bulletins, and 3 Publications of the Institute of Social Anthropology, as follows:

Sixty-ninth Annual Report of the Bureau of American Ethnology, 1951–1952. ii+ 30 pp. 1953.

Bulletin 145. The Indian tribes of North America, by John R. Swanton. vi+726 pp., 5 maps. 1952.

Bulletin 150. The modal personality structure of the Tuscarora Indians, as revealed by the Rorschach test, by Anthony F. C. Wallace. viii+120 pp., 1 pl., 8 figs. 1952.

Bulletin 151. Anthropological Papers, Nos. 33–42. ix+507 pp., 37 pls., 25 figs., 7 maps. 1953.

- No. 33. "Of the Crow Nation," by Edwin Thompson Denig. Edited, with biographical sketch and footnotes, by John C. Ewers.
- No. 34. The water lily in Maya art: A complex of alleged Asiatic origin, by Robert L. Rands.
- No. 35. The Medicine Bundles of the Florida Seminole and the Green Corn Dance, by Louis Capron.
- No. 36. Technique in the music of the American Indian, by Frances Densmore.
- No. 37. The belief of the Indian in a connection between song and the supernatural, by Frances Densmore.
- No. 38. Aboriginal fish poisons, by Robert F. Heizer.
- No. 39. Aboriginal navigation off the coasts of Upper and Baja California, by Robert F. Heizer and William C. Massey.
- No. 40. Exploration of an Adena mound at Natrium, West Virginia, by Ralph S. Solecki.
- No. 41. The Wind River Shoshone Sun Dance, by D. B. Shimkin.

No. 42. Current trends in the Wind River Shoshone Sun Dance, by Fred W. Voget.

Bulletin 153. La Venta, Tabasco: A study of Olmec ceramics and art, by Philip Drucker. x+257 pp., 66 pls., 64 figs. 1952.

Bulletin 155. Prehistoric settlement patterns in the Virú Valley, Perú, by Gordon R. Willey. xxii+453 pp., 60 pls., 88 figs. 1953.

Institute of Social Anthropology Publication No. 13. The Tajín Totonac. Part 1. History, subsistence, shelter, and technology, by Isabel Kelly and Angel Palerm. xiv+369 pp., 33 pls., 69 figs., 18 maps. 1952.

Institute of Social Anthropology Publication No. 15. Indian tribes of northern Mato Grosso, Brazil, by Kalervo Oberg. With appendix entitled "Anthropometry of the Umotina, Nambicuara, and Iranxe, with comparative data from other northern Mato Grosso tribes," by Marshall T. Newman. vii+144 pp., 10 pls., 2 figs., 3 maps, 14 charts. 1953.

Institute of Social Anthropology Publication No. 16. Penny capitalism: A Guatemalan Indian economy, by Sol Tax. x+230 pp., 6 maps, 19 charts. 1953.

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

Bulletin 152. Index to Schoolcraft's "Indian Tribes of the United States," compiled by Frances S. Nichols.

Bulletin 154. River Basin Surveys Papers: Inter-Agency Archeological Salvage Program. Nos. 1–6.

No. 1. Prehistory and the Missouri Valley Development Program: Summary report on the Missouri River Basin Archeological Survey in 1948, by Waldo R. Wedel.

No. 2. Prehistory and the Missouri Valley Development Program: Summary report on the Missouri Basin Archeological Survey in 1949, by Waldo R. Wedel.

No. 3. The Woodruff Ossuary, a prehistoric burial site in Phillips County, Kans., by Marvin F. Kivett.

No. 4. The Addicks Dam sites:

I. An archeological survey of the Addicks Dam basin, Southeast Texas, by Joe Ben Wheat.

II. Indian skeletal remains from the Doering and Kobs sites, Addicks Reservoir, Tex., by Marshall T. Newman.

No. 5. The Hodges site:

I. Two rock shelters near Tucumcari, N. Mex., by Herbert W. Dick.

II. Geology of the Hodges site, Quay County, N. Mex., by Sheldon Judson.

No. 6. The Rembert Mounds, Elbert County, Ga., by Joseph R. Caldwell.

Appendix. List of River Basin Surveys reports published in other series.

Bulletin 156. The Iroquois Eagle Dance, an offshoot of the Calumut Dance, by William N. Fenton, with an analysis of the Iroquois Eagle Dance and songs, by Gertrude Prokosch Kurath.

Bulletin 157. Anthropological Papers, Nos. 43–48.

No. 43. Stone Monuments of the Río Chiquito, Veracruz, Mexico, by Matthew W. Stirling.

No. 44. The Cerro de las Mesas offering of jade and other materials, by Philip Drucker.

No. 45. Archeological materials from the vicinity of Mobridge, S. Dak., by Waldo R. Wedel.

No. 46. The original Strachey vocabulary of the Virginia Indian language, by John P. Harrington.

No. 47. The Sun Dance of the Northern Ute, by John Alan Jones.

No. 48. Some manifestations of water in Mesoamerican art, by Robert L. Rands.

Publications distributed totaled 38,596, as compared with 21,505 for the fiscal year 1952.

COLLECTIONS

Acc. No.

188983. 7 ethnological specimens from States of Washington and California, and from the Amazon Basin; 120 archeological specimens from Texas, México and Panamá.

195312. (Through Dr. F. H. H. Roberts, Jr.) Plesiosaur skeleton and spine of hybodont shark from Graneros formation, Newcastle member, in Keyhole Reservoir area, Crook County, Wyo., collected in June 1952 by Dr. Theodore E. White, River Basin Surveys.

195942. Approximately 74 fossil vertebrates from Oligocene and Miocene deposits of Canyon Ferry Reservoir area in Montana, and 4 mollusks, collected August 1952, by Dr. Theodore E. White, River Basin Surveys.

195943. Skeleton, without skull, of fossil reptile from Tongue River member of Fort Union formation in the Fort Garrison Reservoir area, North Dakota, collected in September 1952 by Dr. Theodore E. White, River Basin Surveys.

197275. Archeological materials excavated by field party under Franklin Fenenga at Slick Rock Village, Tulare County, Calif., River Basin Surveys.

197689. 144 specimens from Georgia including deeply weathered flint artifacts from Macon Plateau, Bibb County, and 1 lot of chips, probably from old Oconeetown, Milledgeville, Baldwin County.

197886. Bones of 2 species of birds from State of Washington. River Basin Surveys.

198525. 613 archeological surface specimens from Eufaula Reservoir, Onapa and Canadian Reservoir areas, southeastern Oklahoma, collected August and September 1948 by David J. Wenner, Jr., River Basin Surveys.

198526. 380 archeological surface specimens from the Eufaula (Gaines Creek) Reservoir, southeastern Oklahoma, collected July and August 1950 by Leonard G. Johnson, River Basin Surveys.

198527. 54 archeological surface specimens from Optima Reservoir, North Canadian River, Texas County, Okla., collected August 1950 by Leonard G. Johnson, River Basin Surveys.

MISCELLANEOUS

Dr. Frances Densmore, Dr. John R. Swanton, and Dr. Antonio J. Waring, Jr., continued as collaborators of the Bureau of American Ethnology. On November 14, 1952, Ralph S. Solecki was named collaborator in archeology.

On February 24, 1953, Mrs. Margaret C. Blaker joined the staff of the Bureau as archives assistant.

Information was furnished during the past year by members of the Bureau staff in reply to numerous inquiries concerning the American Indians, past and present, of both continents. The increased number of requests from teachers, particularly from primary and secondary grades, from Scout organizations, and from the general public, indicates a rapidly growing interest in the American Indian. Various specimens sent to the Bureau were identified and data on them furnished for their owners.

Respectfully submitted.

M. W. Stirling, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

APPENDIX 6

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, 1953:

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 increased by 20,324 to the yearly total of 1,021,938, and the total weight of the packages of publications increased by 29,475 to the yearly total of 855,102 pounds. The average weight of the individual package increased to 13.38 ounces, as compared to the 13.18-ounce average for the fiscal year of 1952. The publications received from both the foreign and domestic sources for shipment are classified as shown in the following table:

Classification	Packages		Weight	
	Number	*Number*	*Pounds*	*Pounds*
United States parliamentary documents sent abroad	571,936		251,190	
Publications received in return for parliamentary documents		14,072		20,588
United States departmental documents sent abroad	196,438		231,985	
Publications received in return for departmental documents		10,657		22,793
Miscellaneous scientific and literary publications sent abroad	163,563		216,036	
Miscellaneous scientific and literary publications received from abroad for distribution in the United States		65,292		112,510
Total	931,937	90,001	699,211	155,891
Grand total	1,021,938		855,102	

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 addressees by direct mail. The number of boxes

shipped to the foreign exchange bureaus was 2,649, or 409 less than for the previous year. Of these boxes 802 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 number of packages forwarded by mail and by means other than freight was 205,666.

Owing to the insufficiency of funds for transportation it was necessary to suspend shipments to the foreign exchange bureaus on March 15. Fortunately, the Institution was able to secure a grant of $6,000 from the National Science Foundation for the transportation of exchange publications. This was made available to the International Exchange Service in the latter part of May, and between that time and the end of June $5,110.18 was expended for the shipment of 98,945 pounds that would otherwise have been delayed pending the receipt of the appropriation for the fiscal year of 1954. The remaining amount will be used in July pending the availability of the new appropriation. The grant made it possible for the International Exchange Service to effect delivery of these important scientific publications to the foreign addressees at least a month earlier than would otherwise have been possible. It not only eliminated the necessity for additional storage space, decreased handling, and lessened the probable percentage of error in transmission, but also obviated the necessity for a great deal of correspondence regarding the nonreceipt of publications.

Transportation rates continue to increase and are primarily responsible for the 235,422 pounds of publications that remained unshipped at the end of the fiscal year.

No shipments are being made to China, North Korea, or Rumania. Publications intended for addressees in Formosa and formerly sent through the Chinese Exchange Bureau at Nanking are now forwarded by direct mail.

Regulations of the Office of International Trade, Department of Commerce, provide that each package of publications exported bear a general license symbol and a legend "Export License Not Required," and the International Exchange Service accepts for transmission to foreign destinations only those packages of publications to which the general license symbol and legend have been applied by the consignor.

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 105 (63 full and 42 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: Public Library of Western Australia, Perth.
AUSTRIA: Administrative Library, Federal Chancellery, Vienna.
BELGIUM: Bibliothèque Royale, Bruxelles.
BRAZIL: Biblioteca Nacional, Rio de Janeiro.
BULGARIA: Bulgarian Bibliographical Institute, Sofia.
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: Ministry of Education, National Library, Nanking, China.[1]
PEIPING: National Library of Peiping.[1]
COLOMBIA: Biblioteca Nacional, Bogotá.
COSTA RICA: Biblioteca Nacional, San José.
CUBA: Ministerio de Estado, Canje Internacional, Habana.
CZECHOSLOVAKIA: National and University Library, Prague.
DENMARK: Institut Danios des Échanges Internationaux, Copenhagen.
EGYPT: Bureau des Publications, Ministère des Finances, Cairo.
FINLAND: Parliamentary Library, Helsinki.
FRANCE: Bibliothèque Nationale, Paris.
GERMANY: Offentliche Wissenschaftliche Biblothek, Berlin.
Parliamentary Library, Bonn.
Free University of Berlin, Berlin.[2]
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.
INDIA: National Library, Calcutta.
Central Secretariat Library, New Delhi.
INDONESIA: Ministry for Foreign Affairs, Djakarta.
IRELAND: National Library of Ireland, Dublin.
ISRAEL: Government Archives and Library, Hakirya.
ITALY: Ministerio della Publica Istruzione, Rome.
JAPAN: National Diet Library, Tokyo.[3]
MEXICO: Secretaría de Relaciones Exteriores, Departamento de Información para el Extranjero, México, D. F.

[1] Shipment suspended.
[2] Added during year.
[3] Receives two sets.

NETHERLANDS: Royal Library, The Hague.
NEW ZEALAND: General Assembly Library, Wellington.
NORWAY: Utenriksdepartmentets Bibliothek, Oslo.
PAKISTAN: Central Secretariat Library, Karachi.
PERU: Sección de Propaganda y Publicaciones, Ministerio de Relaciones Exteriores, Lima.
PHILIPPINES: Bureau of Public Libraries, Department of Education, Manila.
POLAND: Bibliothèque Nacionale, Warsaw.
PORTUGAL: Biblioteca Nacional, Lisbon.
SPAIN: Biblioteca Nacional, Madrid.
SWEDEN: Kungliga Biblioteket, Stockholm.
SWITZERLAND: Bibliothèque Centrale Fédérale, Berne.
TURKEY: Department of Printing and Engraving, Ministry of Education, Istanbul.
UNION OF SOUTH AFRICA: State Library, Pretoria, Transvaal.
UNION OF SOVIET SOCIALIST REPUBLICS: All-Union Lenin Library, Moscow 115.
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.[3]

DEPOSITORIES OF PARTIAL SETS

AFGHANISTAN: Library of the Afghan Academy, Kabul.
ANGLO-EGYPTIAN SUDAN: Gordon Memorial College, Khartoum.
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 Novia 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.
HONDURAS:
Biblioteca y Archivo Nacionales, Tegucigalpa.
Ministerio de Relaciones Exteriores, Tegucigalpa.
ICELAND: National Library, Reykjavik.
INDIA:
BIHAR AND ORISSA: Revenue Department, Patna.
BOMBAY: Undersecretary to the Government of Bombay, General Department Bombay.

INDIA—Continued
UNITED PROVINCES OF AGRA AND OUDH:
University of Allahabad, Allahabad.
Secretariat Library, Uttar Pradesh, 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, Valleta.
NICARAGUA: Ministerio de Relaciones Exteriores, Managua.
PAKISTAN: Chief Secretary to the Government of Punjab, Lahore.
PANAMA: Ministerio de Relaciones Exteriores, Panamá.
PARAGUAY: Ministerio de Relaciones Exteriores, Sección Biblioteca, Asunción.
SCOTLAND: National Library of Scotland, Edinburgh.
SIAM: National Library, Bangkok.
SINGAPORE: Chief Secretary, Government Offices, Singapore.
VATICAN CITY: Biblioteca Apostolica Vaticana, Vatican City, Italy.

INTERPARLIAMENTARY EXCHANGE OF THE OFFICIAL JOURNAL

There are now being sent abroad 92 copies of the Federal Register and 102 copies of the Congressional Record. This is an increase over the preceding year of 5 copies of the Federal Register and 8 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 del Congreso Nacional, Buenos Aires.
Biblioteca del Poder Judicial, Mendoza.[4]
Boletín Oficial de la República Argentina, Ministerio de Justica e Instrucción Pública, Buenos Aires.
Cámara de Diputados Oficina de Información Parlamentaria, Buenos Aires.
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.[4]
WESTERN AUSTRALIA: Library of Parliament of Western Australia, Perth.
BRAZIL:
Biblioteca da Camera dos Deputados, Rio de Janeiro.
Secretaria de Presidencia, Rio de Janeiro.[5]
AMAZONAS: Archivo, Biblioteca e Imprensa Publica, Manáos.
BAHIA: Governador do Estado da Bahia, São Salvador.
ESPIRITO SANTO: Presidencia do Estado do Espirito Santo, Victoria.
RIO GRANDE DO SUL: Imprensa Oficial do Estado, Porto Alegre.
SERGIPE: Biblioteca Pública do Estado de Sergipe, Aracajú.
SÃO PAULO: Imprensa Oficial do Estada, São Paulo.

[4] Federal Register only.
[5] Congressional Record only.

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.[3]
CHINA:
Legislative Yuan, Taipei, Taiwan.[3 4]
Taiwan Provincial Government, Taipei, Taiwan.[3]
CUBA:
Biblioteca del Capitolio, Habana.
Biblioteca Publica Panamericana, Habana.[4]
Biblioteca Martí, Cámara de Representantes, Habana.
CZECHOSLOVAKIA: Library of the Czechoslovak National Assembly, Prague.[5]
EGYPT: Ministry of Foreign Affairs, Egyptian Government, Cairo.[5]
EL SALVADOR: Library, National Assembly, San Salvador.
FRANCE:
Bibliothèque Assemblée Nationale, Paris.
Bibliothèque Conseil de la République, Paris.
Library, Organization for European Economic Cooperation, Paris.[5]
Publiques de l'Institut de Droit Comparé, Université de Paris, Paris.[4]
Research Department, Council of Europe, Strasbourg.[5]
Service de la Documentation Étrangère, Assemblée Nationale, Paris.[5]
GERMANY:
Amerika-Institut der Universität München, München.[5]
Archiv, Deutscher Bundesrat, Bonn.
Bibliotek der Instituts für Weltwirtschaft an der Universität Kiel, Kiel-Wik.
Bibliothek Hessischer Landtag, Wiesbaden.[3 4]
Der Bayrische Landtag, Munich.[3 4]
Deutscher Bundesrat, Bonn.[5]
Deutscher Bundestag, Bonn.[5]
GREAT BRITAIN:
Department of Printed Books, British Museum, London.[5]
House of Commons Library, London.[5]
Printed Library of the Foreign Office, London.
Royal Institute of International Affairs, London.[5]
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.
INDIA:
Civil Secretariat Library, Lucknow, United Provinces.[4]
Indian Council of World Affairs, New Delhi.[5]
Legislative Assembly Library, Lucknow, United Provinces.
Legislative Assembly Library, Trivandrum.[3 4]
Legislative Department, Simla.
Parliament Library, New Delhi.[5]
Servants of India Society, Poona.[3 5]
IRELAND: Dail Eireann, Dublin.
ISRAEL: Library of the Knesset, Jerusalem.[3]
ITALY:
Biblioteca Camera dei Deputati, Rome.
Biblioteca del Senato della Republica, Rome.

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[4] Three copies.

ITALY—Continued

European Office, Food and Agriculture Organization of the United Nations, Rome.[4]

International Institute for the Unification of Private Law, Rome.[4]

JAPAN: Library of the National Diet, Tokyo.

KOREA: Secretary General, National Assembly, Pusan.

LUXEMBOURG: Assemblée Commune de la C. E. C. A., Luxembourg.[2]

MEXICO:

Dirección General Información, Secretaría de Gobernación, México, 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 Gutiérrez.

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.

DURANGO: Gobernador Constitucional del Estado de Durango, Durango.

GUANAJUATO: Secretaría General de Gobierno del Estado, Guanajuato.

GUERRERO: Gobernador del Estado de Guerrero, Chilpancingo.

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, Palacia de Gobierno, Oaxaca.

PUEBLA: Secretaría General de Gobierno, Puebla.

QUERÉTARO: Secretaría General de Gobierno, Sección de Archivo, Querétaro.

SAN LUIS POTOSÍ: Congreso del Estado, San Luis Potosí.

SINALOA: Gobernador del Estado de Sinaloa, Culiacán.

SONORA: Gobernador del Estado de Sonora, Hermosillo.

TABASCO: Secretaría de Gobierno, Sessión 3a, Ramo de Prensa, Villahermosa.

TAMAULIPAS: Secretaría General de Gobierno, Victoria.

TLAXCALA: Secretaría de Gobierno del Estado, Tlaxcala.

VERACRUZ: Gobernador del Estado de Veracruz, Departamento de Gobernación y Justicia, Jalapa.

YUCATÁN: Gobernador del Estado de Yucatán, Mérida.

NETHERLANDS: Koninklijke Bibliotheek, The Hague.[4]

NEW ZEALAND: General Assembly Library, Wellington.

NORWAY: Library of the Norwegian Parliament, Oslo.

PAKISTAN: Punjab Legislative Assembly Department, Lahore.

PANAMA: Biblioteca Nacional, Panama City.[2,3]

PERU: Cámara de Diputados, Lima.

POLAND: Ministry of Justice, Warsaw.[4]

PORTUGAL: Secretaria de Assembla National, Lisbon.[4]

PORTUGUESE TIMOR: Repartição Central de Administração Civil, Dili.[4]

SWITZERLAND: Bibliothèque, Bureau International du Travail, Geneva.[4]

International Labor Office, Geneva.[4,7]

Library, United Nations, Geneva.

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[7] Two copies.

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, Obshchestvennykh, Nauk, Moscow.*
URUGUAY: Diario Oficial, Calle Florida 1178, Montevideo.
VENEZUELA: Biblioteca del Congreso, Caracas.

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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 to the addresses by mail.

LIST OF EXCHANGE SERVICES

AUSTRIA: Austrian National Library, Vienna.
BELGIUM: Service des Échanges Internationaux, Bibliothèque Royale de Belgique, Bruxelles.
CHINA: Bureau of International Exchange, National Central Library, Nanking.[1]
CZECHOSLOVAKIA: Bureau of International Exchanges, National and University Library, Prague.
DENMARK: Institut Danois des Échanges Internationaux, Bibliothèque Royale, Copenhagen K.
EGYPT: Government Press, Publications Office, Bulaq, Cairo.
FINLAND: Delegation of the Scientific Societies, Snellmaninkatu 9–11, Helsinki.
FRANCE: Service des Échanges Internationaux, Bibliothèque Nationale, 58 Rue de Richelieu, Paris.
GERMANY: Notgemeinschaft der Deutschen Wissenschaft, Bad Godesberg.
GREAT BRITAIN AND IRELAND: Wheldon & Wesley, 83/84 Berwick Street, London, W. 1.*
HUNGARY: Hungarian Libraries Board, Ferenciektere 5, Budapest, IV.
INDIA: Superintendent of Government Printing and Stationary, Bombay.
INDONESIA: Department of Cultural Affairs and Education, Djakarta.
ISRAEL: Jewish National and University Library, Jerusalem.
ITALY: Ufficio degli Scambi Internazionali, Ministero della Publica 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 Exchanges of International Publications, Chief Secretary's Office, Brisbane.

* Between the United States and England only.

RUMANIA: Ministère de la Propagande Nationale, Service des Échanges Internationaux, Bucharest.[1]

SOUTH AUSTRALIA: South Australian Government Exchanges Bureau, Government Printing and Stationary Office, Adelaide.

SPAIN: Junta de Intercambio y Adquisición de Libros y Revistas para Bibliotecas Públicas, Ministerio de Educación Nacional, Avenida Calvo Sotelo 20, Madrid.

SWEDEN: Kungliga Biblioteket, Stockholm.

SWITZERLAND: Service Suisse des Échanges Internationaux, Bibliothèque Centrale Fédérale, Palais Fédéral, Berne.

TASMANIA: Secretary of the Premier, Hobart.

TURKEY: Ministry of Education, Department of Printing and Engraving, Istanbul.

UNION OF SOUTH AFRICA: Government Printing and Stationary Office, Cape Town, Cape of Good Hope.

UNION OF SOVIET SOCIALIST REPUBLICS: Bureau of Book Exchange, State Lenin Library, Moscow 19.

VICTORIA: Public Library of Victoria, Melbourne.

WESTERN AUSTRALIA: Public Library of Western Australia, Perth.

YUGOSLAVIA: Bibliografski Institut FNRJ, Belgrade.

Respectfully submitted.

D. G. WILLIAMS, *Chief.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

APPENDIX 7

Report on the National Zoological Park

SIR: Transmitted herewith is a report on the operations of the National Zoological Park for the fiscal year ended June 30, 1953.

This year showed a considerable increase over last in accessions to the Zoo. In all, 810 accessions, comprising 1,797 individual animals, were added to the collection during the year by gifts, deposits, purchases, exchanges, births, and hatchings. Among these were many rare specimens never before shown in this Zoo. The addition of new kinds of animals enhances the value of the collection, which is maintained not only for exhibition but also for research and education, thus fostering the Smithsonian's established purpose of "the increase and diffusion of knowledge." Opportunities for research are afforded students of biology, particularly vertebrate zoology, as well as artists, photographers, and writers. Methods of study that do not endanger the welfare of animals or the safety of the public are encouraged.

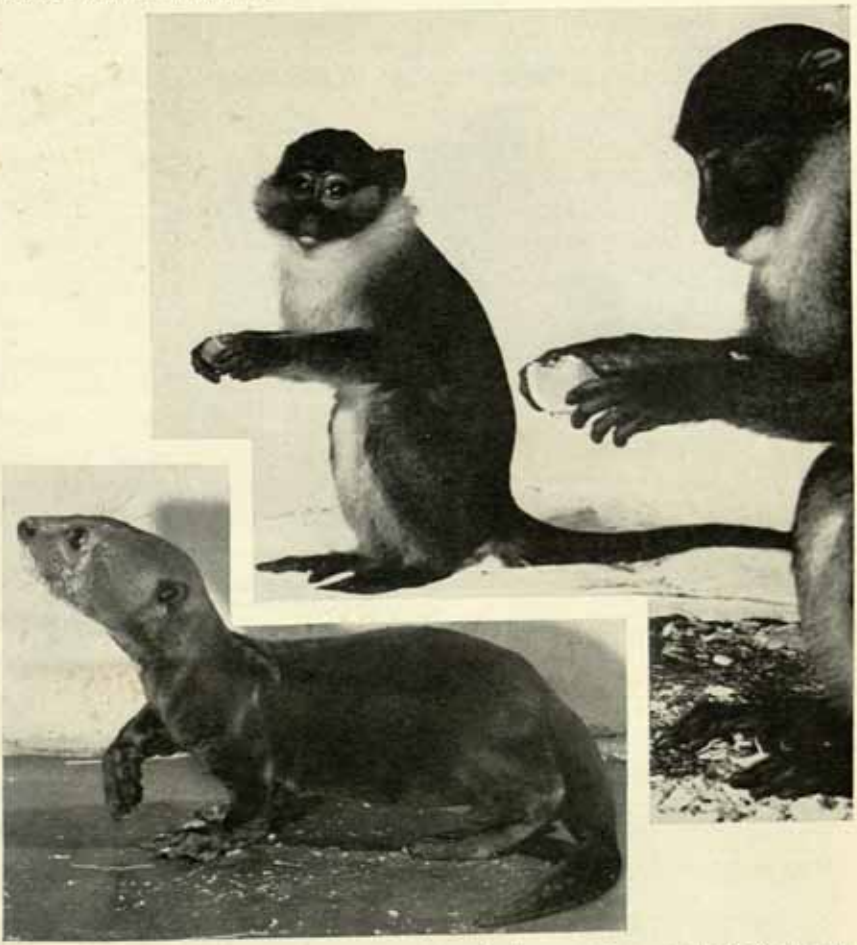
Services of the staff included answering in person or by phone, mail, or telegraph questions regarding animals and their care and transportation; furnishing to other zoos and other agencies, public and private, information regarding structures for housing animals; cooperating with other agencies of Federal, State, and municipal governments in research work; and preparing manuscripts for publication.

The stone restaurant building, which was constructed in the Park in 1940, is leased at $46,212 a year. This money is deposited in the United States Treasury. The concessionaire serves meals and light refreshments and sells souvenirs.

THE EXHIBITS

Animals for exhibition are acquired by gift, deposit, purchase, exchange, birth, and hatching, and are removed by death, exchange, or return of those on deposit. Although depositors are at liberty to remove their specimens, many leave them permanently.

As in any colony of living things, there is a steady turnover, and the exhibits are constantly changing. Thus, the inventory of specimens in the collection on June 30 of each year does not show all the kinds of animals that were exhibited during the year, for sometimes creatures of outstanding interest at the time they were shown are no longer in the collection at the time the inventory is made.



Upper right: Allen's monkeys. These two were the first specimens of their kind to be exhibited in the National Zoological Park and, with the exception of two others received at the San Diego Zoo at about the same time, the first to be exhibited in the United States. They are extremely rare, less than a dozen specimens having heretofore been in zoos or museums anywhere in the world.

Lower left: Young Brazilian flat-tailed otter. This is the first one to be exhibited in the National Zoological Park, or, possibly, in the United States. These are large otters that inhabit streams of the Amazon Basin. The feet are as fully webbed as the common river otter, and the tail is flattened in a peculiar manner.

Photographs by Ernest P. Walker.

Right: Frilled lizard of Australia, in a defensive attitude but without its frill or ruff being fully extended as it is when the lizard is annoyed. This and another specimen were the first to be exhibited in the National Zoological Park. On the limb beneath, an Australian bearded lizard. On the throat are large folds of skin which the animal extends when angry to produce a threatening appearance.

Lower left: European midwife toad. The female lays her eggs in a strand somewhat like beads strung on a cord. The male then wraps them around his body in front of his hind legs and cares for them until they hatch.

Photographs by Ernest P. Walker.

The United States National Museum is given first choice of all specimens that die in the Zoo. If they are not desired for the Museum they are then made available to other institutions or scientific workers. Thus the value of the specimen continues long after it is dead.

ACCESSIONS

GIFTS AND DEPOSITS

The Zoo has been particularly fortunate in having friends who have showed their sincere interest by bringing in specimens, or arranging for acquisitions from foreign countries. During the year, the following have made valuable contributions to the collection:

Lt. Col. Robert Traub, Chief, Department of Entomology, Medical Service Graduate School, Walter Reed Army Medical Center, Washington, D. C., supplied animals from Malaya, Borneo, and Korea.

Thomas McKnew, of the National Geographic Society, interested Sir Gordon H. A. MacMillan of MacMillan, Governor and Commander in Chief of Gibraltar, in presenting two Barbary apes.

Dr. Robert E. Kuntz, of the United States Naval Medical Research Unit No. 3, Cairo, Egypt, and George Malakatis, gave reptiles that they had obtained in Egypt.

Dr. Donald J. Pletsch, of the World Health Organization at Taipeh, Taiwan, sent a fine, tame civet (*Paguma larvata taviana*), a form found only on the island of Formosa. This was the first of its kind exhibited in the Zoo.

Dr. Egberto Garcia S., Director of the Department of Public Health of Ecuador, sent two large Galápagos turtles.

The Honorable Carlton Skinner, Governor of Guam, gave three East Indian monitor lizards.

Forest Bartl, of Edgewater, Md., presented a specimen of the beautiful eclectus parrot, a native of the Papuan Islands and rare in collections.

Mrs. Helen B. Irwin, Washington, D. C., gave a beautiful sulphur-crested cockatoo.

Paul M. Menendez and Bernard F. Salb, both of Washington, D. C., each presented a white-armed marmoset.

The National Institutes of Health deposited a chimpanzee.

The Round Table Kennels, of Middletown, Del., presented 12 young blue peafowl.

Dorothy Schenck, Willimantic, Conn., gave a ball python.

The United States Fish and Wildlife Service, through various members of its staff, continued to assist during the year in maintaining an interesting collection.

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J. E. Bannister, St. Leonards, Md., went to considerable effort to bring to the Zoo a scarlet king snake, one of the more beautifully marked of North American snakes, and very rare in this region.

The Philadelphia Zoological Gardens gave two Arctic foxes.

Dr. E. Raymond Hall and Richard P. Grossenheider, of the University of Kansas, presented two Point Barrow lemmings; these are rare in collections because they do not ordinarily thrive in capitivity.

W. W. Dornin, Phoenix, Ariz., personally collected and shipped to the Zoo representatives of 13 species of reptiles of the southwestern United States.

Superintendent Curtis Reid, of the District of Columbia Jail, and William Stokes gave a Virginia deer that had been raised from a fawn at the jail.

Mrs. Fred J. McKay, Arlington, Va., gave an American crocodile.

This year, as in many years past, various individuals have deposited in the Zoo animals to which they desired to retain title. These specimens are most acceptable additions to the exhibits. Depositors are assured that the animals will receive routine care, but the Zoo assumes no responsibility for their return or no obligation to replace any that do not survive.

This year a group of 42 mammals and reptiles was deposited by Gordon Gaver, who operates an animal exhibit at Thurmont, Md., during the summer. He deposited his specimens with the Zoo in the fall and removed them in the spring.

A similar procedure has been adopted by M. A. Stroop, of New Market, Va., who deposited 68 specimens with us this year.

There was a decided increase in the number of spectacled caimans (*Caiman sclerops*) received as gifts, due to the fact that Florida is now prohibiting exportation of baby alligators and so dealers are selling instead young spectacled caimans from Central and South America, and many of these eventually reach the zoos.

DEPOSITORS AND DONORS AND THEIR GIFTS

(Deposits are marked *; unless otherwise indicated, addresses of donors are Washington, D. C.)

Aben, Jerry, 8 golden hamsters, *golden hamster.
Abramson, Karen, Alexandria, Va., 2 Pekin ducks.
Adair, Ralph, Chevy Chase, Md., opossum.
Adams, John, Arlington, Va., Pekin duck.
Allen, Ronald, 2 common newts.
Alsever, Mrs. Margery, opossum.
Alston, Hezekiah, Pekin duck.
Altman, Franklin O., Takoma Park, Md., 2 domestic rabbits.
Alvard, Kathy, robin.
Anderson, Mrs. M., 2 cardinals.
Animal Rescue League, woodcock.
Animal Welfare League, Arlington, Va., skunk.
Army Medical Service, through Col. Robert Traub, *2 rajah tree rats, *2 wood rats, *2 Asiatic squirrels, *2 southern Asiatic squirrels, *2 Berdmore's squirrels, *6 Siamese rats, *4 large spiny-backed tree rats, *1 lesser bandicoot rat, *4 Allegheny wood rats, *2 raccoon dogs.

Arons, Mrs. H. C., Silver Spring, Md., white rabbit.
Ashton, Francis, 3 rabbits, 3 guinea pigs, hamster, painted turtle, opossum.
Ayer, Lorraine, domestic rabbit.
Baber, James M., squirrel monkey.
Babst, Carol L., black rabbit.
Baden, Mrs. G., robin.
Bailey, George, Pekin duck.
Baker, James, chain or king snake.
Baker, Judd O., alligator.
Baker, N. B., Alexandria, Va., 3 Pekin ducks.
Bannister, J. E., St. Leonards, Md., scarlet king snake.
Bargmann, Louis, Arlington, Va., pilot black snake.
Bartl, Forest F., Edgewater, Md., eclectus parrot.
Belintende, S. J., Silver Spring, Md., summer tanager.
Benn, Mrs. W. G., Falls Church, Va., pine lizard, blue-tailed skink.
Bennett, Mrs. Robert, Silver Spring, Md., 4 guinea pigs.
Berliner, Steve, coot.
Bernstein, Ed, *white-throated capuchin.
Berryman, Mrs. R. M., false map turtle.
Berthold, Alfred, Chevy Chase, Md., Cumberland turtle.
Betz, Thomas, black widow spider.
Bigio, Fred, 3 tree frogs.
Blackman, Robert, Arlington, Va., 4 false chameleons.
Bond, Danny, 2 rabbits.
Bower, Clayton, Fort Howard, Md., fighting fowl.
Brady, Thomas, timber rattlesnake.
Breed, Harold A., Clifton, Va., copperhead.
Breslin, G. L., 2 Cook's tree boas.
Brickham, Marguerite H., Annandale, Va., 2 hamsters.
Brill, Mrs. Alice, Eastpine, Md., 5 gray squirrels.
Broadhurst, Joe, and Kern, Gary, 2 water snakes, snapping turtle.
Brockdorff, P. F., Silver Spring, Md., horned lizard.
Broodwater, Bobby, Hyattsville, Md., pilot black snake.
Brown, Mrs. Clark E., Chevy Chase, Md., robin.
Brown, George Jr., Silver Spring, Md., rabbit.
Brown, Lynn R., Bladensburg, Md., and McCrory, V. E., Alexandria, Va., *hawk-billed turtle.
Brown, Mrs. Ray, *Pekin duck.
Brucker, W. B., Long Beach, Calif., *Pacific rattler.
Brunhouse, Mrs. Helen, 2 pickerel frogs, alligator, 3 red-lined turtles, 3 Cumberland turtles, geographic turtle, 2 green frogs, 2 common newts, hamster.
Buck, Sally, Garrett Park, Md., alligator.
Burgess, Pamela, Pekin duck.
Burke, William L., Alexandria, Va., 16 opossums.
Burrows, Mrs. Inez C., Takoma Park, Md., opossum.
Bushnell, Guy, water snake, 8 bullfrogs.
Caldwell, William Jr., 2 Pekin ducks.
Calvert, Miss Ann, Pekin duck.
Campbell, Harold F., Bethesda, Md., 5 fighting game chickens.
Camp Detrick, Frederick, Md., copperhead.
Cardozo High School, spectacled caiman.
Carew, H. E., Silver Spring, Md., cottontail rabbit.
Carey, J., Edgewater, Md., brown capuchin.
Carson, James, Arlington, Va., burrowing snake.
Carter, C. Glen, Silver Spring, Md., 2 Pekin ducks.
Cartner, Mrs. Helen, wood thrush.
Castell, Bill, Arlington, Va., spectacled caiman.
Charles, Frank, Takoma Park, Md., domestic rabbit.
Christel, Mrs. C. J., domestic rabbit.
Clapp, Dr. Stewart, Kensington, Md., barred owl.
Clark, Mrs. Austin, snapping turtle.
Clarke, Mrs. Mary Elizabeth, Silver Spring, Md., skunk.
Clarke, Mrs. Peggy, Landover, Md., *2 Indian pythons, *3 Florida king snakes, *alligator, *Indian rock python.
Cleary, Mrs. Mary D., domestic rabbit.
Clow, Mrs. Kenneth A., Chevy Chase, Md., domestic pigeon.
Coffin, David M., Silver Spring, Md., opossum.
Coleman, Elizabeth Ann, *Pekin duck.
Colison, C. W., domestic rabbit.
Collady, S. F., 2 white rabbits.
Connelly, Marc, Falls Church, Va., 2 Pekin ducks.
Connett, Mrs. W. B., Fairfax, Va., South American turtle.
Connolly, John Alfred, copperhead.
Cook, Martin Thomas, ring-necked snake.
Coray, Mrs. J. B., robin.
Corbet, Pat, Silver Spring, Md., tree frog.
Cordle, Farman E., Vienna, Va., *rhesus monkey.
Covan, Mrs. W. C., Arlington, Va., white rabbit.
Craig, Col. Malin, Jr., Chevy Chase, Md., mourning dove.
Cramer, Corliss, Arlington, Va., sparrow hawk.
Crawford, William E., East Riverdale, Md., king snake.

Cross, Miss Ann G., Sweet Briar, Va., ringed aracari toucan.
Crowley, Mrs. H. G., blue jay.
Crowley, Mrs. Thomas B., Kensington, Md., skunk.
Czizauskas, Edward, domestic pigeon.
Dale, C. E., *wood turtle, *2 box turtles, *3 pilot black snakes, *water snake, *keeled green snake, *ringneck snake, *worm snake, *queen snake, *mole snake, *2 blue-tailed skinks.
Daniel, Wayne L., Kensington, Md., 2 guinea pigs.
Dann, Douglas B., Jr., Alexandria, Va., snapping turtle.
Danneman, Eli, Silver Spring, Md., Pekin duck.
Dante, Robert, 2 golden hamsters.
Darnell, Basil, opossum.
Davis, Frank A., Silver Spring, Md., albino corn snake.
Davis, Col. Homer, Arlington, Va., 2 Pekin ducks.
Davis, Malcolm, painted bunting.
Davis, Mrs. R. F., Takoma Park, Md., pilot black snake.
Dawson, John Henry, Bethesda, Md., guinea pig.
Deddo, Tony Nick, sooty mangabey.
DePrato, Jack, Langley Park, Md., water snake.
DePrato, Jack and Joe, Langley Park, Md., gopher tortoise, pygmy rattlesnake, *young anaconda, wood toad, ground skink.
Dickson, J. T., horned lizard.
Dillon, Tandy N., Silver Spring, Md., 2 Pekin ducks.
DiMaggio, Andrea, pilot black snake.
District of Columbia Jail, through Superintendent Curtis Reid and William Stokes, Virginia deer.
Dopp, H. G., Bladensburg, Md., red fox.
Dornin, W. W., Phoenix, Ariz., 2 gila monsters, chuckwalla lizard, 3 California horned lizards, chain king snake, 3 bull snakes, LeConte's snake, 2 garter snakes, ribbon snake, 18 rattlesnakes, including Western diamond-backed rattlers, red diamond-backed rattlers, sidewinders, Mohave rattlers, Pacific rattlers.
Dowad, Charles, alligator.
Drumheller, Ralph P., District Heights, Md., opossum.
Dunn, April, Pekin duck.
Dunn, D. M., Takoma Park, Md., guinea pig.
Dunn, Mrs. H. E., Takoma Park, Md., white-throated capuchin.
Ecuador, Department of Public Health, through Dr. Egberto Garcia S., Director, 2 Galápagos turtles.
Eddy, Chip, opossum.
Edelon, Mrs. E. J., Jr., Port Tobacco, Md., barn owl.
Edwards, Joan, 2 Pekin ducks.
Erwin, Mrs. Helen B., sulphur-crested cockatoo.
Evans, Radie, Potomac, Md., *2 lions.
Evans, S. W., *5 desert tortoises.
Ewing, Mrs. F. W., Kenwood, Md., 2 Muscovy ducks.
Faquih, Khaled, robin.
Faust, Mrs. Mary D., domestic rabbit.
Felix, Mary Katherine, Pekin duck.
Ferguson, Robert, Chevy Chase, Md., Cumberland turtle.
Ferguson, Mrs. Robert, *ferret.
Finney, Mr. and Mrs. Edward G., Waynesboro, Pa., 2 red foxes.
Fisher, Mrs. J., Alexandria, Va., red-bellied woodpecker.
Fisher, Sydney N., gray squirrel.
Flanagan, Mrs. Matthew, spectacled caiman.
Ford, Douglas O., Kensington, Md., 2 Pekin ducks.
Foster, Bonnie, Pekin duck.
Fowler, Mr. and Mrs. S. Robert, West Beach, Md., *alligator.
Fratt, N. D., Arlington, Va., spectacled caiman.
Freedenberg, Norman, Pekin duck.
Friedman, Seymour, Mount Rainier, Md., Pekin duck.
Fruland, Roddy, Falls Church, Va., screech owl.
Gault, Albert, Paradise fish, 5 blue acaras.
Gaver, Gordon, Thurmont, Md., *Javan macaque, *2 water snakes, *king cobra, *brown water snake, *2 regal pythons, *2 South American boa constrictors, *African python, *Indian python, *ball python, *rainbow boa, *king snake, *Indian cobra, *gray rat snake, *corn snake, *6 alligators, *2 eastern diamond-backed rattlesnakes, *2 timber rattlesnakes, *2 copperheads, *12 water moccasins.
Geier, Mrs. John, 3 opossums.
Gelwicks, Maj. Harold G., Arlington, Va., 2 Pekin ducks.
Gibbs, Mary, 2 white mice.
Gibson, Mrs. William, Bethesda, Md., 2 Pekin ducks.
Gideon, Bobby, Arlington, Va., boa constrictor.
Gilden, Mrs. J. E., Arlington, Va., common pigeon.
Gilpin, Kenneth B., Bethesda, Md., raccoon.
Ginsburg, Jerome, milk snake, garter snake, smooth-scaled green snake.
Glazier, Dr. Manuel, Newton, Mass., 2 chameleons.
Glenn, Mr. and Mrs. Robert A., squirrel monkey.
Godfrey, H. R., Hyattsville, Md., spotted catfish, 40 flag-tailed guppies, four-horned snail, 12 Siamese fighting fish, 1 short-tailed shrew, 2 catfish.

Goodnough, Mrs. C. W., Arlington, Va., robin.
Gordon, Keith W., Pekin duck.
Gottlieb, Mrs. Joanne, blue jay.
Greco, Mrs. Joseph, Hyattsville, Md., 2 Pekin ducks.
Grieve, Wesley I., Vienna, Va., 4 bantam fowl.
Griggs, John A., 8 painted turtles, spotted turtle, 2 musk turtles, queen snake.
Grillo, Mrs. Berta J., 2 Pekin ducks.
Groshon, E. N., Hyattsville, Md., Pekin duck.
Grusd, Dulcy, domestic rabbit.
Haennie, Carol Anne, Bethesda, Md., box turtle, Pekin duck.
Hall, Dr. E. Raymond, and Grossenheider, Richard P., Lawrence, Kans., 2 Point Barrow lemmings.
Hall, M. W., barred owl.
Hall, Tommie C., Arlington, Va., 2 barred owls.
Hall, W. L., Pekin duck.
Hanagon, John G., golden eagle.
Handy, Benjamin H., III, Arlington, Va., horned lizard.
Hansen, Mrs. Ira H., Arlington, Va., robin.
Hansion, John, flicker.
Hanson, Charles L., Alexandria, Va., *Central American boa.
Harig, J. M., Arlington Va., rhesus monkey.
Harry, Charles William, Arlington, Va., *broad-winged hawk.
Hassett, B. C., Arlington, Va., 2 Pekin ducks.
Hay, Michael, Pekin duck.
Haynes, Mrs. Evan A., Pekin duck.
Henderson, Mrs. Agnes, box turtle.
Hendricks, Frankie, guinea pig.
Herbert, Robert, red fox.
Hewitt, Paul, Falls Church, Va., pilot black snake.
Hogan, Bart, Bethesda, Md., Eastern skunk.
Hogan, Mrs. Viola, Bethesda, Md., grass parakeet.
Hohensee, B. G., Great Mills, Md., barred owl.
Hoke, John, *2 common iguanas, *2 Central American boas.
Horton, Ruth, red-lined turtle.
Hough, Royce, 3 Cumberland turtles.
Houston, Robert H., 2 Pekin ducks.
Howard University, *9 pigeons.
Hubert, Mabel, eastern skunk.
Huff, Herbert, spotted salamander.
Hughes, David, 2 horned lizards.
Hutchins, Mrs. Dorothy, Alexandria, Va., 3 Pekin ducks.
Hutchins, Trafton and Paula, Pekin duck.
Hutchinson, Jim, Arlington, Va., American crow.
Iraneta, Mrs. Pedro, Silver Spring, Md., cottontail rabbit.
Irons, Donald W., Lewisdale, Md., 3 Pekin ducks.
Irwin, Mrs. Helen B., sulphur-crested cockatoo.
Jacobs, Mrs. L. P., Arlington, Va., 2 Pekin ducks.
Jani, Gary, horned lizard.
Jenkins, Herschel, Mosley, Va., 5 copperheads.
Johns, Mrs. Jerrold, Bethesda, Md., blue racer snake.
Johnson, Eugene R., domestic rabbit.
Johnstone, Delight and Kathy, white rabbit.
Jones, Mrs. A., 2 ring-necked doves.
Jones, Robert M., 2 Pekin ducks.
Kahn, Hermine, Arlington, Va., Pekin duck.
Kane, Gerard J., Kensington, Md., Pekin duck.
Karchner, Donald, green guenon.
Karn, Norman, Arlington, Va., 2 hog-nosed snakes.
Kefauver, David, blue jay.
Keller, Gary, Silver Spring, Md., Pekin duck.
Kelley, Mike, Silver Spring, Md., 2 Pekin ducks.
Kenn, Gary, water snake.
Kerkom, Mrs. William B., mourning dove.
Ketchum, Harry W., Silver Spring, Md., domestic rabbit.
Key, Mr., Bethesda, Md., copperhead.
Kiger, Carol M., Westhaven, Md., 2 Pekin ducks.
Kilsheimer, Linda, 3 Pekin ducks.
King, Francis, domestic rabbit.
Klaben, Mrs. R., spectacled caiman.
Klein, Barbara Ann, black rabbit.
Klinger, R. L. raccoon.
Knapp, Earl L., 2 domestic rabbits.
Kneessi, John, South American caiman.
Knott, John E., Arlington, Va., DeKay's snake.
Koff, Mrs. M. Polle, Silver Spring, Md., domestic rabbit.
Krumke, Karl E., III, spectacled caiman.
Kuntz, Dr. Robert E. and Malakatis, George, Cairo, Egypt, 25 worm snakes, 3 sand boas, horned viper.
Lacey, Dale, red-bellied turtle.
Lamb, Mrs. Geo. P., 2 Pekin ducks.
Langer, W. C., Silver Spring, Md., Pekin duck.
Large, Mrs. E. E., yellow-naped parrot.
Lawrence, Jane, *eastern mockingbird.
Lawrence, Mrs. Jane, robin.
Lawrence, Lt. Rex D., 2 spectacled caimans.
Lee, Jackson D., Arlington, Va., rabbit.
Leek, Jackie, Pekin duck.
Lehman, J. W., Los Angeles, Calif., *mole snake.
Leva, Leo Marx, blue jay.
Levin, Jerry, Pekin duck.

Liebert, Mrs. John, Bethesda, Md., 2 rabbits.
Linkins, Bernard R., Silver Spring, Md., blue jay.
Litoff, Louis, horned lizard.
LoCastro, Frank J., alligator.
Locke, Frederick W., robin.
Lockhart, Lt. Col. Eugene E., Carlisle, Pa., 13-lined ground squirrel.
Loftis, James Robert, Pekin duck.
Long, Clifford E., Alexandria, Va., 3 Java finches.
Long, Mr. and Mrs. M. G., McLean, Va., Chinese golden pheasant.
LoPresti, Sammy Joe and Vinny, and Wilson, Harry and Kendall, red-bellied turtle.
Lose, Mrs. W. C., Chevy Chase, Md., 4 domestic rabbits.
Lucas, Ethel M., domestic rabbit.
Lund, E. A., Ishpeming, Mich., raven.
Lyle, Evelyn, Herndon, Va., opossum.
Lynn, David, 2 Pekin ducks.
MacMillan of MacMillan, Sir Gordon H. A., Governor and Commander in Chief, Gibraltar, 2 Barbary apes.
Madden, Judge J. Warren, pilot black snake.
Mainhart, Howard, Bethesda, Md., domestic rabbit.
Malakoff, Leon, 2 Pekin ducks.
Manning, Kenneth M., *Pekin duck.
Marsh, Francis, alligator.
Marshall, John G., anolis lizard.
Marth, Leonard E., Silver Spring, Md., 2 Pekin ducks.
Martin, Mrs. R. B., Newport News, Va., 2 woodchucks.
Mask, Dudley L., Hyattsville, Md., domestic rabbit.
Master, Sieber F., Arlington, Va., Cumberland turtle.
Masters, Carl, Beltsville, Md., water snake.
Matter, John M., Arlington, Va., 2 Pekin ducks.
McCorkle, Miss, 2 horned lizards.
McCreight, William, College Park, Md., hog-nosed snake.
McFarland, Mrs. Nina, robin.
McGreevy, Leo, 5 domestic rabbits.
McKay, Mrs. Fred J., Arlington, Va., American crocodile.
McKeldin, Lt. Col. James R., opossum.
McKenny, Mrs. W. E., Silver Spring, Md., 3 Pekin ducks.
Meggers, John C., eastern skunk.
Menendez, Paul M., white-armed marmoset.
Messenga, Missy, domestic rabbit.
Meyer, Hanny, weasel.
Meyer, Robert J., Silver Spring, Md., opossum.
Miller, Mrs. Beatrice, hamster.
Miller, C. R., Bethesda, Md., Pekin duck.
Miller, Roger, Silver Spring, Md., spectacled caiman.
Miller, W. T., Ancon, Canal Zone, yellow atelopus frog, small tree frog.
Mills, Mrs. W. M., Silver Spring, Md., domestic rabbit.
Monagan, Kathy, gray squirrel.
Montgomery, C. R., Sarasota, Fla., *2 Indian rock pythons.
Moore, Mrs. B. E., Pekin duck.
Moore, Mrs. Bessie, 2 mockingbirds.
Morris, Roland, ferret.
Morrison, Mrs. James, 4 white rabbits.
Muir, R. D., 2 Pekin ducks.
Munday, Charles H., Sterling, Va., 3 gray foxes.
Murphy, Carl D., Norbeck, Md., 2 garter snakes.
Naber, R. H., 2 gopher tortoises.
National Capital Parks, Superintendent, copperhead.
National Institutes of Health, Bethesda, Md., *chimpanzee.
Newton, J. O., Jr., 2 rabbits.
Noble, Patricia, and Candee, Joan, wild rabbit.
Novack, Mrs. W., Takoma Park, Md., 2 canaries.
O'Brien, P. G., Silver Spring, Md., Pekin duck.
O'Connor, Adele R., 19 canaries, 2 spice finches.
O'Hare, Patty, Bethesda, Md., grass parakeet.
Orrison, Mrs. A. B., rabbit.
Oxenberg, Jerome, 2 domestic rabbits.
Pantill, Mrs., Takoma Park, Md., eastern skunk.
Paranich, Mrs. J. A., Hyattsville, Md., Pekin duck.
Paulin, W. B., Arlington, Va., Pekin duck.
Payne, L. E., Falls Church, Va., raccoon.
Pearson, Billy, Silver Spring, Md., white rabbit.
Pemberton, Mrs. F. D., Alexandria, Va., Pekin duck.
Philadelphia Zoological Gardens, Philadelphia, Pa., 2 Arctic foxes.
Pietsch, Dr. Donald J., Ping Yong, Tiawan, kitsume or civet.
Porter, Mrs. Martha, domestic fowl.
Potter, W. Taylor, Silver Spring, Md., screech owl.
Powers, Patricia, alligator.
Pratt, Richard A., Arlington, Va., Pekin duck.
Presley, T. W., Arlington, Va., hamster.
Pryce, Wendy, Arlington, Va., Pekin duck.
Pumphrey, D., Bladensburg, Md., *2 black racers.
Ragan, Rodney, Silver Spring, Md., Pekin duck.
Rauh, Carl, 4 American anolis.
Raver, Dean, Bethesda, Md., Pekin duck.
Ray, H. A., Arlington, Va., skunk.

Reinoehl, Mrs. Elmer S., domestic pigeon.
Reiser, C. L., Cottage City, Md., horned lizard.
Reutiman, E. R., Arlington, Va., rabbit.
Revelee, Robert and William, Canadian goose.
Rhue, Bond, domestic pigeon.
Robbins, Larry, Silver Spring, Md., 2 water snakes.
Robinson, Mrs. Mark T., 2 Java sparrows, grass parakeet.
Roebuck, Marion C., Falls Church, Va., 3 Pekin ducks.
Rogers, Mrs. Charles, Silver Spring, Md., Pekin duck.
Rohwer, Dru, Arlington, Va., fish hawk.
Ronnie, J. C., Silver Spring, Md., screech owl.
Rothbard, Charles, Pekin duck.
Rothrock, W. L., diamond-backed turtle.
Round Table Kennels, Middletown, Del., 12 blue peafowl.
Royer, Jon, Bethesda, Md., *copperhead, 3 ferrets, 2 ring-necked doves.
Russel, Robert, *Nias wattled mynah.
Russel, W. F., Hyattsville, Md., white-nosed guenon.
Russell, Warren H., Arlington, Va., domestic pigeon.
Ryan, James T., Jr., 2 rabbits.
Ryan, John E., Arlington, Va., *squirrel monkey.
Salb, Bernard F., white-armed marmoset.
Sams, Mrs. Clifton, domestic rabbit.
Sapp, Chris and Vincent, Bethesda, Md., opossum.
Sargent, Virginia W., Garrett Park, Md., domestic pigeon.
Satterfield, Mrs. W. J., Silver Spring, Md., yellow-bellied turtle.
Sayre, Rev. Francis B., cacomistle.
Schenck, Dorothy, Willimantic, Conn., ball python.
Scher, Mrs. Irene, 2 Pekin ducks.
Scherer, Charles, 8 hamsters.
Scherer, James, Java finch, Chinese goose.
Schmid, Paul, Bethesda, Md., *corn snake, *rat snake, *pilot black snake, *black racer, *2 garter snakes.
Schriner, Frank, box turtle.
Schrum, Ted, Mount Rainier, Md., 2 Pekin ducks.
Schuld, J. G., 2 Pekin ducks.
Schwartz, Greta, spectacled caiman.
Searls, Loyes, *2 white mice.
Selby, William E., coatimundi.
Self, Edward C., Glenwood, Ga., spectacled caiman.
Sheas, James H., domestic pigeon.
Shelldrake, T. W., 5 opossums.
Shipley, Carl, western porcupine.
Shirey, William N., Frederick, Md., copperhead.
Shoemaker, Mrs. Charles G., Bethesda, Md., 2 domestic rabbits.
Siemel, Sasha, Green Lane, Pa., *2 jaguars, *2 anacondas.
Sills, Mrs. R., grass parakeet.
Simpson, Mrs. Berry, Alexandria, Va., 2 Pekin ducks.
Sipes, Richard, Alexandria, Va., keeled green snake.
Skelly, Mrs. Ed, Augusta, Ga., fox squirrel, pilot black snake, gopher tortoise.
Skinner, Hon. Carlton, Governor of Guam, 3 East Indies monitor lizards.
Smith, C. W., 2 domestic rabbits.
Smith, Mrs. Paula, Falls Church, Va., robin.
Smith, Ronald E., water snake.
Souder, Virgil B., Deerwood, Md., 5 copperheads.
Spears, Mrs. Loma, Takoma Park, Md., 10 Pekin ducks.
Spirlet, Gilbert, Takoma Park, Md., sparrow hawk.
Staight, David, Alexandria, Va., garter snake.
Starkey, R. B., Bethesda, Md., alligator.
Steadman, C. R., brown capuchin.
Storitz, Ned, Silver Spring, Md., cottontail rabbit.
Stroop, M. A., New Market, Va., 9 American alligators, *sulphur-breasted toucan, *2 red, blue, and yellow macaws, *17 alligators, *4 boa constrictors, *anaconda, *10 pilot black snakes, *10 water moccasins, *timber rattlesnake, *2 eastern diamond-backed rattlesnakes, *copperhead, *yellow bull snake, *indigo snake, *2 yellow chicken snakes, *milk snake, *3 water snakes, *pine snake, *king snake.
Stroup, R. W., College Park, Md., Pekin duck.
Stubbs, Lee, Bethesda, Md., 2 Pekin ducks.
Tackett, J. Anderson, green tree frog.
Tansley, Doris, Takoma Park, Md., spectacled caiman.
Taylor, Mrs. M. C., Falls Church, Va., alligator.
Taylor, Robert, 2 Pekin ducks.
Teagle, Roy, *10 bull frogs.
Thomas, Mrs., Riverdale, Md., 2 Pekin ducks.
Thomas, R. B., Jr., Sandy Spring, Md., 2 sparrow hawks.
Thomas, Mrs. William R., Silver Spring, Md., domestic rabbit.
Thompson, Loren L., Arlington, Va., 2 copperheads, box turtle.
Thornton, Abigail, Pekin duck.

Tracewell, Mrs. C. E., Chevy Chase, Md., robin.
Trimble, James L., Pekin duck.
Triplet, William S., Arlington, Va., 2 Muscovy ducks.
Troobnick, Doris, Burke, Va., pilot black snake.
Trott, Fred P., Pekin duck.
Twiford, Mrs. Nan B., 4 grass parakeets, 8 canaries.
Tyler, E. D., Jr., Alexandria, Va., 2 barred owls.
United States Fish and Wildlife Service: From Blackwater National Wildlife Refuge, Cambridge, Md., 1 red-headed duck, 2 ring-necked ducks, bald-pate duck, 2 pintail ducks, 2 blue-winged teal, green-winged teal, 2 black ducks, 2 blue geese. From Bluepoint, Long Island, N. Y., cardinal, 2 indigo buntings. From Newburyport, Mass., golden-eyed duck. From Orlando, Fla., bald eagle. From Washington, D. C., through Robert O. Halstead, 2 whistling swans. Through Mr. Seth Low, osprey.
Uransky, Mrs. Gayna, Arlington, Va., spectacled caiman.
Valore, Mrs. Patricia T., white rabbit.
Vanchura, Samuel M., sparrow hawk.
Van Eckhardt, Mrs. Greve W., woodcock.
Vasquez, Alberto, Arlington, Va., *gopher snake, *California garter snake, *10 western swifts, *ground lizard, *3 alligator lizards, *3 pond turtles.
Vieth, Janie, domestic goose.
Voigt, Fred and Sally, Arlington, Va., 2 Pekin ducks.
Votey, Charles H., tree boa, *2 red, blue, and yellow macaws.
Wade, J. L., Bethesda, Md., domestic rabbit.
Waldrop, Robert, Bethesda, Md., *king snake.
Waldrop, Robert S., Jr., Bethesda Md., *black snake.
Walker, H. P., Silver Spring, Md., 2 white rabbits.
Walker, Lewis Wayne, Pacific Beach, Calif., 2 Tortuga rattlesnakes.
Walkup, Joe, Landover, Md., tarantula, brown scorpion, spiny-tailed iguana.
Ward, Lt. Charles R., Hyattsville, Md., lesser scaup duck.
Warner, Mrs. Sturgis, 3 Pekin ducks.
Wasuta, F. R., Alexander, Va., Pekin duck.
Watson, J. Harold, spectacled caiman.
Weaver, L. E., red fox.
Weckerly, Ida, hamster.
West, David W., Chevy Chase, Md., domestic rabbit.
White, E. J., Arlington, Va., 2 Pekin ducks.
White, Richard O., Jr., Hyattsville, Md., brown king snake.
Wiengen, Albin, Alexandria, Va., *skunk.
Wilkerson, David R., rabbit.
Wilkins, Mrs. John H., 3 grass parakeets.
Willard, Mr., rabbit.
Willey, Don, Arlington, Va., horned lizard.
Williamson, Robert E., *blue jay.
Willingham, Maurice, Alexandria, Va., 3 horned lizards.
Wilson, Mrs. E. R., Hyattsville, Md., Pekin duck.
Wilson, Susan, Arlington, Va., Pekin duck.
Wilt, J. Bernard, 4 ribbon snakes, garter snake, indigo snake, 2 Florida water snakes, Florida king snake, 3 racers.
Withrow, Robert, skunk.
Witt, Bill, Arlington, Va., black widow spider, DeKay's snake.
Wood, Col. Frank, Arlington, Va., 2 Pekin ducks.
Wood, Glenn N., Mount Rainier, Md., horseshoe crab.
Wrenn, Raymond, Wheaton, Md., tiger salamander.
Xanten, Bill, 2 rabbits.
Yatsevitch, Mrs. Gael, Chevy Chase, Md., garter snake.
Yingling, Mrs. Milton L., Silver Spring, Md., 3 wild rabbits.
Yokum, Otis, Pekin duck.
Young, Teddy and Stephen, 2 Pekin ducks.
Young, Tina, Takoma Park, Md., domestic rabbit.
Zumstein, Mrs. Jessie S., crow.

PURCHASES

Among a number of interesting specimens obtained by purchase were:

Two Allen's monkeys (*Allenopithecus nigroviridis*), which were the prize acquisition of the year, as they are among the half dozen exceedingly rare primates of the world. They are not conspicuous animals,

but are active and entertaining, and give scientists and others their first glimpse of this extremely rare form.

A flat-tailed otter (*Pteronura brasiliensis*), the first of its kind to be exhibited in the Zoo. It was a young of the large river otter of Brazil that is fairly well known in its native habitat but so far as is known has not previously been exhibited in the United States.

Two wombats had been ordered as a pair, but on arrival one was found to be the rare hairy-nosed wombat (*Lasiorhinus latifrons*), an even more desirable specimen than the common wombat (*Vombatus hirsutus*) that accompanied it. This is the first hairy-nosed wombat exhibited in this Zoo.

Two lesser pandas (*Ailurus fulgens*), the first in the collection for many years, were received in June. These relatives of the raccoons are uncommon in collections largely because of the difficulty of getting them to eat the food that can be provided. One of these has apparently adapted itself to conditions in the Zoo and appears to be thriving on its favorite food, bamboo leaves and shoots, plus pablum and eggs.

Four young gibbons (*Hylobates*) constituted one of the most entertaining exhibits in the park. All are still in their immature buff-colored coat but are gradually acquiring the markings characteristic of the adults so that definite identification can later be made.

A fine pair of cheetahs (*Acinonyx jubatus*) were received. These large, graceful, long-legged, spotted cats are the swiftest of all four-legged animals and are frequently tamed and trained for hunting. Their feet are unique among those of cats in that they resemble the feet of dogs in not having retractile claws.

A choice pair of young tayras (*Tayra barbara*) are so active in their cage that they have greatly interested the public. These giant weasel-like creatures of South America are dark brown with gray heads and have a striking cream-colored marking on the throat.

A pair of giant Indian squirrels (*Ratufa indica*) also provide excellent entertainment by playing in their big wheel and displaying their brilliant coloration of rich reddish brown and buff.

Three young South American tapirs (*Tapirus terrestris*) were purchased. The appearance of young tapirs in contrast to the adults is particularly interesting. The young are longitudinally striped with rows of whitish spots on a dull brownish-gray background, whereas the adults are almost black.

A young female black rhinoceros (*Diceros bicornis*) was bought as a possible mate for the male which has been in the Zoo 1½ years.

A beautiful specimen of Wilson's bird-of-paradise (*Schlegelia*

wilsoni) was secured through the kindly interest of W. J. C. Frost, of the Zoological Society of London.

Two shipments of African sunbirds collected by John Seago were received. These little feathered jewels, representing three species, were the first ever exhibited in this Zoo.

Three specimens of the showy Cuban trogon (*Prinotelus temnurus*) were obtained.

A golden eagle (*Aquila chrysaetos*), which had been captured in the Tennessee region, was turned over to the Zoo by the United States Fish and Wildlife Service. Golden eagles are rather rare in the southeastern United States and so this specimen is of more than ordinary interest.

Of particular interest in a shipment received from Australia were:

Two examples of the very rare Australian frilled lizard (*Chlamydosaurus kingii*). These are the first ever exhibited in this Zoo. They are large lizards and unique in having around the neck a fold of skin that can be extended to project outward from the neck like a ruff when the animal is excited. The red coloration in the ruff makes a striking display.

Six bearded lizards (*Amphibolurus barbatus*), so-called because of their peculiar habit of distending the loose skin of the throat to form what appears to be a beard.

Three beautiful specimens of the poisonous banded krait (*Bungarus fasciatus*), relatives of the cobras, were received.

A specimen of the false cobra (*Phrynonax sulphureus*), not previously exhibited in this Zoo, was purchased.

With the growth of the Washington metropolitan region there has been a constant increase in the number of local wild creatures found helpless and rescued by kind people, and turned over to the Zoo. Some of those that seem to have a fair chance of survival are liberated, and some are exchanged for material that is needed for the Zoo. During the past year there was a total of 191 such accessions. Also, ducks and rabbits given to children at Easter time that have outgrown their homes are turned over to the Zoo. This gives unduly large accession and removal lists, but to receive, care for, and place such creatures appears to be a proper function of the Zoo.

BIRTHS AND HATCHINGS

Conditions under which animals are kept on exhibition are usually not favorable for breeding or raising young. However, occasionally young are born or hatched that are of outstanding interest to the public, and are valuable as additions to the group, or for exchange.

The following were produced in the Zoo during the fiscal year:

A baby female giraffe (*Giraffa camelopardalis*), the fifth born here, was a choice addition to the herd.

A pygmy hippo (*Choeropsis liberiensis*), the thirteenth for this Zoo.

A gaur calf (*Bibos gaurus*), the tenth of this species born in the Park.

A vulpine phalanger (*Trichosurus vulpecula*) was born to one of the females in the group that were obtained from Sir Edward Hallstrom in November 1951.

The pair of Kinabalu tree shrews (*Tupai montana baluensis*) that were deposited with us by Lt. Col. Robert Traub, gave birth to young three times during the year. Unfortunately the mother killed the young within a few hours or a few days. However, by these births the gestation period has been determined as not more than 21 days. Colonel Traub is much interested in the ability of these animals to produce young in captivity, as it indicates that the food mixture that was developed by the Assistant Director of the Zoo and which was described in the Annual Report of the Zoo for 1950 is satisfactory for tree shrews as well as other shrews and bats. Colonel Traub, who has been engaged in work concerning certain human diseases, thinks it possible that tree shrews, which are believed by some zoologists to be a primitive primate type, might be suitable animals for laboratory studies of the diseases of man. Therefore, the successful keeping and rearing of tree shrews in captivity might be of considerable importance.

The little herd of Chinese water deer (*Hydropotes inermis*) was increased by the birth of three sets of twins. These small deer are of particular interest because of their habit of living in swampy areas in their native haunts and because of the fact that the males lack horns but have considerably enlarged canine teeth.

Another slender-tailed cloud rat (*Phloeomys cumingi*) has been born to augment the family group of this very rare Philippine high-altitude relative of the rat. This species has more the appearance of an opossum than of a rat.

Another young was born to the group of pacas (*Cuniculus paca*). These are large, conspicuously marked rodents that are always a satisfactory exhibit.

Twice during the year a pair of African porcupines (*Hystrix galeata*) produced a single young. It was interesting to witness the remarkable maneuvers of the parents and the older young one to protect the newborn.

A pair of crested screamers (*Chauna torquata*) hatched and raised one young.

Following is a complete list of the births and hatchings:

MAMMALS

Scientific name	*Common name*	*Number*
Alopex lagopus	Arctic fox	4
Ammotragus lervia	Aoudad	9
Ateles vellerosus	Mexican spider monkey	1
Bibos gaurus	Gaur	1
Bos taurus	British Park cattle	1
	West Highland cattle	1
Cercopithecus aethiops sabaeus × *C. a. pygerythrus*	Green guenon × vervet guenon	1
Cervus canadensis	Elk	1
Cervus nippon	Japanese deer	3
Choeropsis liberiensis	Pygmy hippopotamus	1
Choloepus didactylus	Two-toed sloth	1
Cuniculus paca	Paca	2
Dama dama	Brown fallow deer	4
	White fallow deer	4
Equus burchellii	Grant's zebra	1
Erethizon epixanthum	Western porcupine	1
Felis concolor × *Felis patagonica*	Hybrid puma	2
Felis leo	Lion	3
Felis tigris	Bengal tiger	3
Giraffa camelopardalis	Nubian giraffe	1
Hydropotes inermis	Chinese water deer	6
Hystrix galeata	African porcupine	2
Lama glama	Llama	2
Lama pacos	Alpaca	1
Leontocebus rosalia	Silky marmoset	2
Mephitis mephitis nigra	Eastern skunk	4
Mustela eversmanni	Ferret	5
Myocastor coypus	Coypu	3
Odocoileus virginianus	Virginia deer	4
Papio hamadryas	Hamadryas baboon	1
Phloeomys cumingi	Slender-tailed cloud rat	1
Procyon lotor	Raccoon	6
Taurotragus oryx	Eland	1
Thalarctos maritimus × *Ursus middendorffi*	Hybrid bear	2
Trichosurus vulpecula	Vulpine phalanger	2
Tupai montana baluensis	Kinabalu tree shrew	7
Ursus horribilis	Grizzly bear	1

BIRDS

Anas platyrhynchos	Mallard duck	18
	White mallard duck	9
Branta canadensis	Canada goose	15
Chauna torquata	Crested screamer	1
Larus novaehollandiae	Silver gull	2
Lonchura leucogastroides	Bengali finch	2
Nycticorax nycticorax hoatli	Black-crowned night heron	20
Pavo cristatus	Peafowl	1
Streptopelia tranquebarica	Blue-headed ring dove	2
Taeniopygia castanotis	Zebra finch	47
Zenaida asiatica	White-winged dove	2

REPTILES

Boa enydris	Tree boa	13
Boa imperator	Central American boa	20

MAINTENANCE AND IMPROVEMENTS

Maintenance and repair work at the Zoo suffered considerably during the fiscal year 1953 owing mainly to shortage of funds for the hire of personnel. Being forced to absorb the salary increases, the

Zoo had to reduce greatly the use of temporary labor and also had to leave vacant positions of personnel concerned with maintenance work.

The installation of zone heat regulators in the small-mammal and reptile houses was completed. These provide even and adequate distribution of heat, so necessary to the health and well-being of the animals housed in these buildings.

In addition to the daily work of cleaning cages, buildings, and grounds and making minor repairs, the construction and maintenance department is constantly engaged in making necessary improvements for the proper care of the animals and the safety of visitors to the Park. The following are some of the more important projects undertaken during the year:

In the bird house, glass was installed in the upper half of the fronts of 34 cages to replace wire that had deteriorated. Nine cages outside of the monkey house were extensively repaired and new partitions between the cages installed. A 2,000-gallon water tank was installed in the basement of the reptile house to supplement the 1,000-gallon tank, which has never been adequate. Concrete floors were laid in 6 cages in the antelope building and in the 3 buildings housing the zebras, wild horses, wild ass, and Scotch cattle. The series of cages between the reptile house and the small-mammal house were given an extensive overhauling, and five new cinder-block shelters for the animals were built, replacing the old wooden ones no longer usable. Small concrete shelters were constructed in the American waterfowl pond to replace the decaying wooden ones. The slope of the moat back of the bears was faced with concrete to prevent erosion and the resultant stoppage of the drain.

The fight to eradicate poison ivy in the Zoo grounds is being continued. This plant pest has been almost completely eliminated in those parts most frequented by the public, and control measures are being extended to more remote sections to keep it from returning to areas used by visitors. Otherwise the long-established policy of leaving the woodlands undisturbed is being followed.

Over a period of years there has been a gradual increase in the amount of trimming of trees necessary along the roads, walks, and paths, and in the exhibition area. Because of disease or age, some of the trees are dying and must be cut down. Others must be trimmed to remove dead or broken limbs which might fall and injure people or animals, or damage automobiles or structures.

Temporary policemen were employed this year to assist the regular police during days of heaviest attendance or when the force was short-handed. This has been a highly satisfactory arrangement and much more economical than employing additional full-time policemen when the permanent personnel now authorized is adequate for a large proportion of the time.

As in previous years the Zoo received gifts of various kinds of food that could not be sold for human consumption but was suitable for animals. Some of this material was turned over to the Zoo at the suggestion of District of Columbia food inspectors. This helps considerably to hold purchases to a minimum.

Through the office of United States Marshal W. Bruce Matthews, food that had been condemned by the courts was sent to the Zoo for the animals. This consisted of 1,544 pounds of frozen shrimp, 291 pounds of chickens, 170 pounds of peanut butter, and 570 pounds of pecan halves.

In a few instances such materials as rice, flour, and beans unacceptable for human use have been purchased at low prices from General Services Administration or commercial firms.

The National Institutes of Health, Navy Medical Center, and Army Medical Center gave the Zoo mice, rats, guinea pigs, rabbits, and other animals no longer suitable for their purposes.

The practice has been continued of picking up from grocery stores in the vicinity of the Zoo quantities of discarded green material such as beet tops, celery stalks, and the outer leaves of cabbage, cauliflower, and lettuce. This provides an abundance of greens for the animals and helps reduce purchase of such foods.

COOPERATION

At all times special efforts are made to maintain friendly contacts with other Government 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 specimens, and in turn the Zoo furnishes information and, whenever possible, specimens not needed.

In 1950 Dr. Willard H. Eyestone, veterinary pathologist of the National Cancer Institute, Bethesda, Md., requested permission to examine animals that died at the Zoo in order to obtain information regarding cancer and other diseases affecting human beings. Accordingly arrangements were made to notify Dr. Eyestone of all deaths of animals in the Zoo and give him an opportunity to perform autopsies, if he desired. The following two paragraphs are from a brief report on the results of this work:

> Over 250 autopsies have been performed since 1950. Among them six cancers have been discovered. The most striking pathological change common to any group is found in the thyroid gland of carnivores, in which all gradations from the slightest proliferative growths to spreading cancer have been seen. Most deaths are caused by infectious agents, including bacteria, fungi, and the animal parasites. Some deaths are the result of degenerative diseases of old age.
>
> A summary of the interesting highlights covering the Zoo autopsies was presented before the Washington Society of Pathologists on October 8, 1952. Similar reports are planned for the future, besides the publishing of scientific papers

in research journals concerning the pathologic data obtained from the examination of the Zoo animals.

Special acknowledgment is due to the United States Dispatch Agent in New York City, Howard Fyfe, an officer of the State Department, who has frequently been called upon to clear shipments of animals coming from abroad. This he has done, often at great personal inconvenience, and the animals have been forwarded to Washington without the loss of a single specimen.

NEEDS OF THE ZOO

Replacement of antiquated structures that have long since ceased to be suitable for the purposes for which they are used is still the principal need of the Zoo. The more urgently needed are:

A building, to be situated in a central location, to have toilet facilities, a first-aid room, police headquarters, and, incidentally, with basement space for a gardener's headquarters and storage for the gardener's supplies and small equipment. The few old, dilapidated toilet facilities in the Park have not been adequate for many years and are now in such a deplorable state from normal deterioration and as a result of vandalism that it is difficult and unduly expensive to keep them in a sanitary condition.

A new administration building to replace the 148-year-old historic landmark now in use as an office building but which is neither suitably located nor well adapted for the purpose.

A building to house antelopes and other medium-sized hoofed animals that require a heated building.

A fireproof service building for receiving shipments of animals, quarantining them, and caring for those in ill health or those that cannot be placed on exhibition.

A new ventilating system for the bird house.

Lesser items of equipment that are needed are a vacuum pump for more efficient and economical operation of the heating system in the reptile house; a band saw to replace one that is more than 40 years old; and an air compressor for general use about the Park.

The enclosures and pools for beavers, otters, seals, and nutrias, in the ravine, need to be reconstructed. Owing to lack of funds for upkeep and consequent deterioration, this area has become unsightly and inadequate for the proper care and exhibition of these animals.

Experience with the young Indian elephants makes it appear probable that it will be necessary to construct an elephant-proof fence around the outdoor yard now occupied by these elephants.

The job of cleaning up the grounds is a major undertaking. Using all available manpower, it usually takes 5 to 10 days to pick up the trash and restore the Park to a fair degree of presentability after

Easter Sunday and Monday. Because of the shortage of help, clean-up work has of necessity been reduced to a minimum, with the result that the Zoo has been criticized by correspondents and the press for the condition of the grounds. Two permanent additional laborers are needed for proper maintenance, removal of broken or fallen tree limbs and other safety hazards, and repair of walks, guard rails, and other structures, for the protection of the public.

In addition, temporary manpower is needed to supplement the regular personnel at certain times of the year. These periods are during the summer, when vegetation is growing vigorously and must be kept under control, and when the greatest number of visitors are coming to the Park with a corresponding increase in trash left on the grounds; and in the fall and early winter, when leaf removal is necessary to keep the fire hazard at a minimum and prevent leaves from clogging drains. Also, additional help is needed during the summer, when certain construction and repair work can be carried on more advantageously than at other times.

By employing men temporarily when actually needed to handle the peak workloads, work can be performed satisfactorily at considerably less cost than by increasing the permanent personnel. For several years this was done but the practice had to be abandoned during the past year as available funds had to be used to absorb the salary increases authorized by Congress, to pay for accumulated annual leave of retiring employees, and contribute to Federal social security for indefinite employees. For employment of temporary help an additional appropriation of $9,000 is needed, to be allotted as follows:

Mechanical department	$5,000
Grounds department	3,000
Police department	1,000

Also, $1,000 is needed for the Zoo's contribution to the cost of social security for employees not under civil service.

There is need for a veterinarian to assist the animal department in selecting suitable foods, presenting foods to the animals in a satisfactory manner, practicing preventive medicine, and performing autopsies to determine causes of death.

The steadily increasing popularity of the Zoo, as a source of both entertainment and education, has developed such a volume of requests for information that there is now need for an additional scientist to share the load of answering queries and to assist in other administrative work so that the Director and Assistant Director can devote more time to general supervision of the Zoo.

To comply with the requirements of keeping property and inventory records, in accordance with the program laid down by the General Services Administration, by authority of Federal Property and Ad-

ministrative Services Act of 1949 (Public Law 152, 81st Congress, approved June 30, 1949) General Regulation 100 of the General Accounting Office, and Budget-Treasury Regulation No. 1, there is need for three additional clerks.

VISITORS

The estimated number of visitors to the Zoo was 3,231,450, which was 63,119 less than for the year 1952, a decrease due mainly to several rainy or threatening weekends in the spring.

Estimated number of visitors for fiscal year 1953

July (1952)	389,000	February	101,500
August	413,800	March	211,600
September	346,000	April	353,000
October	246,700	May	467,000
November	186,600	June	377,300
December	65,800		
January (1953)	73,150	Total	3,231,450

Groups came to the Zoo from schools in Mexico, South America, Japan, and 30 States, some as far away as Maine, Florida, Kansas, and Wisconsin. There was an increase of 36 groups and 3,681 individuals in groups over last year.

Number of groups from schools

Locality	Number of groups	Number in groups	Locality	Number of groups	Number in groups
Alabama	22	768	Mississippi	2	158
Connecticut	12	619	Missouri	2	56
Delaware	17	769	New Hampshire	3	120
District of Columbia	114	5,837	New Jersey	17	1,210
Florida	7	1,222	New York	72	5,811
Georgia	61	7,679	North Carolina	213	9,261
Illinois	2	634	Ohio	53	2,485
Indiana	13	729	Pennsylvania	261	14,159
Iowa	1	16	South America	1	40
Japan	1	29	South Carolina	53	1,876
Kansas	1	32	Tennessee	62	2,864
Kentucky	19	671	Texas	1	19
Maine	13	658	Virginia	516	27,738
Maryland	611	36,701	West Virginia	45	3,902
Massachusetts	19	749	Wisconsin	2	111
Mexico	1	28			
Michigan	7	470	Total	2,227	127,553
Minnesota	3	132			

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 came. 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 of the District of Columbia, Maryland, and Virginia cars come to the Zoo to bring

guests from other States. The tabulation for the fiscal year 1953 is as follows:

	Percent		Percent
Maryland	27	Ohio	1.8
Virginia	22.5	New Jersey	1.6
Washington, D. C.	20.8	West Virginia	1.4
Pennsylvania	4.3	Massachusetts	1.1
New York	3	Florida	1.1
North Carolina	2.2	California	1.1

The cars that make up the remaining 12.1 percent came from every one of the remaining States, as well as from Alaska, Canada, Canal Zone, Cuba, England, Germany, Guam, Hawaii, Honduras, Japan, Mexico, the Philippines, Puerto Rico, and the Virgin Islands.

On the days of small attendance there are cars parked in the Zoo from at least 15 States, Territories, the District, and foreign countries. On average days there are cars from about 22 States, Territories, the District, and foreign countries; and during the periods of greatest attendance the cars represent not less than 34 different States, Territories, and countries.

STATUS OF THE COLLECTION

Class	Species or subspecies	Individuals	Class	Species or subspecies	Individuals
Mammals	210	699	Arachnids	2	3
Birds	307	1,111	Insects	1	100
Reptiles	129	518	Mollusks	1	2
Amphibians	23	87			
Fish	21	221	Total	694	2,741

SUMMARY

Animals on hand July 1, 1952	2,675
Accessions during the year	1,797
Total number of animals in collection during the year	4,472
Removals for various reasons such as death, exchanges, return of animals on deposit, etc	1,731
In collection on June 30, 1953	2,741

Respectfully submitted.

W. M. MANN, *Director.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

APPENDIX 8

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, 1953.

The Astrophysical Observatory comprises two divisions: the original division of astrophysical research devoted to solar radiation problems, and the division of radiation and organisms established in 1929 to study the effects of radiation on organisms. Funds available for the Observatory included an allotment of $119,841.10 from "Salaries and expenses, Smithsonian Institution, 1953," and $2,500 from private funds of the Institution. At the end of the fiscal year all equipment and buildings were in satisfactory condition.

DIVISION OF ASTROPHYSICAL RESEARCH

Two high-altitude observing stations, on Montezuma, Chile, and Table Mountain, Calif., have continued in operation. The goal of the two stations is to obtain complete solar-constant observations by the long or short method, or both, on each day presenting a sky sufficiently clear and uniform for satisfactory results.

The principal and most time-consuming event of the year was the preparation of volume 7 of the Annals of the Astrophysical Observatory. The completed manuscript, covering the work of the division of astrophysical research during the years 1939 through 1952, was submitted to the editor on April 29, 1953. The following are the main subjects included:

1. Studies of the characteristics of the silver-disk pyrheliometer.
2. Recent tests of the Smithsonian standard water-flow pyrheliometer.
3. Ultraviolet and infrared corrections to the solar constant.
4. The scale of the solar-constant record.
5. Instrumental developments.
6. Summaries of total sun and sky radiation, and the relative energy in ultraviolet, visible, and infrared regions, as measured at Camp Lee, Va., Miami, Fla., and Montezuma, Chile.
7. Description of the method of Dr. Oliver R. Wulf, of the United States Weather Bureau, for determining the amount of ozone above Table Mountain, Calif., from regular solar-constant bolographs.

8. Summary of 13 years of solar-constant determinations. This, added to 17 years published in volume 6 of the Annals, forms as nearly as possible a homogeneous record covering 30 years, based upon the scale of the original Mount Wilson work.

Work in Washington.—William H. Hoover, chief of the division, in April 1953 completed a study of the silver-disk pyrheliometer under carefully controlled conditions of temperature, timing, shutter operation, and source of energy. This important work, together with a report of new calibrations against the standard water-flow pyrheliometer which Mr. Hoover and Mr. Froiland made in September 1952 on Table Mountain, is described in a paper to be published in the Smithsonian Miscellaneous Collections.

Preliminary to certain laboratory tests of new equipment, the observatory siderostat was completely overhauled by Mr. Talbert and Mr. Harrison. This excellent instrument, built by Grubb of Dublin over 60 years ago, is now fitted with a synchronous motor instead of clock drive, new bearings have been installed, and the instrument carefully adjusted. A new sliding house of aluminum protects it from the weather. Inside the laboratory a light-tight housing has been built around the spectrometer to reduce stray light.

Last year's report referred to cooperative work with the United States Weather Bureau in an effort to improve the method of calibrating the Eppley pyrheliometers in use by the Bureau. This cooperation has continued and the results will shortly be published under the auspices of the Weather Bureau.

The Smithsonian standard scale of radiation, established in 1913 and widely adopted, has been further disseminated during the year by the sale, at cost, of two silver-disk pyrheliometers, built and calibrated at the Institution, as follows:

S. I. 91 to the Observatory, India Meteorological Department, New Delhi, India.

S. I. 92 to the University of Wisconsin, Madison, Wis.

All the galley proof of the Ninth Revised Edition of the Smithsonian Physical Tables has been received from the printer.

An important paper by Dr. C. G. Abbot, research associate, summarizing all his findings concerning the effect of solar-radiation changes upon weather, was in press at the close of the year.

Andrew Kramer, instrument maker of the Observatory for nearly 61 years, retired on June 30, at the age of 84. His record is unique. Not only was his work outstanding, but his kindliness and cooperative spirit endeared him to many Smithsonian employees.

Work in the field.—At Montezuma, Chile, the series of tape exposures made under contract with the Office of the Quartermaster General was continued during the year. Daily measurements are made of the total sun and sky radiation as received upon a horizontal

surface and as received upon the exposed tapes which are mounted at an angle of 45° facing north. After a predetermined quantity of solar radiation has fallen upon the tapes they are returned to the Philadelphia Quartermaster Depot for a study of the amount of deterioration of the textiles due to humidity and to the amount of radiation received.

Seismographic records have been maintained for some years at Montezuma for the United States Coast and Geodetic Survey. The Survey recently sent to Montezuma a new modern seismometer, with accessories, which is now being installed. It is expected that greatly improved earthquake records will result.

At Table Mountain, Calif., Hoover and Froiland obtained a very complete series of comparisons between the Smithsonian double-tube, water-flow, standard pyrheliometer and substandard silver-disk pyrheliometer S. I. 5. These comparisons confirm the results of three previous determinations made at Mount Wilson in the years 1932, 1934, and 1947. This confirmation of the permanence of the constants of the instruments is very gratifying since the 1952 comparisons are entirely independent, being made at a different station and by different observers.

The filter form of pyranometer, mentioned in last year's report as sent to Table Mountain for testing, proved to have a troublesome drift under field conditions. It was returned to Washington for alterations. At the close of the year a new series of tests was in progress at Table Mountain.

The instrument installed last year by Mr. Hoover to measure the optical quality of the sky continues to serve as an independent means for judging the steadiness of the sky during observations. It has now been altered to register through a Beckman photopen recorder, thus eliminating the process of daily removing and developing a photographic record.

Owing to a temporary shortage of personnel, progress in the ozone studies referred to in last year's report was somewhat delayed. This project is being resumed as rapidly as possible.

DIVISION OF RADIATION AND ORGANISMS

(Report prepared by Dr. R. B. Withrow, chief of the division)

The research of the Division has been concerned chiefly with investigations of the physiological and biochemical processes by which light regulates plant growth and the mechanisms of the action of the auxin-type growth hormones. While most of the sunlight absorbed by plants is used in the production of food materials through the process of photosynthesis, a small part of the light energy is required for the production of chlorophyll and in the initiation of photochemi-

cal reactions which control the development of the various organs of the plant. In the absence of light and in the presence of adequate food reserves, higher plants fail to develop normal leaves and stems, and in the dicotyledonous plants the hook that forms in the stem of the germinating seed never completely disappears.

Dr. W. H. Klein and V. Elstad have continued investigations of the effect of light intensity and various growth regulatory chemicals on the opening of the hypocotyl hook in Black Valentine bean. A new set of subirrigated growth chambers has been constructed which yield plant material of very great uniformity. By the use of a special green fluorescent safe light employing a filter transmitting light between 520 and 610 millimicrons, it is possible to remove the hooks from the plants and make measurements on them without producing any detectable light effect. The hook sections are placed in petri dishes containing a small amount of water and exposed to various light and chemical treatments. A 24-hour exposure to very weak red light in the region of 650 millimicrons at an intensity of 0.01 microwatt per square centimeter produces a 45° opening in a 24-hour period; in the dark there is no significant opening of the hook in this period. The rate of opening of the hook is proportional to the logarithm of the light intensity. It appears that this organ is a very useful tool for the bioassay of photochemically synthesized growth factors.

The auxin group of hormones such as indoleacetic acid opposes the effect of the light. The effect is proportional to the logarithm of the concentration of the auxin over a very wide range and the test appears to have a sensitivity nearly equal to the classical *Avena* test, but is a much simpler one to execute.

Thus far no pigment system has been extracted from plants whose absorption spectrum can account for the regulatory effect of the longer wavelengths in the visible spectrum. In order to obtain information as to the absorption spectrum of the pigment system, work has been started by Dr. Withrow, Dr. Klein, and Mr. Elstad on determining the effectiveness spectrum of the stem-hook response and the synthesis of anthocyanin in bean stems. A system of 10 interference filter monochromator units has been constructed, each of which employs two interference filters in tandem for isolating a narrow band of wavelengths about 20 millimicrons wide. Each monochromator unit has a separate source and cabinet, and the whole system is in a room maintained at constant humidity and temperature.

Dr. W. D. Bonner and L. Price have initiated a systematic biochemical study of various fractions from dark-grown and far-red-irradiated bean seedlings with the objective of finding those biochemical systems that are associated with the light-initiated responses. Estimations of the activities of various enzyme systems have shown no significant differences between the dark- and the light-

treated seedlings. The systems that have been studied are the ascorbic acid and polyphenol oxidases involving the copper proteins; catalase and peroxidase involving the iron proteins; and various components of the cytochrome enzyme systems.

Research by Dr. Alice P. Withrow on the effect of plant growth regulators on salt exchange of plants has indicated that high salt–low carbohydrate plants lose salt more rapidly when treated with ammonium 2,4-dichlorophenoxyacetate and that low salt–high carbohydrate plants absorb salts less rapidly under the influence of this growth regulator as compared with untreated plants.

Studies have been initiated on the effect of plant-growth regulators on the respiratory processes in mitochondrial preparations of bean seedlings and rat livers.

The following research papers by members of the staff have been published during the past year:

Withrow, R. B., Klein, W. H., Price, L., and Elstad, V. Influence of visible and near infrared radiant energy on organ development and pigment synthesis in bean and corn. Plant Physiol., vol. 28, pp. 1–14, 1953.

Withrow, R. B., and Price, L. Filters for the isolation of narrow regions in the visible and near-visible spectrum. Plant Physiol., vol. 28, pp. 105–114, 1953.

Withrow, R. B., and Elstad, V. Water-cooled lamp systems with refluxing aqueous filters. Plant Physiol., vol. 28, pp. 334–338, 1953.

Withrow, R. B., and Withrow, Alice P. A linear recording ac conductance bridge for measuring salt exchange in plants. Physiol. Plantarum, vol. 6, pp. 444–450, 1953.

Respectfully submitted.

L. B. ALDRICH, *Director.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

APPENDIX 9

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, 1953:

GENERAL STATEMENT OF CONDITIONS

The care of the stored material in the national aeronautical collection continues to be the principal concern of the staff. Aircraft and components that are awaiting provision of an adequate building for the National Air Museum comprise more than two-thirds of the total collection, and although there are several renowned aircraft among the 35 exhibited in the Smithsonian buildings in Washington, there are a number that are regarded with near-equal esteem and are of great value in depicting aeronautical progress among the 74 being preserved at Park Ridge, Ill., and those others being retained for the Museum at naval bases and in scattered places.

As stated in last year's report, the Air Museum had been ordered to vacate the storage facility at the Air Force Base at Park Ridge. Therefore, at the beginning of the fiscal year, efforts were made to establish near Washington a storage base for the material to be moved. The urgency of this move was somewhat relaxed as the result of an inspection of the storage area by an official of the Budget Bureau who was so impressed by the efforts of the Museum personnel to preserve its material and at the same time comply with the requirements of the Air Force that he directed that more consideration be given the needs of the Museum. The Air Force finally agreed that the Museum could temporarily remain on the base. However, this does not solve the problem because the space assigned to the Museum—30,000 square feet in Building T-6—is inadequate, and most of the aircraft will still have to remain outdoors. A storage base was started at Suitland, Md., about a mile beyond the District of Columbia line, but lack of funds to complete the project still leaves the Museum with inadequate storage space.

In spite of these difficulties progress has been made at Park Ridge in caring for the stored material there, and the facility at Suitland has been developed sufficiently to take care of 20 loads of material brought in from Park Ridge. Details of these operations are given in later portions of this report.

Although every effort has been made to keep up the other functions of the Museum at the Washington office, the maintenance of exhibits, public services, research, and planning have reluctantly been given less attention owing to reduction in personnel and enforced priority of other projects. Normally the staff includes an administrative head, a curator, and two associate curators. With the retirement last year of the former head of the Museum and the addition of his administrative duties to those of the curator, plus the continued absence on naval duty of one of the two associates, there are now only two persons to do the work previously assigned to four.

Because the Fiftieth Anniversary of Powered Flight is being celebrated during the calendar year 1953, the National Air Museum has experienced a very busy period, with many requests to assist the national anniversary committee, State organizations, industrial units, airlines, aeronautical groups, and others who have joined to mark the progress of a half century of human flight. This concentration of interest in past accomplishments since the marvelous flight by the Wright Brothers in 1903 has brought due recognition to the National Air Museum as the authoritative source of records of the past. The staff has frequently been called upon to furnish data on historic aircraft, biographies of noted airmen and engineers, photographs and descriptions of aeronautical events, drawings of airplanes, and other material. Authors have come to the Museum to consult the staff and to examine the library and reference files; teachers have requested assistance in planning courses; students have sought help in meeting assignments; and compilers of textbooks and pictorials have found much needed data. As opportunity permitted, the staff worked on the Museum's own feature exhibit that is to further honor the Wright Brothers and mark the anniversary. This will be put on display during December 1953 and will emphasize the fact that the Wright Brothers not only invented the aeroplane but also developed it to a practical form and in addition taught others to fly.

As part of its function in distributing aeronautical knowledge, the Museum issued a number of texts on airmen and aircraft for free distribution to correspondents, students, and others, and as the fiscal year closed the ninth edition of the "Handbook of the National Aeronautical Collections" was being prepared.

ADVISORY BOARD

Although there were no formal meetings of the Advisory Board during the fiscal year, the Board members gave generously of their time to advance the projects of the Museum. Informal conferences were held at which the problems of the Museum were discussed, constructive suggestions made, and progressive action planned. Dr.

Leonard Carmichael, present Secretary of the Smithsonian, succeeded former Secretary Alexander Wetmore on the Advisory Board upon the latter's retirement December 31, 1952.

STEPHENSON BEQUEST

The bequest of George H. Stephenson, of Philadelphia, provides for a sculptured figure of Gen. William Mitchell, as a gift to the National Air Museum. Arrangements for procurement of the statue have been in charge of the Director of the Smithsonian's National Collection of Fine Arts and officials of the National Gallery of Art and the Fine Arts Commission. During the year a number of prominent sculptors were considered for this undertaking.

SPECIAL EVENTS AND DISPLAYS

Throughout the year the National Air Museum participated in many special events and exhibits and arranged several special displays:

Three occasions commemorative of the beginning of the airmail service—the forerunner of commercial aviation—are noteworthy. On August 12, 1952, the 34th anniversary of the date the Post Office Department took over operation of the airmail, All American Airways (now Allegheny Airlines) presented to the Air Museum a scale model of the Stinson SR-10 airplane used by that airline for airmail pickup service from 1939 to 1949. This took place at a luncheon given by that airline to several officials of the Post Office Department, the Smithsonian Institution, the Air Museum, and about 50 persons of prominence in aeronautics. Whereas August 12, 1918, was the date when the Post Office began operations with its own pilots and planes and assisting personnel, airmail service on a permanently scheduled basis had been inaugurated on May 15, 1918, by the Signal Corps Aviation Section as a military experiment. The anniversary of that date in 1953 was observed by the Aero Club of Washington. The head curator of the Air Museum, who had been present at the original occasion, pointed out to members of the Club the location from which the first mail planes took off; he also composed the text of a marker, which was turned over to the National Park and Planning Commission, to commemorate that event and mark the location. On May 24, 1953, the Indiana State Society gave a luncheon at the National Airport in honor of Robert Shank, who was one of the original four pilots hired by the Post Office when that Department took over the airmail service from the military. Three weeks earlier Governor George N. Craig of Indiana, Representatives Charles A. Halleck and Charles B. Brownson, and E. C. Gaertner, a member of the Society, had visited the Museum in order to see the airmail exhibit

and better acquaint themselves with the personal story of Robert Shank. They were shown the Museum's Curtiss JN-4 airplane, similar to one in which the early airmail was flown, and models of other types flown by Shank and his fellow mail pilots. Upon request, several of these models were shown at the Society's luncheon, together with a series of photographs, taken in 1918, of airmail events. The head curator of the Air Museum described these models and photographs and spoke from personal recollections of early airmail service.

Another noted pilot, Roscoe Turner, was honored August 14, 1952, when he was presented with the Distinguished Flying Cross. The Air Museum assisted with an exhibit in the Pentagon Building of aircraft models representing types flown by Turner.

At the annual banquet of the Aero Club of Washington on December 17, to mark the anniversary of the Wright Brothers' first flight, the Museum provided a Wright engine of 25 horsepower to serve as a contrast to a modern jet engine of about 5,000 pounds thrust. At this banquet the Museum also helped with preliminary arrangements for the presentation of the Robert J. Collier Trophy, symbolic of outstanding achievement, to John Stack, engineer of the National Advisory Committee for Aeronautics.

At the meeting of the Board of Regents of the Smithsonian Institution on January 16, 1953, the Air Museum exhibited the rocket engine popularly known as *Black Betsy*. This is the prototype of those that powered the first manned supersonic flight and established current records for altitude and speed.

During February, in conjunction with the National Collection of Fine Arts, an exhibition of watercolors by Lt. Col. H. H. Sims of the Air Force was shown. These had been painted during visits to various interesting parts of the world, in connection with his assigned duties. At the end of March a special exhibit was held in the D. C. National Guard Armory illustrating the many uses of magnesium. One of the first aircraft to employ this remarkably light metal was the Northrop *Black Bullet*, XP-56, made for the Air Force in 1943, and now in the Air Museum collection. It was among those stored at Park Ridge but was brought to Washington for this showing and then placed in storage at Suitland. During April, by courtesy of the Westinghouse Electric Corporation and the Navy Bureau of Aeronautics, a cutaway operating example of the J-34 jet engine was shown in the Aircraft Building. This type powers the Navy's Douglas F3D *Skyknight* and the McDonnell F2H *Banshee*, used in Korea.

The Museum participated in or assisted with several television programs during the year.

SURVEY

In determining the whereabouts and suitability of material required for the national collection, either as evidence of current prog-

ress or to fill in historical and technical gaps, most of the inquiries and negotiations can be conducted by mail, but in many cases personal visits by members of the staff are desirable to learn the story behind the material under consideration and attend to the many details involved in securing it for the Museum. The following trips were made in this connection.

July 8, by the head curator, to the Glenn L. Martin Aircraft Co. at Middle River, Md., to inspect models of the PBM and JRM aircraft.

August 11–15, by the associate curator, Robert Strobell, to Wright-Patterson Air Force Base, Dayton, Ohio, to determine progress being made on models of Wright Brothers' aircraft and examine data on the aerial torpedo of World War I.

October 5–7, by Mr. Strobell ,to Great Neck, L. I., N. Y., and Wood-Ridge, N. J., to obtain data on guided missiles, determine progress on instrument exhibit, and examine and select photographs of Curtiss aircraft.

May 4–6, by the head curator, to Langley Field, Va., to attend an inspection of the laboratory of the National Advisory Committee for Aeronautics and determine the availability to the Museum of displayed material.

June 26–27, by the senior exhibits worker, Stanley Potter, to Indianapolis, Ind., to discuss methods of delivering and disassembling the Boeing 247–D airplane being considered for transfer to the Museum by the Civil Aeronautics Administration.

ADDITIONS TO THE COLLECTION AND IMPROVEMENT OF EXHIBITS

New material received this year covers a wide range—from items representative of past accomplishments to objects showing recent developments. These form a permanent record of progress and outstanding achievement.

Of the full-sized aircraft received, an impressive gift is the Douglas DC–3 transport airplane presented by Eastern Air Lines through its president, Edward V. Rickenbacker, with the helpful assistance of Beverly Griffith. Before World War II the DC–3 was used on airlines throughout the world. During that war this type, appropriately named the *Sky Train* and known as C–47 to the Air Force, R4D to the Navy, *Dakota* to the British, was used in every theater of operations and is still giving the same reliable passenger service. The airplane presented by Eastern Air Lines has flown 8,517,000 miles, and carried 213,000 passengers. Since its purchase in 1937 and until its retirement, it had been in operation on an average of 10½ hours per day.

The *Excalibur III* airplane in which a series of remarkable flights were made, was presented to the Museum by Pan American Airways. This is the P–51 *Mustang*, made by North American Aviation, Inc., and powered with a Packard Rolls-Royce Merlin engine. Transcontinental records were made in it by Paul Mantz in 1946 and 1947, and in 1951 Charles Blair flew it nonstop from New York to London at a record speed averaging 446 miles an hour, and made the first solo

flight across the North Pole from Bardufoss, Norway, to Fairbanks, Alaska, 3,260 miles in 10½ hours.

Another important accession was a German Me 163, known as a rocket interceptor, used by our adversaries in World War II. The Museum was also fortunate in receiving as a gift from Hiller Helicopters the XH–44, the original *Hiller-copter* devised by Stanley Hiller in California in 1944, and one of the first successful types to use contrarotating blades. The control stick from a much earlier helicopter, the one designed by Dr. George DeBothezat and Ivan Jerome and constructed by the Engineering Division of the Army Air Service at McCook Field in 1922, was presented by Mr. Jerome, together with photographs, drawings, and other data.

Many types of aircraft that cannot be represented in the Museum by full-sized examples are illustrated by scale models. Two models received this year are almost as large as some full-sized planes. These were received from the Glenn L. Martin Co., one being the quarter-sized PBM Naval *Mariner* patrol plane and the other a quarter-sized model of the JRM *Mars* long-range flying boat. The PBM model was made in 1937, as a flyable test unit to determine the characteristics and performance of the large craft which was then only on the drawing boards. It proved to be a very valuable and prophetic means of "working out the bugs" at reduced expense. The JRM model was made for testing in the large-scale wind tunnel at the Langley Memorial Laboratory of the National Advisory Committee for Aeronautics, and through such testing revealed the probable performance of the type, again saving the time and cost of determining this information by full-scale experiments. Another acquisition is the original test model of the Northrop Flying Wing, a skillfully made lightweight miniature, about 3 feet in span, which was hand-launched and glided to test the lift and stability of a type from which developed the large B–35 and B–49 bombers of our Air Force. It is exhibited in the Museum beside photographs of its huge descendants. One of the earliest configurations of the delta design was devised by Michael E. Gluhareff of Sikorsky Aircraft in 1939, starting by experiments with light balsa-wood glider models which demonstrated the utility of the dartlike pattern. His tests the next year were even more convincing, and in 1941 he designed a pursuit interceptor for the Air Force of that delta-wing shape. That was before the current era of jet power, and he planned to use contrarotating pusher propellers. Concentration by Sikorsky Aircraft upon the helicopter program prevented continuation of the experiments with this design at that time, but today delta-winged aircraft have been successfully flown in Germany, America, and England, and are recognized as especially adapted to solving the problems encountered at supersonic speeds.

Other scale models of full-sized aircraft received this year represent

the Wright Brothers' first glider of 1900, the Gallaudet D–4 of 1918—one of the advanced types produced by the Gallaudet Aircraft Corporation for the United States Navy during the first World War—and the McDonnell *Phantom* FH–1, a current type of Navy fighter employed in Korea. M. A. Krieger donated an excellent scale model of the V–1 German buzz bomb. A full-sized specimen of this weapon, which caused such destruction in England during World War II, is in the Museum's collection, but is not exhibited for lack of space. The Army and Navy Club of Washington presented to the Museum an automatic pilot from an actual V–1 which fell in the vicinity of the United Service Club in London. The Navy has added this year to the Museum's series of small airplane "recognition" models which show the characteristics of ex-enemy and other foreign aircraft, as well as current United States types. These are used in the Navy for training purposes, and are of value in the Museum for preserving the record of service types.

Two very famous power units have been added to the Museum's "Engine Row" this year: The Pratt and Whitney R–4360–35 Wasp Major engine, number 1 of the four which powered the United States Air Force Boeing B–50 bomber *Lucky Lady II* when it made the first nonstop world flight, taking off from Fort Worth, Tex., February 26, 1949; and the famous *Black Betsy*, a four-tube liquid-propellent rocket designed and built in 1940 by Reaction Motors, Inc. In great contrast to the complicated fuel system of these modern engines is a little "puddle carburetor" sent in by a friend of the Museum who had found it among some relics of pioneer flying. Several propellers were received; also a unique electric generator showing the application of the airplane type of propeller to power production. This wind-driven generator was developed by H. R. Stuart and E. N. Fales in 1922, and came into commercial use a year later.

Mementos of famous flyers provide personal associations which increase interest in the collections. Two exhibits of this nature have been added to the group of World War I airplanes. One was prepared with the cooperation of Capt. Edward V. Rickenbacker and includes his uniform, scale models of his Nieuport 28 and Spad 13 airplanes, records and photographs of the members of the 94th Squadron which he commanded, and photographs of enemy aircraft which they engaged. This has been placed near the Spad fighter. A panel recording some of the accomplishments of Col. Harold H. Hartney, who was commanding officer of the First Pursuit Group which captured the German Fokker D–7—now in the Museum—has been installed near that plane. The first world-flight flagplane, Douglas Cruiser *Chicago*, now has beside it, in a case containing a scale model of his *Cloudster*, a portrait sculpture of the aircraft designer, Donald Douglas. This was given by the artist, W. F. Engelman, of Florida, who also pre-

sented his sculpture of Admiral Richard E. Byrd, which has been placed with instruments and other material recalling the polar fights of that great explorer. Woodward Burke, famous pilot who test-flew some of the Brewster Naval fighters during World War II, was one of the first to develop a pressure-bearing garment for aviators which aided in controlling the abnormal passage of blood during aerial maneuvers at extreme speeds. This elementary "G-suit," so named because it restricts the effects of gravity, has been given to the Museum by his widow. In the memorial exhibit to Amelia Earhart has been placed a small American flag, a gift from the family of ex-Mayor Malcolm E. Nichols of Boston, carried by Miss Earhart on her first flight across the Atlantic in the Fokker airplane *Friendship*, 1928.

The Navy's P2V Lockheed airplane, *Truculent Turtle*, which established the current nonstop distance record, flying from Perth, Australia, to Columbus, Ohio, about 11,822 miles in slightly over 55 hours, is being held for the Museum by the Department of the Navy until space can be provided for its display; in the meanwhile the "How-Goes-It-Board" used on that flight has been placed on exhibit. That is the navigator's sheet on which the plan of the flight was drawn up, and which was consulted by pilot and navigator as the flight progressed. The Navy has also presented parts of two historic wind tunnels, recently decommissioned at the Washington Naval Gun Factory. In these tunnels scale models of many of the Navy's earliest and most renowned aircraft were first tested. Individual listing of the year's accessions is given in the final pages of this report.

The two exhibits workers of the Museum, in addition to assisting with unloadings and other operations at the Suitland storage area, received and placed much of the material above described and in addition made improvements in existing displays. The parts of the original John J. Montgomery gliders of 1905 and 1911 were mounted in new frames, thereby improving this exhibit. The Naval Curtiss F9C–2 *Sparrowhawk* fighter of 1935 was completed by addition of its overhead hook-on gear supplied by the Navy Department Bureau of Aeronautics. The scale model of the U. S. S. *Pennsylvania*, which had been reconstructed to show the landing deck on which Eugene Ely made the first landing followed by a take-off on January 18, 1911, was provided with a more attractive base on which photographs of the event are mounted and in which a slide projector recounts the story of the evolution of aircraft carrier operations. The showing of scale models of aircraft used in World War II was improved; changes and additions were made in the impressive lineup of aircraft engines in the Aircraft Building. The famous aeronautical trophies were placed in larger cases, and material showing the histories of these trophies and their presentations was added, making the display more attractive and of greater educational value.

STORAGE

The difficulties experienced during the year in operating the Park Ridge, Ill., storage facility and in establishing the one at Suitland, Md., have been reviewed in the general statement. In spite of these problems, considerable progress was made in the operations at Park Ridge.

Because the shipment of the stored material to Washington is the final objective of the storage facility, the principal project at Park Ridge is the disassembly, preservation, and boxing of aircraft, engines, and other materials. During the year 9 full-sized airplanes were taken apart to their major components, given preservative treatment, and boxed, bringing the total of airplanes so prepared to 72 and leaving but 10 presently scheduled for such treatment. Several of these, however, are large aircraft and will present serious problems in disassembly because they are foreign types for which little or no breakdown data exists, and, having been constructed for immediate and nearby combat operations they do not have the disassembly features common to American aircraft. Of the aircraft boxes formerly built, 17 were repaired and weatherproofed, 100 were sprayed with protective material, 4 were provided with new skids, and all were weighed to obtain data for final shipment. In the latter operation, the assistance of the State of Illinois Traffic Police, who lent their large scales, was particularly appreciated. Of the engines, 140 were given cleaning and preservative treatment, and boxes were constructed for 8, while all the engine boxes were checked for ventilation and a number of new lids constructed. In the final weeks of the fiscal year, when 20 truckloads of boxes containing components were shipped to Suitland, all those boxes were examined, repaired, their contents given cleaning and preservation treatment where necessary, the closed boxes banded, the material prearranged in load lots, and finally loaded on the trucks. In addition there were times when the two carpenters were required to construct office space or enclosures and shelves for tools, supplies, and equipment, and when the three mechanics had to stop their aircraft work in order to repair the crane, forklifts, and other handling equipment and vehicles. The guards frequently volunteered a helpful hand, and the manager, Walter Male, to whom much credit for the efficient operation at Park Ridge is due, apportioned his time so that he was able to visit the plant of Airwork Corporation at Millville, N. J., where they kindly explained to him their techniques for preserving aircraft, enabling these methods to be added to our processing. Mr. Male also visited Wright-Patterson Field at Dayton, where he searched for data on foreign aircraft in order to better care for those in the Museum collection; and, at the Naval Base in Mechanicsburg and other places, learned about their methods of storing aircraft, and related operations.

At Suitland, continuing with the erection of the prefabricated Butler buildings, the remaining 4 of the 6 purchased last year were assembled on concrete bases by late November. The 6 buildings provide a total of 24,000 square feet and enabled the Museum to accept custody of 3 of the 4 full-sized airplanes received this year and of the 2 large Martin models; but of very great assistance was the storage of the 20 loads of components shipped from Park Ridge. This operation saved double handling of those 3,000 boxes which, had Suitland been unavailable, would have had to be moved again from one building to another at Park Ridge, stacked in vitally needed space, and otherwise cared for. As it is, they are now near their final destination, some have been inspected, and a few of the more interesting specimens that can be accommodated are being prepared for exhibition.

Within the Smithsonian buildings in Washington where there have been two rooms devoted to aeronautical storage, the congestion has been greatly relieved by transferring material to Suitland; these rooms are being prepared as extensions of the reference-file space, and for keeping handling equipment and exhibition supplies.

ASSISTANCE TO OTHER AGENCIES

A large portion of the time of the staff is required in answering requests for information. During this anniversary year this public service has increased greatly in volume and variety, and many projects that are part of the general effort to make this an outstanding year in aeronautical progress have been aided by the Museum. One undertaking that will be of great permanent value is the compilation by the Division of Aeronautics of the Library of Congress of two volumes intended to be a complete record of the work by the Wright Brothers. The Museum made available its exhibits and files to the staff of that division. Other departments of the Government have their Anniversary projects: the Civil Aeronautics Administration is preparing exhibits featuring famous flights, the Office of Education is compiling lists of aeronautical material for distribution to schools, the Navy's Bureau of Aeronautics assembled several displays showing historic and current developments, and the Air Force for Armed Forces Day prepared impressive shows. All these projects received help from the Museum. Some units of the Government in need of assistance in connection with current work were the Department of Justice, wishing construction details on cockpit harnesses, parachute hardware, and engine starters; the Air Force, asking for the loan of ex-enemy aircraft in order that the crews who were to examine the shot-down planes of our adversaries in Korea could be indoctrinated in foreign techniques, and requesting help in preparing educational and historical displays for student airmen. The Navy received descriptions of helicopter

developments; the State Department asked for help in preparing articles on aeronautical subjects for use in foreign broadcasts and papers; and the Weather Bureau was supplied with photographs of famous flights for which that Bureau had supplied vital meteorological information. The artist Allyn Cox required accurate details of the Wright Brothers' first aeroplane and facts about the air pioneers Langley and Chanute for incorporation in the frieze which he is completing on the rotunda wall of the United States Capitol. Several schools, including the Northrop Aero Institute and the School of Aeronautics in Denver, requested and received help from this Museum. The Institute of Aeronautical Sciences sent its curator to the National Air Museum to study exhibition procedures and methods of recording material; and drawings, photographs, and data on aircraft were exchanged to mutual advantage with museums in California, France, Holland, and England. Slides for lectures were supplied to B. L. Whelan of Sikorsky Aircraft recalling early days in aviation, and to Capt. Ralph Barnaby, USN Ret., describing the gliders of the Wright Brothers. The head curator gave 11 lectures during the year on various phases of aeronautics and the work of the National Air Museum, speaking to Reserve units of the Navy and Air Force, airline groups, and to the American Society of Civil Engineers at their national meeting in Chicago, September 5.

IMPROVEMENTS IN REFERENCE MATERIAL

The documentation of the aeronautical collection is an important phase of museum work and must be maintained together with the preservation of the specimens. Without such documents as original correspondence records, descriptions of technical details and performance, drawings, photographs, and related texts, the labeling of specimens and the furnishing of information about them would be difficult and perhaps inaccurate. With each accession the Museum endeavors to obtain such data as opportunity permits, and seeks to procure books, magazines, catalogs, and other literature pertinent to the general history of aeronautics. Frequently other persons studying the history and development of aircraft and patriotically interested in improving the national collections will give or exchange with the Museum from their collections. Some material has been received from bequests.

From the Air Force, 170 boxes of technical orders were received. These cover such subjects as maintenance of aircraft, instructions for disassembly and overhaul, pilot's operating instructions and other operational data, and are a very valuable source of information. These documents are being screened in order to extract data relative to the collection. The General Services Administration, Department of Archives, has generously supplied from its files a number of photo-

graphs of aircraft, and many aircraft manufacturers have responded to requests for photographs of their current and earlier types. Having established a periodical library during the previous fiscal year, the Museum has endeavored to maintain these aeronautical publications current and to add missing issues. To assist the Museum in filling requests for information on current aircraft the magazine *Aero Digest* very generously gave 500 reprints of their March 1953 Directory number which featured a complete listing of types now in production. Maj. Kimbrough Brown of the Air Force, during his recent duty in Europe, collected much valuable information for the Museum and assisted with its incorporation into the files upon his return to this country. Bell Aircraft supplied material for the improvement of the Museum exhibition of the supersonic X–1 and another local exhibit. The Air Force Association assisted in supplying a catalog of the paintings by Col. H. H. Sims exhibited during February. The Museum is particularly indebted to Charles Taylor, the mechanic associated with the Wright Brothers, who worked on the construction of the engine for their first airplane and helped to build and repair many of their aircraft. From his recollections he has been most helpful in answering questions about the engine, construction details of Wright aircraft, and events of those wonderful days.

The following lots of reference material have been separately acknowledged and entered:

Mrs. Gretchen Schneider Black, Fort Worth, Tex.: The Eddie A. Schneider Memorial Library consisting of 67 books, 35 pamphlets, and a painting.

Division of Military and Naval History, U. S. National Museum: A collection of 18 books from the Gen. John J. Pershing Library.

Mrs. M. S. Gilpatric, New York, N. Y.: Four scrapbooks, a poster, an insignia of the First Aero Squadron, photographs, etc., collected by her son, Guy Gilpatric, renowned pioneer flier and World War I aviator. These are largely descriptive of the aircraft flown by him, and his piloting experiences.

J. C. MacCartee, Sr., Osteen, Fla.: A collection of 64 photographs taken by him at College Park, Md., during 1911 and 1912, showing early aircraft and flights, principally those in Wright Brothers' airplanes, and by notable military pilots of that era.

Joseph Nieto, San Antonio, Tex.: Four 3-view scale-dimensioned drawings of famous aircraft, drawn by himself.

North American Aviation, Inc., Los Angeles, Calif.: A collection of 36 photographs, enlarged and framed, of types produced by this company.

James J. Sloan, Aero Historical Society, Van Nuys, Calif.: A group of 11 3-view scale-dimensioned drawings of aircraft, including several unique types of World War I.

Stanford University Libraries, Stanford, Calif.: A collection of 60 bound volumes of aviation periodicals.

RESEARCH

The quantity of work involved in other phases of the Museum program limits the amount of time that can be devoted to personal re-

search by the staff, but as opportunity permitted, several projects were advanced.

Anticipating that the Fiftieth Anniversary of Powered Flight would be celebrated during 1953, the Museum intensified the collecting of photographs and other material relative to the Wright Brothers. Persons who had taken pictures of the Wrights and their aircraft and pupils in America were generous in sharing them with the Museum, but it was difficult to find photographs taken when the brothers were in Europe. Persistent correspondence by the associate curator finally located several helpful sources in England, France, Germany, and Holland and, thanks to such cooperation, the Museum's collection is now one of the most complete. This material has been of great service to many publishers, writers, artists, modelmakers, and others, and selections will form part of the special Wright display being planned for December of 1953.

Efforts were continued throughout the year to procure authentic documents and drawings about America's early work in the guided-missile field. Extensive material was obtained describing the Dayton-Kettering developments during the First World War, but little has been received about the Long Island-Sperry efforts.

ACCESSIONS

This year the National Air Museum received 32 accessions from 28 sources totaling 112 specimens. Those from Government departments are recorded as transfers; others were received as gifts except as noted.

AIR FORCE, DEPARTMENT OF, Washington, D. C.: German Messerschmitt Me 163 rocket interceptor, used in World War II to oppose operations of American and English bombers (N. A. M. 763). (Through Pratt & Whitney Aircraft) The Pratt & Whitney R-4360-35 Wasp Major aircraft engine, Serial No. P-675, from the B-50-A bomber *Lucky Lady II* which made the first nonstop flight around the world, February 26–March 2, 1949 (N. A. M. 753).

ALLEGHENY AIRLINES, Washington, D. C.: Scale exhibition model 1:16 of Stinson SR-10 airplane of type used by the predecessor company, All American Airways, from 1939 to 1949 for airmail service, featuring a unique pickup-in-flight system (N. A. M. 758).

ARMY AND NAVY CLUB, Washington, D. C.: An automatic pilot from a German V-1 flying bomb which came down in the vicinity of the United Service Club, London, England, World War II (N. A. M. 757).

AUGUSTINE, DAVID, Landover, Md.: An airplane propeller of Micarta, a compressed resinous material, in use about 1928 (N. A. M. 782).

BURKE, MRS. OLIVIA BENDELARI, New Hope, Pa.: An aviator's restrictive garment for maintaining pressure on parts of the body to reduce effects of inertia during extreme maneuvers at high speeds. Devised by her husband, Woodward Burke, test pilot, who gave his life in 1945 during development of a Navy jet fighter (N. A. M. 765).

EASTERN AIR LINES, New York, N. Y.: Douglas DC-3 airplane No. 164, constructed 1937, and veteran of over 8½ million air miles (N. A. M. 766).

EMSCHWILLER, LT. WILLIAM M., U. S. M. C., Hyattsville, Md.: Scale exhibition model 1:24 of the McDonnell FH-1 *Phantom*, a current type of Naval jet-powered airplane (N. A. M. 752, loan).

ENGLEMAN, WILLIAM F., Miami, Fla.: Two portrait busts, one of Adm. Richard E. Byrd, Naval pilot and polar explorer, and one of Donald W. Douglas, noted aircraft designer and manufacturer (N. A. M. 755).

GARBER, PAUL EDWARD, Washington, D. C.: Five kites, one a reproduction of that used by Benjamin Franklin 200 years ago in his experiments with lightning, and four of Chinese origin in outlines of a butterfly, fish, bat, and bird (N. A. M. 761).

HARTNEY, MRS. HAROLD, Washington, D. C.: Material associated with the military and aeronautical accomplishments of her husband, the late Col. Harold Hartney, commander of the First Pursuit Group, World War I (N. A. M. 767).

HERRING, M. G., Washington, D. C.: An aircraft propeller, wooden, two-bladed, from an Aeromarine-40 flying boat, about 1921 (N. A. M. 779).

HILLER HELICOPTERS, Palo Alto, Calif.: The XH-44, original *Hiller-copter* designed and constructed by Stanley Hiller in 1944; it has two 2-bladed contra-rotating rotors (N. A. M. 769).

HUBBELL, CHARLES, Cleveland, Ohio: Scale exhibition model 1:16 of the Wright Brothers' first glider, 1900 (N. A. M. 771, purchase).

HUNDEMER, CHARLES, Baton Rouge, La.: A mixing valve or "puddle carburetor" used on an airplane engine of the period 1908-1910 (N. A. M. 780).

JEROME, IVAN, Massapequa, L. I., N. Y.: Original control stick from the helicopter constructed by the Engineering Division of the U. S. Army Air Service, McCook Field, Dayton, Ohio, 1922, designed by Dr. George DeBothezat and Mr. Jerome (N. A. M. 768).

KICKERT, HOWARD, Arlington, Va.: An aircraft propeller, wooden, 2-bladed, of early design, used with a low-horsepower engine (N. A. M. 772, loan).

KRIEGER, M. A., Dallas, Tex.: Scale exhibition model 1:24 of transparent materials showing construction of a German V-1 buzz bomb as used against England, World War II; with associated data (N. A. M. 781).

MARTIN, GLENN L., Co., Middle River, Md.: Two quarter-sized models of Martin flying boats, one being the flying model with which characteristics of the Navy PBM *Mariner* were predetermined; the other the wind-tunnel model of the Navy JRM *Mars*, long-range patrol and cargo plane (N. A. M. 774).

MODEL BUILDERS, INC., William Chaffee, President, Chicago, Ill.: Two scale exhibition models, 1:16, illustrating the Nieuport 28 and Spad 13 airplanes flown in World War I by Capt. Edward V. Rickenbacker (N. A. M. 760, purchase).

NAVY, DEPARTMENT OF, Washington, D. C.: Parts of two wind tunnels recently decommissioned at the Naval Gun Factory in Washington; the earlier was the 8-foot square-throat wooden tunnel built in 1914; the other circular, of metal, was constructed about 15 years later (N. A. M. 776). The "How-Goes-It-Board" used by pilot and navigator of the Navy's Lockheed *Truculent Turtle* which established the world record for nonstop distance, 11,822 miles, October 1, 1946 (N. A. M. 777). (Through Reaction Motors, Inc., Rockaway, N. J.) The original *Black Betsy* rocket engine which served as prototype for the engines that powered the first manned supersonic flight by the Air Force's Bell X-1 and the Navy's Douglas D-558-2, which has flown higher and faster than any other manned aircraft (N. A. M. 754). A collection of 48 aircraft models, scale 1:72, of recent and current types; used for training in aircraft recognition (N. A. M. 751).

NICHOLS, MALCOLM E., THE FAMILY OF, Boston, Mass.: A small American flag, carried by Amelia Earhart on her first flight across the Atlantic Ocean, with

Wilmer Stultz, pilot, and Lew Gordon, mechanic, in the Fokker seaplane *Friendship*, June 17–18, 1928 (N. A. M. 762).

NORTHROP AIRCRAFT, INC., Hawthorne, Calif.: Experimental glide model of the flying wing, used for the original test of this configuration (N. A. M. 778).

PAN AMERICAN AIRWAYS, New York, N. Y.: The airplane *Excalibur III* in which Capt. Charles Blair made a transatlantic record flight and the first nonstop solo flight over the North Pole, 1951 (N. A. M. 775).

RICKENBACKER, CAPT. EDWARD V., New York, N. Y.: The uniform worn by him in World War I with records and photographs of members of the 94th Squadron which he commanded (N. A. M. 759).

RODERICK, HARRY M., Oakland, Calif.: Compressed-air-powered experimental model airplane, 1909 (N. A. M. 773).

SHORT, ROXOR V., Madison, Conn.: Scale exhibition model, 1:16, of the Gallaudet D-4 Navy seaplane, 1918, an advanced pusher biplane design (N. A. M. 756, purchase).

SIKORSKY AIRCRAFT, Division of the United Aircraft Corp., Bridgeport, Conn.: Scale exhibition model, 1:16, of the proposed delta-winged fighter designed by M. E. Gluhareff in 1941 (N. A. M. 770).

STUART, H. R., and FALES, E. N., Washington, D. C.: Original wind-driven electric generator, equipped with a propeller similar to the airplane type, developed jointly by the donors in 1922 (N. A. M. 764).

Respectfully submitted.

PAUL E. GARBER, *Head Curator.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

APPENDIX 10

Report on the Canal Zone Biological Area

SIR: It gives me pleasure to present herewith the annual report of the Canal Zone Biological Area for the fiscal year ended June 30, 1953.

BUILDINGS AND EQUIPMENT

The major accomplishment at Barro Colorado Island during the year was the installation of two 15-KVA Diesel-driven generators. This required the construction of a concrete foundation, to which the generators had to be anchored, and a well-ventilated building to house the units; the installation of large instrument panels and insulated pipes for overhead distribution; and procurement of necessary accessories for operation. Although the annual operating cost of the generators amounts to about $1,650, the benefits to be derived from a constant flow of current are inestimable; and being able to operate the refrigerator, deep freeze, dry cabinets, and dehumidifiers 24 hours a day, thereby eliminating spoilage, will result in considerable savings. Also, an adequate and uninterrupted supply of electricity should attract many more investigators who need current at all hours.

The pit for the rainwater reservoir, west of the new laboratory building, was completed, and the reinforcing steel and form lumber were cut to size. Because of deficient rainfall, there was not enough water to mix the concrete, and so this project was not finished.

Shelving was added to the large (original) laboratory building for a collection of reptiles and amphibians, largely from the island, and for the extensive collection of Central American fruits, mostly from Panama, obtained by the resident manager during his years of study of fruit flies of the genus *Anastrepha*. Dr. and Mrs. E. R. Dunn, of Haverford College, put most of the reptile and amphibian specimens in new jars and relabeled them.

An electrically heated plant drier was built and has already been put to good use by scientists.

It was necessary to build an extension to the dock at the island, and also to the covered area for the launches. Both launches required minor repairs to the hulls, and the engine of one needed replacement of parts. A large, well-built cayuco was obtained, for use with an outboard motor, in order to police the island more adequately.

The trails are in good condition, but some of the markers need to be replaced.

The Fuertes house and the houses at the end of Drayton trail are in excellent condition. The old main laboratory is in good shape, except for minor repairs, and can accommodate at least 20 scientists a day. The Chapman house can still be used as a laboratory building, and with a minimum of repairs should serve well for 5 years or more. The buildings occupied by the warden-caretaker and the cook are in good condition; the one used by the laborers needs some repairs. The plywood building at the tower was primarily a test for termites and resin glues, and can still be used as a shelter.

MOST URGENT NEEDS

Most urgently needed is the rainwater reservoir. It is hoped that the concrete for this can be poured early in the next fiscal year and that funds will be available to cover it with concrete slabs, add the necessary pipes, and divert the runoff from the aluminum roof into the tank. Also, a new 2-horsepower electric motor to run the pump must be purchased. With this reservoir we should have adequate "safe" water to last through even a dry season.

Next in importance is the need for electric wiring in the new building, water service for the lower floor, the installation of sinks, tables, and shelves, so that at least the two main laboratory rooms (each accommodating four persons) can be made available to scientists; and the installation of exhaust fans, shelves, and other equipment in the photographic dark room. Dehumidifiers will have to be purchased; these are very necessary to prevent deterioration and corrosion from the high humidity.

With these things accomplished, the library, herbarium, and index cabinets can be transferred from the Haskins building to the new building, and the kitchens moved to the fireproof Haskins building. Purchase of an electric water heater for the kitchen, an urgent need, has been approved.

SCIENTISTS AND THEIR STUDIES

The primary purpose of the Canal Zone Biological Area is to provide a safe and accessible area for scientific research in the lower humid tropics in the Americas. Probably nowhere else in the world can be found the combination of unspoiled tropical jungle and healthful laboratory surroundings. Here scientists find a profusion of plants and animals and are able to carry on a wide variety of special studies.

During the 1953 fiscal year, 57 scientists came to the island. The high cost of transportation prevents many from coming and also, in

many cases, curtails the length of stay. A list of the season's investigators, with a brief summary of their interests, follows:

Investigator	*Principal interest or special study*
Ajello, Dr. Libero, U. S. Public Health Service, Atlanta, Ga.	Environmental factors.
Anderberg, T., Sweden.	Member of Blomberg expedition. (See Dr. Rolf Blomberg.)
Andrew, Dr. Warren, Bowman Gray School of Medicine, Winston-Salem, N. C.	Land mollusks.
Ansley, Dr. Hudson R., Columbia University, New York, N. Y.	Sex determination in centipedes.
Bloedel, Prentiss, University of California, Berkeley, Calif.	Orientation in bats.
Blomberg, Dr. Rolf, Sweden and Ecuador.	Color photography, stills, and sound recordings; intensive study of tropical wildlife.
Boberg, Walter, Sweden.	Member of Blomberg expedition. (See Dr. Rolf Blomberg.)
Bradley, John C. Waterbury, Conn.	Mollusks.
Bromfield, Louis, Malabar Farm, Lucas, Ohio.	Tropical flora and birds.
Buchanan, Charles, Puerto Rico.	Bird survey and habitats.
Burk, Gordan, Scripps Institution of Oceanography, La Jolla, Calif.	Mammals and birds.
Chamberlain, Mrs. Florence, Des Moines, Iowa.	Bird survey and nests.
Clark, Dr. Walter, Eastman Kodak Research Laboratories, Rochester, N. Y.	Review of Eastman Kodak exposure tests; color photography and sound recordings.
Crookchewit, Hans, Amsterdam, Holland.	Birds.
Drury, Dr. William, Harvard University, Cambridge, Mass.	Forest topography as affecting bird life.
Dunn, Dr. and Mrs. E. R., Haverford College, Haverford, Pa.	Amphibians and reptiles and rearrangement of island collection.
Eisenmann, Dr. Eugene, New York, N. Y.	Continuation of long-range bird studies.
Erickson, Clarence O., Paramount Pictures, Hollywood, Calif.	Appraisal of island for motion film of army ants.
Geysa, Vanita von, Illinois.	Continuation of her painting.
Goelet, Dr. Robert, New York Zoological Society, New York, N. Y.	Birds, mammals, and flora.
Goodale, Dr. Robert L., Boston, Mass.	Bird studies.
Graham, Dr. E. H., U. S. Soil Conservation Service, Washington, D. C.	Wildlife and flora.
Griffin, Dr. Donald R., Cornell University, Ithaca, N. Y.	Orientation in bats.
Hartman, Dr. Frank M., Ohio State University, Columbus, Ohio.	Continuation of studies on adrenals of birds and mammals.
Heim, Roger, Museum of Natural History, Paris, France.	Fungi and environment.

Investigator	*Principal interest or special study*
Henry, Mr. and Mrs. Thomas R., Washington Star, Washington, D. C.	To collect data on plants and animals for press releases.
Hiestand, Dr. Norman T., Los Alamos, N. Mex.	General biology, color photography, and sound recordings.
Hodgson, Dr. Edward S., Barnard College, Columbia University, New York, N. Y.	Behavior of leaf-cutting ants.
Kelly, Dr. Junea, Alameda, Calif.	Continuation of bird studies.
Kerr, Miss Charlotte, U. S. Embassy, Panama.	Observations on birds and mammals.
Koronda, John, Michigan State College, East Lansing, Mich.	Algae.
Loegering, William I., IICA Turrialba, Costa Rica.	Plants and ecology.
Lundy, William E., Assistant Paymaster, Panama Canal.	Continuation of studies on birds and mammals.
MacLeish, Kenneth, Life Magazine, New York, N. Y.	Appraisal of animal life in rain forest of American Tropics.
Martin, Dr. George W., State University of Iowa, Iowa City, Iowa.	Fungi.
McGinty, Thomas, Florida.	Mollusks.
Miller, Melville W., Vermillion, S. Dak.	Birds, mammals, and flora.
Monros, Dr. and Mrs. F., Instituto Miguel Lillo, Tucumán, Argentina.	Coleoptera.
Morris, Robert C., U. S. Bureau of Entomology and Plant Quarantine, Gulfport, Miss.	Termites.
Murie, Dr. Olaus J., Wilderness Society, Moose, Wyo.	Animal footprints.
Nadler, Aaron M., Brooklyn, N. Y.	Intensive collecting and study of Psocidae.
Olsson, Dr. A. A., Academy of Natural Sciences of Philadelphia.	Paleontology.
Parsons, Dr. James J., University of California, Berkeley, Calif.	Grasses.
Perrygo, Watson M., U. S. National Museum, Washington, D. C.	Birds.
Prescott, Dr. George W., Michigan State College, East Lansing, Mich.	Algae.
Rimmer, David, Malabar Farm, Lucas, Ohio.	Birds and plants.
Scattergood, Dr. Leslie, U. S. Legation Mission.	Tropical flora.
Setzer, Dr. Henry W., U. S. National Museum, Washington, D. C.	Mammals.
Soper, Dr. Cleveland C., Tropical Research Laboratory, Eastman Kodak Co., Panama City, Panama.	Deterioration and corrosion of photographic equipment and supplies. Gave technical advice and help on Diesel generators.
Steward, Richard, National Geographic Society, Washington, D. C.	Photography.
Stirling, Dr. and Mrs. M. W., Smithsonian Institution.	General biology and reconnaissance.

Investigator	*Principal interest or special study*
Swift, Lloyd W., U. S. Forest Service, Washington, D. C.	Wildlife and flora.
Weber, Dr. Jay A., Miami, Fla.	Mollusks.
Weldon, A. L., State University of Iowa, Iowa City, Iowa.	Fungi.
Wetmore, Dr. Alexander, Smithsonian Institution.	Birds, and general inspection of the plant.

VISITORS

There were about 700 visitors to the island during the year. Most of them came in small groups, and quite a number stayed overnight or for a few days. Among these were Boy Scouts, Girl Scouts, and photography clubs; groups from schools in Panama City, Colon, and elsewhere; from colleges, and from the University of Panama. There were also a number of groups from the Armed Forces, the United States Embassy in Panama, many technical and specialized missions, and branches of the Point-4 Program.

DONATIONS

The resident manager donated to the library a complete series of bound volumes of the Journal of Agricultural Research; a series of Natural History magazines, complete to date; many miscellaneous publications; and a quantity of laboratory glassware, chemicals, and other supplies.

RAINFALL

In 1952, during the dry season (January to April) rains of 0.01 inch or more fell on 36 days (98 hours), and on 203 days (744) hours during the 8 months of the wet season.

Rainfall was 9.26 inches below the station average for 28 years—an excess of 1.09 inches during the dry season and a deficiency of 10.35 inches during the wet season. March was the driest month, 0.11 inch, and October the wettest, 16.96 inches.

TABLE 1.—*Annual rainfall, Barro Colorado Island, C. Z.*

Year	*Total inches*	*Station average*	*Year*	*Total inches*	*Station average*
1925	104. 37	------	1939	115. 47	110. 94
1926	118. 22	113. 56	1940	86. 51	109. 43
1927	116. 36	114. 68	1941	91. 82	108. 41
1928	101. 52	111. 35	1942	111. 10	108. 55
1929	87. 84	106. 56	1943	120. 29	109. 20
1930	76. 57	101. 51	1944	111. 96	109. 30
1931	123. 30	104. 69	1945	120. 42	109. 84
1932	113. 52	105. 76	1946	87. 38	108. 81
1933	101. 73	105. 32	1947	77. 92	107. 49
1934	122. 42	107. 04	1948	83. 16	106. 43
1935	143. 42	110. 35	1949	114. 86	106. 76
1936	93. 88	108. 98	1950	114. 51	107. 07
1937	124. 13	110. 12	1951	112. 72	107. 28
1938	117. 09	110. 62	1952	97. 68	106. 94

TABLE 2.—*Comparison of 1951 and 1952 rainfall, Barro Colorado Island, C. Z. (inches)*

Month	Total		Station average	Years of record	Excess or deficiency	Accumulated excess or deficiency
	1951	1952				
January	2.21	2.40	1.77	27	+0.63	+0.63
February	3.76	.39	1.26	27	−.87	−.24
March	.30	.11	1.20	27	−1.09	−1.33
April	8.53	5.46	3.04	28	+2.42	+1.09
May	12.19	12.39	10.89	28	+1.50	+2.59
June	10.94	11.76	11.40	28	+.36	+2.95
July	5.37	6.01	11.28	28	−5.27	−2.32
August	11.29	9.11	12.16	28	−3.05	−5.37
September	9.62	11.13	10.06	28	+1.07	−4.30
October	19.43	16.96	13.52	28	+3.44	−.86
November	16.15	9.50	19.10	28	−9.60	−10.46
December	12.93	12.46	11.26	28	+1.20	−9.26
Year	112.72	97.68	106.94			−9.26
Dry season	14.80	8.36	7.27			+1.09
Wet season	97.92	89.32	99.67			−10.35

The maximum yearly rainfall of record on the island was 143.42 inches, and the minimum 76.57 inches. The maximums of record for short periods were as follows: 5 minutes, 1.30 inches (a new record) ; 10 minutes, 1.65 inches (a new record) ; 1 hour, 4.11 inches; 2 hours, 4.81 inches; 24 hours, 10.48 inches.

During 1952 the maximums were: 5 minutes, 1.30 inches; 10 minutes, 1.65 inches; 15 minutes, 1.71 inches; 30 minutes, 2.15 inches; 1 hour, 2.86 inches; 2 hours, 3.43 inches; 24 hours, 4.48 inches.

FISCAL REPORT

Trust funds during the 1953 fiscal year amounted to $11,255.03, as follows: Balance from fiscal year 1952, $264.03; fees from scientists, $2,501.16; fees from visitors, $2,177; table subscriptions, $1,900; Smithsonian Institution private funds, $2,800; donations, $1,130; miscellaneous, $482.84.

Items paid from trust funds are: Wages of warden-caretaker and laborers, food, office expenses, and miscellaneous items for upkeep and repairs. Wages amounted to 58.2 percent of the expenditures, and food and kitchen needs 35.8 percent, a total of 94 percent. At the close of the 1953 fiscal year there remained a balance of $437.74 in the trust funds.

The Smithsonian Institution allotted $7,033.29 from Government-appropriated funds. Approximately 60 percent of this was expended for supplies from Panama Canal Storehouses, the major items being $614.63 for lumber; $198.98 for gravel; $490.88 for cement; $192.94 for water lines and toilets; $390.77 for reinforcing steel, pipe, etc., for the water reservoir; $550.90 for the overhead installation of the Diesel generators; $493.66 for Diesel fuel; $72.08 for lubricating oil;

$114.64 for the dock extension; $346.62 for the extension of the sheds for the launches; and $60.78 for materials for the launches.

The other 40 percent covered such items as gasoline, ice, freight, telephone, and rentals; repairs to launches ($214.74); transportation of the two Diesels to the Isthmus ($190.74); parts, filters, repairs, and maintenance inspections for the generators ($370.96); and shelving ($255.86).

The rates for scientists and visitors now in effect are $3 a day per person for 1-day visitors, $4 a full day for scientists from institutions that support the laboratory through table subscriptions, and $5 a full day for all others. A 1-day visit includes the use of the launch to and from the island, the noon meal, and the guide in the morning. A full day for scientists includes three meals and lodging.

The following institutions continued their support to the laboratory through the payment of table subscriptions:

Eastman Kodak Co	$1,000
New York Zoological Society	300
American Museum of Natural History	300
Smithsonian Institution	300

It is gratifying to record again donations from Dr. Eugene Eisenmann of New York, Dr. Robert L. Goodale of Boston, and Dr. Robert Goelet of New York.

Those contemplating a visit to this unique spot of the Americas should communicate with the Secretary of the Smithsonian Institution, Washington 25, D. C., or with the Resident Manager of the Canal Zone Biological Area, Drawer C, Balboa, Canal Zone.

ACKNOWLEDGMENTS

Thanks are due to the Panama Canal Company, particularly the Dredging and Commissary Divisions and the Storehouses; the Canal Zone Government, especially the Police Division; and the officials and employees of the Panama Railroad for their wholehearted cooperation. Without their generous and unfailing assistance, the Area could not function so successfully.

Respectfully submitted.

JAMES ZETEK, *Resident Manager.*

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, 1953:

More than 100 foreign countries, including dominions, colonies, and protectorates, were represented among the 68,414 publications that came to the Smithsonian library, many of them through the International Exchange Service, during the past year. Of these publications, all except 734 books which were purchased, and the serial parts of the 430 journals for which the library subscribed, came either in exchange for Smithsonian publications or as gifts. The acquisiiton by exchange or gift of so large a proportion of the important additions, mostly serials, to the library each year is made possible by the cordial cooperation of issuing agencies all over the world and by the generosity of many friends. The constant inflow of these records of scientific and cultural advance is the lifeblood of research, and the library is the pipeline through which this indispensable material is channeled to all parts of the Institution.

The postwar years have seen many changes among scientific and other journals, but "births" continue to outnumber "deaths"; and in spite of wars and other vicissitudes the continuity of a surprising number of the series of publications issued by long-established institutions and learned societies has been unbroken. So eternal vigilance is necessary not only to see that important new serials are obtained but also that missing parts of old ones are procured as promptly as possible. This is especially true of complicated irregularly issued foreign serials, often published in very small editions which quickly go out of print. To meet the larger number of these needs, 573 new exchanges were arranged during the year, and 7,073 volumes and parts were obtained by exchange to fill gaps in existing sets or to supply individual publications on special subjects.

Of the many gifts presented to the library by generous friends, the Eugene N. Costales philatelic library was one of the largest. Together with the many rare nineteenth-century publications on philately that Malcom MacGregor added to his previously reported gifts, these were especially important additions to the library's fast-growing collection of philatelic literature.

Extensive as are the exchange relations of the Institution, there are many books and periodicals in its subject fields that can be ob-

tained only by purchase. In the face of limited funds, rising prices, and the unceasing and increasing output of scientific and technical literature, careful screening is imperative. Of the many books requested during the year only 734 could be bought. About half the allotment of funds had to be earmarked for subscriptions to periodicals; and as usual allowance had to be made for the purchase of the annual volumes of reference books on special subjects.

The library has no interest in acquiring rare books as such, but occasionally it is possible through one of the Institution's special funds to acquire a much-needed rare work. Notable among such during the year was the purchase out of the Frances Lee Chamberlain fund of the extremely rare Gastropoda parts, by W. Wenz, of the "Handbuch der Paläozoologie," for the division of mollusks. At present, this is the only complete and original copy of this very important work, published in seven parts in Berlin in 1938–44, known to be in this country. The stock of some of the parts was almost completely destroyed during the war.

Additions to the Smithsonian Deposit at the Library of Congress, mostly parts of serial publications, numbered 5,840, of which 261 went to the Langley Aeronautical Library. Other publications sent to the Library of Congress, counted but not individually cataloged or entered here in the serial records, were 2,250 doctoral dissertations, chiefly from European universities, 5,507 documents, mostly from foreign governments, and 14,231 miscellaneous pieces of literature, from all over the world, on subjects of little or no immediate interest to the Institution.

Many publications on subjects in the special fields of other Government agencies were transferred to those agencies, the largest number being 4,104 pieces sent to the Armed Forces Medical Library, 881 of which were medical dissertations.

Every effort was made to keep additions to the library's collection of duplicates to a minimum; 14,326 pieces sent to the United States Book Exchange for exchange credit reduced the collection somewhat but still made no appreciable visible impression on the whole.

Statistics of the catalog section show that 3,185 books were cataloged, 22,625 periodicals entered, and 31,761 new cards added to the catalog and shelf lists and that more than 110,000 cards were handled in the task of merging the two formerly separately maintained main catalogs. This merging of records points continually to the large amount of greatly needed cataloging or recataloging to be done, notably of special collections, which have previously been sketchily recorded, or not cataloged at all.

Funds for binding permitted only 700 volumes to be sent to the Government Printing Office bindery, and so the large backlog of binding continued to increase. In the library, 1,527 books were expertly repaired.

The 8,641 loans recorded during the year show only a fraction of the use of the library's collections. Many more than this number of books were consulted in the reference room and in the stacks of the main and branch libraries, while the annual use of publications on the highly specialized subjects of the different divisions of the Museum, shelved in their sectional liabraries, could certainly be counted well up in the thousands. Intramural circulation of the 3,370 publications, mostly parts of periodicals, assigned to the sectional libraries for filing this past year, would alone, in terms of use, need to be multiplied by several times that number.

Beside the use of books within the Institution, the library serves, and is in turn served by, outside libraries through interlibrary loans. During the year, 82 different libraries throughout the country borrowed 965 books from us for the use of local scientists and other serious students. In addition to the many books borrowed from the Library of Congress, a large number of which were Smithsonian Deposit copies, 891 were borrowed from other libraries, chiefly from the library of the Department of Agriculture.

The reference and informational use of the library was especially heavy, and more than 27,000 questions, many of them in response to letters and telephone calls from outside the Institution, were answered in the reference and circulation section.

The virtual closing of the branch libraries because of understaffing made it extremely difficult to give more than token service from them to the staff of the Institution; and special arrangements had to be made to serve the visiting scholars who needed to have access to the material housed in them. The scattered, inconveniently arranged, and overcrowded housing of the library throughout the Institution, worsened by the hundreds of volumes needing binding or repair, has long since become a chronic and increasinly serious condition, for the full relief of which a practical solution is yet to be found.

SUMMARIZED STATISTICS

ACCESSIONS

	Volumes	Total recorded volumes, 1953
Smithsonian Deposit at the Library of Congress	82	584, 295
Smithsonian main library (includes former Office and Museum branches)	2, 142	289, 787
Astrophysical Observatory (includes Radiation Organisms)	62	14, 102
Bureau of American Ethnology	282	35, 350
National Air Museum	18	306
National Collection of Fine Arts	599	13, 284
National Zoological Park		4, 204
Total	3, 185	941, 328

Cataloged volumes only have been counted in the records of current accessions, and no incomplete volumes of serial publications or separates and reprints from serial publications are included in any of the totals.

EXCHANGES

New exchanges arranged	573
189 of these were for the Smithsonian Deposit.	
Specially requested publications received	7,073
999 of these were obtained to fill gaps in Smithsonian Deposit sets.	

CATALOGING

Volumes cataloged	3,185
Cards added to catalogs and shelf lists	31,761

PERIODICALS

Periodical parts entered	22,625
5,758 were for the Smithsonian Deposit.	

CIRCULATION

Loans of books and periodicals	8,641
Circulation of books and periodicals in sectional libraries is not counted, except in the division of insects.	

BINDING

Volumes sent to the Government Printing Office bindery	700
Volumes repaired in the library	1,527

Respectfully submitted.

LEILA F. CLARK, *Librarian.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

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APPENDIX 12

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, 1953:

The publications of the Smithsonian Institution are in two categories—those issued from federally appropriated funds (particularly the publications of the National Museum and the Bureau of American Ethnology, and the Smithsonian Report) and those issued under income from the Institution's various endowment funds (Smithsonian Miscellaneous Collections, publications of the Freer Gallery of Art, and special publications). Eight regular series are issued, plus six others that appear less frequently. Publications are distributed free to more than a thousand libraries, both in this country and abroad, as well as to a large list of educational and scientific organizations and specialists in various fields. The Smithsonian publications program is a major part in the Institution's endeavor to fulfill the diffusion-of-knowledge function prescribed by its founder.

During 1952–53 the Institution published 23 papers in the Smithsonian Miscellaneous Collections and title page and table of contents for 1 volume in this series; 1 Annual Report of the Board of Regents and pamphlet copies of 20 articles in the Report appendix, 1 Annual Report of the Secretary, and 1 special publication.

The United States National Museum issued 1 Annual Report of the Director, 13 Proceedings papers, 3 Bulletins, and 1 paper in the series Contributions from the United States National Herbarium.

The Bureau of Amercan Ethnology issued 1 Annual Report, 5 Bulletins, and 3 papers in the series Publications of the Institute of Social Anthropology.

The National Collection of Fine Arts issued 6 catalogs; and the Freer Gallery of Art published 1 paper in the Occasional Papers series.

At the end of the year practically all the galley proofs of the tables in the ninth revised edition of the Smithsonian Physical Tables had been received from the printer.

Of the publications there were distributed 177,675 copies, which included 11 volumes and separates of Smithsonian Contributions to Knowledge, 50,185 volumes and separates of Smithsonian Miscellaneous Collections, 31,317 volumes and separates of Smithsonian Annual Reports, 1,988 War Background Studies, 4,582 Smithsonian

special publications, 49 reports and 142 sets of pictures of the Harriman Alaska Expedition, 41,111 volumes and separates of National Museum publications, 30,281 publications of the Bureau of American Ethnology, 8,315 publications of the Institute of Social Anthropology, 2,817 catalogs of the National Collection of Fine Arts, 583 volumes and pamphlets of the Freer Gallery of Art, 9 Annals of the Astrophysical Observatory, 2,554 reports of the American Historical Association, and 3,731 miscellaneous publications not published by the Smithsonian Institution (mostly Survival Manuals).

In addition, 22,851 picture pamphlets, 97,922 guide books, 119,881 natural-history, Smithsonian buildings, and art postcards, 14,825 sets of photo cards and picture postcards, 18 sets and 8 prints of North American Wild Flowers, and 4 volumes of Pitcher Plants were distributed.

The 1953 allotment from Government funds of $92,320 for printing and binding was entirely obligated at the close of the year.

SMITHSONIAN PUBLICATIONS

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOLUME 117

No. 12. Two aboriginal works of art from the Veracruz coast, by Philip Drucker. 7 pp., 3 pls., 1 fig. (Publ. 4091.) Aug. 26, 1952. (20 cents.)

No. 13. Primitive fossil gastropods and their bearing on gastropod classification, by J. Brookes Knight. 56 pp., 2 pls., 10 figs. (Publ. 4092.) Oct. 29, 1952. (60 cents.)

No. 14. New and unusual species of brachiopods from the Arbuckle group in Oklahoma, by G. Arthur Cooper. 35 pp., 4 pls. (Publ. 4093.) Sept. 23, 1952. (50 cents.)

No. 15. The foraminiferal genus *Triplasia* Reuss, 1854, by Alfred R. Loeblich, Jr., and Helen Tappan. 61 pp., 8 pls., 11 figs. (Publ. 4094.) Sept. 9, 1952. (60 cents.)

No. 16. Solar variation and precipitation at Peoria, Illinois, by C. G. Abbot, 18 pp., 8 figs. (Publ. 4095.) Sept. 3, 1952. (30 cents.)

No. 17. A generic synopsis of the lizards of the subfamily Lygosominae, by M. B. Mittleman. 35 pp. (Publ. 4096.) Nov. 4, 1952. (50 cents.)

No. 18. The lower Eocene Knight formation of western Wyoming and its mammalian fauna, by C. Lewis Gazin. 82 pp., 11 pls., 6 figs. (Publ. 4097.) Dec. 9, 1952. ($1.00.)

Title page and table of contents. (Publ. 4134.) [May 27] 1953.

VOLUME 119

No. 1. Cambrian stratigraphy and paleontology near Caborca, northwestern Sonora, Mexico, by G. Arthur Cooper et al. 184 pp., 31 pls., 9 figs., 2 charts. (Publ. 4085.) Aug. 6, 1952. ($3.00.)

No. 2. Permian fauna at El Antimonio, western Sonora, Mexico, by G. Arthur Cooper et al. 111 pp., 25 pls., 3 figs. (Publ. 4108.) June 25, 1953. ($2.50.)

VOLUME 121

No. 1. Geology of the San Jon site, eastern New Mexico, by Sheldon S. Judson. 70 pp., 5 pls., 22 figs. (Publ. 4098.) Mar. 5, 1953. ($1.15.)

No. 2. The birds of the Islands of Taboga, Taboguilla, and Uravá, Panamá, by Alexander Wetmore. 32 pp., 3 pls. (Publ. 4099.) Dec. 2, 1952. (35 cents.)

No. 3. A revision of the Colombian species of *Monnina*, by Ramón Ferreyra. 59 pp., 7 figs. (Publ. 4100.) Feb. 3, 1953. (50 cents.)

No. 4. Structure and function of the genitalia in some American agelenid spiders, by Robert L. Gering. 84 pp., 72 figs. (Publ. 4101.) Mar. 17, 1953. (80 cents.)

No. 5. Solar variation and precipitation at Albany, N .Y., by C. G. Abbot. 16 pp., 6 figs. (Publ. 4103.) Jan. 27, 1953. (30 cents.)

No. 6. Sponges of the Alaskan Arctic, by M. W. de Laubenfels. 22 pp., 12 figs. (Publ. 4104.) Mar. 19, 1953. (30 cents.)

No. 7. Some Recent Arctic Foraminifera, by Alfred R. Loeblich, Jr., and Helen Tappan. 150 pp., 24 pls., 1 fig. (Publ. 4105.) Apr. 2, 1953. ($2.00.)

No. 8. Western Atlantic scorpionfishes, by Isaac Ginsburg. 103 pp., 6 figs. (Publ. 4106.) May 28, 1953. ($1.10.)

No. 9. A new Devonian crinoid from western Maryland, by Arthur L. Bowsher. 8 pp., 1 pl., 1 fig. (Publ. 4107.) Apr. 16, 1953. (20 cents.)

No. 10. The Tillodontia: An early Tertiary order of mammals, by C. Lewis Gazin. 110 pp., 16 pls., 38 figs. (Publ. 4109.) June 23, 1953. ($1.50.)

No. 11. Geologic background of Iyatayet archeological site, Cape Denbigh, Alaska, by D. M. Hopkins and J. L. Giddings, Jr. 33 pp., 4 pls., 7 figs. (Publ. 4110.) June 11, 1953. (50 cents.)

No. 13. Regarding Washington, D. C., precipitation and temperature, 1952 and 1953, by C. G. Abbot. 7 pp., 2 figs. (Publ. 4130.) Mar. 3, 1953. (10 cents.)

VOLUME 122

No. 1. Long-range effects of the sun's variation on the temperature of Washington, D. C. 14 pp., 5 figs. (Publ. 4131.) May 12, 1953. (25 cents.)

No. 3. The metamorphosis of a fly's head, by R. E. Snodgrass. 25 pp., 7 figs. (Publ. 4133.) June 25, 1953. (30 cents.)

ANNUAL REPORTS

Report for 1951.—The complete volume of the Annual Report of the Board of Regents for 1951 was received from the printer October 7, 1952:

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, 1951. ix + 449 pp., 69 pls., 16 figs. (Publ. 4062.) 1952.

The general appendix contained the following papers (Publs. 4063–4082):

Stormy weather on the sun, by Walter Orr Roberts.

An appraisal of cloud seeding as a means of increasing precipitation, by Henry G. Houghton.

On Einstein's new theory, by Leopold Infeld.

Some results in the field of high-pressure physics, by P. W. Bridgman.

Ultrasonics, by Arthur R. Laufer.

The industrial applications of atomic energy, by M. L. Oliphant.

Some prospects in the field of electronics, by V. K. Zworykin.

The new chemical elements, by Saul Dushman.

The insides of metals, by Carl A. Zapffe.
Atomic weapons against cancer, by E. N. Lockard.
Enzymes: Machine tools of the cellular factory, by B. A. Kilby.
The fauna of America, by Austin H. Clark.
The mechanics of snakes, by Alfred Leutscher.
Hormones and the metamorphosis of insects, by V. B. Wigglesworth.
Utilizing our soil resources for greater production, by Robert M. Salter.
The carbon-14 method of age determination, by Frank H. H. Roberts, Jr.
River Basin Surveys: The first five years of the Inter-Agency Archeological and Paleontological Salvage Program, by Frank H. H. Roberts, Jr.
Artificial lighting in America: 1830–1860, by C. Malcolm Watkins.
The development of the halftone screen, by Jacob Kainen.
The artist and the atom, by Peter Blanc.

Report for 1952.—The Report of the Secretary, which will form part of the Annual Report of the Board of Regents to Congress, was issued January 8, 1953:

Report of the Secretary of the Smithsonian Institution and financial report of the executive committee of the Board of Regents for the year ended June 30, 1952. ix + 175 pp., 3 pls., 1 fig. (Publ. 4102.) 1953.

SPECIAL PUBLICATIONS

Dresses of the First Ladies of the White House, by Margaret W. Brown. 149 pp., 70 pls. (35 in color). (Publ. 4060.) [Aug. 19] 1952. ($6.00.)

PUBLICATIONS OF THE UNITED STATES NATIONAL MUSEUM

The editorial work of the National Museum continued under the immediate direction of the editor, John S. Lea. Ernest E. Biebighauser was added to the editorial staff on January 5, 1953, by transfer from the Public Health Service. The Museum issued during the year 1 Annual Report, 13 Proceedings papers, 3 Bulletins, and 1 paper in the series Contributions from the United States National Herbarium, as follows:

ANNUAL REPORT

Annual Report for the year ended June 30, 1952. iv + 103 pp. [Jan. 15, 1953.]

PROCEEDINGS

VOLUME 102

No. 3306. The sipunculid worms of California and Baja California, by Walter Kenrick Fisher. Pp. 371–450, pls. 18–39. July 8, 1952.

VOLUME 103

No. 3311. Two new naucorid bugs of the genus *Ambrysus*, by Ira La Rivers. Pp. 1–7, fig. 1. Feb. 12, 1953.
No. 3312. Two new scale-mite parasites of lizards, by R. F. Lawrence. Pp. 9–18, figs. 2–7. Mar. 10, 1953.
No. 3313. Notes on the biology and immature stages of a cricket parasite of the genus *Rhopalosoma*, by Ashley B. Gurney. Pp. 19–34, pl. 1, figs. 8 and 9. Mar. 10, 1953.

No. 3314. *Photuris bethaniensis*, a new lampyrid firefly, by Frank A. McDermott. Pp. 35–37. Feb. 26, 1953.

No. 3315. Distribution, general bionomics, and recognition characters of two cockroaches recently established in the United States, by Ashley B. Gurney. Pp. 39–56, pl. 2, fig. 10. Mar. 10, 1953.

No. 3316. Biting midges of the heleid genus *Stilobezzia* in North America, by Willis W. Wirth. Pp. 57–85, figs. 11 and 12. May 15, 1953.

No. 3317. Beetles of oedemerid genus *Vasaces* Champion, by Ross H. Arnett, Jr. Pp. 87–94, fig. 13. Apr. 30, 1953.

No. 3318. Scarabaeid beetles of the genus *Bradycinetulus* and closely related genera in the United States, by O. L. Cartwright. Pp. 95–120, pls. 3 and 4, figs. 14–16. June 5, 1953.

No. 3319. The chrysomelid beetles of the genus *Strabala* Chevrolat, by Doris Holmes Blake. Pp. 121–134, fig. 17. June 5, 1953.

No. 3320. American biting midges of the heleid genus *Monohelea*, by Willis W. Wirth. Pp. 135–154, figs. 18 and 19. June 17, 1953.

No. 3321. A review of the beetle family Cephaloidae, by Ross H. Arnett, Jr. Pp. 155–161, pl. 5, fig. 20. May 15, 1953.

No. 3322. The fresh-water triclads (Turbellaria) of Alaska, by Roman Kenk. Pp. 163–186, pls. 6–8, figs. 21–25. June 5, 1953.

BULLETINS

200. The generic names of the beetle family Staphylinidae, by Richard E. Blackwelder. iv + 483 pp. July 21, 1952.

203. Life histories of North American wood warblers, by Arthur Cleveland Bent. Pp. xi + 734, 83 pls. June 15, 1953.

204. Catalog of the cycle collection of the Division of Engineering, United States National Museum, by Smith Hempstone Oliver. Pp. vi + 40, 24 pls., 1 fig. May 26, 1953.

CONTRIBUTIONS FROM THE UNITED STATES NATIONAL HERBARIUM

VOLUME 30

Part 5. Studies of Pacific Island plants, XV. The genus *Elaeocarpus* in the New Hebrides, Fiji, Samoa, and Tonga, by A. C. Smith. Pp. i–v + 523–575. [May 8] 1953.

PUBLICATIONS OF THE BUREAU OF AMERICAN ETHNOLOGY

During the year the Bureau issued 1 Annual Report, 5 Bulletins, and 3 papers in the series Publications of the Institute of Social Anthropology, as follows:

ANNUAL REPORT

Sixty-ninth Annual Report of the Bureau of American Ethnology, 1951–1952. ii + 30 pp. [Feb. 6] 1953.

BULLETINS

145. The Indian tribes of North America, by John R. Swanton. Pp. i–vi + 1–726, 5 maps. [Nov. 10] 1952.

150. The modal personality structure of the Tuscarora Indians, as revealed by the Rorschach test, by Anthony F. C. Wallace. Pp. i–viii + 1–120, 1 pl. 8 figs. [Oct. 9] 1952.

151. Anthropological Papers, Nos. 33–42. Pp. i–ix + 1–507, 37 pls., 25 figs., 7 maps. [Mar. 16] 1953.

No. 33. "Of the Crow Nation," by Edwin Thompson Denig, edited, with biographical sketch and footnotes, by John C. Ewers.

No. 34. The water lily in Maya art: A complex of alleged Asiatic origin, by Robert L. Rands.

No. 35. The Medicine Bundles of the Florida Seminole and the Green Corn Dance, by Louis Capron.

No. 36. Technique in the music of the American Indian, by Frances Densmore.

No. 37. The belief of the Indian in a connection between song and the supernatural, by Frances Densmore.

No. 38. Aboriginal fish poisons, by Robert F. Heizer.

No. 39. Aboriginal navigation off the coasts of Upper and Baja California, by Robert F. Heizer and William C. Massey.

No. 40. Exploration of an Adena mound at Natrium, West Virginia, by Ralph S. Solecki.

No. 41. The Wind River Shoshone Sun Dance, by D. B. Shimkin.

No. 42. Current trends in the Wind River Shoshone Sun Dance, by Fred W. Voget.

153. La Venta, Tabasco: A study of Olmec ceramics and art, by Philip Drucker. Pp. i-x+1-257, 66 pls., 64 figs. [Dec. 17] 1952.

155. Prehistoric settlement patterns in the Virú Valley, Perú, by Gordon R. Willey. Pp. i-xxii + 1-453, 60 pls., 88 figs. [Apr. 10] 1953.

PUBLICATIONS OF THE INSTITUTE OF SOCIAL ANTHROPOLOGY

No. 13. The Tajín Totonac. Part 1. History, subsistence, shelter, and technology, by Isabel Kelly and Angel Palerm. Pp. i-xiv + 1-369, 33 pls., 69 figs., 18 maps. [Sept. 22] 1952.

No. 15. Indian tribes of northern Mato Grosso, Brazil, by Kalervo Oberg. Pp. i-vii+1-144. 10 pls., 2 figs., 3 maps, 14 charts. [Apr. 2] 1953.

No. 16. Penny Capitalism: A Guatemalan Indian economy, by Sol Tax. Pp. i-x + 1-230, 6 maps, 19 charts. [June 16] 1953.

PUBLICATIONS OF THE NATIONAL COLLECTION OF FINE ARTS

Contemporary Swiss paintings. (Smithsonian Institution Traveling Exhibition Service). Illustrated. [July 1952.]

Reveries of Paris, by Edwin Scott (1863-1929). Illustrated. [August 1952.]

French drawings. (Smithsonian Institution Traveling Exhibition Service.) Illustrated. [November 1952.]

Pastel portraits by Alice Pike Barney, and Paintings of Paris by Edwin Scott. Illustrated. [November 1952.]

Art and magic in Arnhem Land. (Smithsonian Institution Traveling Exhibition Service.) Illustrated. [November 1952.]

Design from Britain. (Smithsonian Institution Traveling Exhibition Service.) Illustrated. [May 1953.]

PUBLICATIONS OF THE FREER GALLERY OF ART

OCCASIONAL PAPERS

VOLUME 2

No. 1. Fourteenth-century blue-and-white: A group of Chinese porcelains in the Topkapu Sarayi Müzesi, Istanbul, by John Alexander Pope. 85 pp., 44 pls. [July 1] 1952.

REPORT 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 by the act of incorporation of the Association. The following report volumes were issued during the year:

Annual Report of the American Historical Association, 1950. Vol. 2. Writings on American history, 1948. xxxiii + 462 pp. [Oct. 31] 1952.

Annual Report of the American Historical Association, 1951. Vol. 1. Proceedings and list of members. 207 pp. [Apr. 14] 1953.

REPORT OF THE NATIONAL SOCIETY, DAUGHTERS OF THE AMERICAN REVOLUTION

The manuscript of the Fifty-fifth Annual Report of the National Society, Daughters of the American Revolution, was transmitted to Congress, in accordance with law, on January 28, 1953.

Respectfully submitted.

PAUL H. OEHSER, *Chief, Editorial 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, 1953

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 ENDOWMENT FUND

The original bequest of James Smithson was £104,960 8s. 6d.—$508,318.46. Refunds of money expended in prosecution of the claim, freights, 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.

Since the original bequest, the Institution has received gifts from various sources, the income from which may be used for the general work of the Institution. These, including the original bequest, plus savings, are listed below, together with the income for the present year.

ENDOWMENT FUNDS

(Income for the unrestricted use of the Institution)

Partly deposited in the United States Treasury at 6 percent and partly invested in stocks, bonds, and other holdings

Fund	Investment	Income present year
Parent fund (original Smithson bequest, plus accumulated savings)	$728,977.24	$43,726.13
Subsequent bequests, gifts, and other funds, partly deposited in the U. S. Treasury and partly invested in the consolidated fund:		
Abbott, W. L., special fund	5,270.00	52.00
Avery, Robert S. and Lydia, bequest fund	57,267.18	3,031.80
Endowment fund	387,154.40	19,612.18
Habel, Dr. S., bequest fund	500.00	30.00
Hachenberg, George P. and Caroline, bequest fund	4,405.40	223.12
Hamilton, James, bequest fund	2,942.20	172.42
Henry, Caroline, bequest fund	1,324.81	67.09
Hodgkins, Thomas G. (general gift)	149,182.04	8,640.91
Porter, Henry Kirke, memorial fund	313,713.17	15,891.75
Rhees, William Jones, bequest fund	1,108.21	61.67
Sanford, George H., memorial fund	2,075.12	115.37
Witherspoon, Thomas A., memorial fund	141,360.51	7,160.86
Total	1,066,303.04	55,059.17
Grand total	1,795,280.28	98,785.30

The Institution holds also a number of endowment gifts, the income of each being restricted to specific use. These, plus accretions to date, are listed below, together with income for the present year.

Fund	Investment	Income present year
Abbot, William L., fund, for investigations in biology	$114,655.51	$5,786.26
Arthur, James, fund, for investigations and study of the sun and annual lecture on same	43,808.44	2,219.20
Bacon, Virginia Purdy, fund, for traveling scholarship to investigate fauna of countries other than the United States	54,880.05	2,779.99
Baird, Lucy H., fund, for creating a memorial to Secretary Baird	26,373.56	1,335.98
Barney, Alice Pike, memorial fund, for collecting of paintings and pastels and for encouragement of American artistic endeavor	26,477.87	1,341.25
Barstow, Frederick D., fund, for purchase of animals for Zoological Park	1,095.17	55.49
Canfield Collection fund, for increase and care of the Canfield collection of minerals	41,895.57	2,122.29
Casey, Thomas L., fund, for maintenance of the Casey collection and promotion of researches relating to Coleopters	13,730.13	695.53
Chamberlain, Francis Lea, fund, for increase and promotion of Isaac Lea collection of gems and mollusks	30,846.83	1,562.61
Dykes, Charles, bequest fund, for support in financial research	47,166.59	2,388.99
Eickemeyer, Florence Brevoort, fund, for preservation and exhibition of the photographic collection of Rudolph Eickemeyer, Jr.	11,906.67	603.17
Hillyer, Virgil, fund, for increase and care of Virgil Hillyer collection of lighting objects	7,199.12	364.67
Hitchcock, Albert S., library fund, for care of the Hitchcock Agrostological library	1,728.46	87.56
Hodgkins fund, specific, for increase and diffusion of more exact knowledge in regard to nature and properties of atmospheric air	100,000.00	6,000.00
Hrdlička, Aleš and Marie, fund, to further researches in physical anthropology and publication in connection therewith	34,747.61	1,675.31
Hughes, Bruce, fund, to found Hughes alcove	20,967.27	1,062.16
Long, Annette and Edith C., fund, for upkeep and preservation of Long collection of embroideries, laces, and textiles	594.78	30.12
Maxwell, Mary E., fund, for care and exhibition of Maxwell collection	21,485.60	1,088.36
Myer, Catherine Walden, fund, for purchase of first-class works of art for use and benefit of the National Collection of Fine Arts	20,763.96	1,051.81
Nelson, Edward W., fund, for support of biological studies	5,290.60	147.43
Noyes, Frank B., fund, for use in connection with the collection of dolls placed in the U. S. National Museum through the interest of Mr. and Mrs. Noyes	1,052.40	53.33
Pell, Cornelia Livingston, fund, for maintenance of Alfred Duane Pell collection	8,119.55	411.31
Poore, Lucy T. and George W., fund, for general use of the Institution when principal amounts to $250,000	155,971.69	7,757.27
Rathbun, Richard, memorial fund, for use of division of U. S. National Museum containing Crustacea	11,650.56	590.19
Reid, Addison T., fund, for founding chair in biology, in memory of Asher Tunis	31,440.75	1,692.52
Roebling Collection fund, for care, improvement, and increase of Roebling collection of minerals	132,200.95	6,696.88
Rollins, Miriam and William, fund, for investigations in physics and chemistry	102,854.58	5,210.36
Smithsonian employees' retirement fund	30,221.14	1,590.59
Springer, Frank, fund, for care and increase of the Springer collection and library	19,643.49	995.06
Strong, Julia D., bequest fund, for benefit of the National Collection of Fine Arts	10,952.22	554.79
Walcott, Charles D. and Mary Vaux, research fund, for development of geological and paleontological studies and publishing results thereof	486,060.81	21,419.18
Walcott, Mary Vaux, fund, for publications in botany	63,407.02	3,212.10
Younger, Helen Walcott, fund, held in trust	69,077.72	3,120.88
Zerbee, Frances Brinckle, fund, for endowment of aquaria	1,039.05	52.65
Total	1,749,305.72	86,162.30

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 stock and securities to the estimated value of $1,958,591.42, as an endowment fund for the operation of the Gallery.

The above fund of Mr. Freer was almost entirely represented by 20,465 shares of stock in Parke, Davis & Co. As this stock advanced in value, much of it was sold and the proceeds reinvested so that the fund now amounts to $6,951,703.80 in selected securities.

SUMMARY OF ENDOWMENTS

Invested endowment for general purposes	$1, 795, 280. 28
Invested endowment for specific purposes other than Freer endowment	1, 749, 305. 72
Total invested endowment other than Freer endowment	3, 544, 586. 00
Freer invested endowment for specific purposes	6, 951, 703. 80
Total invested endowment for all purposes	10, 496, 289. 80

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	$873, 194. 93	
Stocks	1, 558, 447. 71	
Real estate and first-mortgage notes	6, 071. 00	
Uninvested capital	106, 872. 36	
		2, 544, 586. 00
Total investments other than Freer endowment		3, 544, 586. 00
Investments of Freer endowment (cost or market value at date acquired):		
Bonds	$4, 012, 130. 08	
Stocks	2, 925, 890. 21	
Uninvested capital	13, 683. 51	
		6, 951, 703. 80
Total investments		10, 496. 289. 80

CASH BALANCES, RECEIPTS, AND DISBURSEMENTS DURING FISCAL YEAR 1953[1]

Cash balance on hand June 30, 1952		$511, 063. 79
Receipts, other than Freer endowment:		
Income from investments	$207, 174. 39	
Gifts and contributions	120, 932. 05	
Books and publications	42, 325. 07	
Miscellaneous	30, 612, 65	
Proceeds from real estate	8, 643. 96	
Payroll withholdings and refund of advances (net)	375. 05	
Proceeds from other stocks and bonds (net)	102, 912. 53	
Total receipts other then Freer endowment		512, 975. 70
Receipts from Freer endowment:		
Interest and dividends	$326, 453. 31	
Proceeds from sales and purchases (net)	13, 477. 04	
Total receipts from Freer endowment		339, 930. 35
Total		1, 363, 969. 84
Disbursements other than Freer endowment:		
Administration	$95, 643. 45	
Publications	28, 196. 50	
Library	855. 51	
Custodian fees and servicing securities	1, 260. 72	
Miscellaneous	2, 213. 40	
Researches	194, 674. 67	
S. I. Retirement System	2, 768. 34	
U. S. Government and other contracts (net)	571. 63	
Purchase and sale of securities (net)	130, 637. 20	
Total disbursements other than Freer endowment		456, 821. 42
Disbursements from Freer endowment:		
Salaries	$108, 485. 59	
Purchases for art collection	134, 955. 00	
Custodian fees and servicing securities	10, 494. 99	
Miscellaneous	20, 041. 87	
Total disbursements from Freer endowment		273, 977. 45
Disbursements of current funds for investments in U. S. Government bonds:		
Purchases	$798, 746. 76	
Sold or redeemed	699, 406. 13	
Total disbursements of current funds for investments in U. S. Government bonds (net)		99, 340. 63
Total disbursements		830, 139. 50
Cash balance June 30, 1953		533, 830. 34
Total		1, 363, 969. 84

[1] This statement does not include Government appropriations under the administrative charge of the Institution.

ASSETS

Cash:			
United States Treasury current account	$369, 195. 19		
In banks and on hand	164, 665. 15		
	533, 860. 34		
Less uninvested endowment funds	120, 555. 87		
		$413, 304. 47	
Travel and other advances		16, 252. 81	
Cash invested (U. S. Treasury notes)		699, 594. 60	
			$1, 129, 151. 88
Investments—at book value:			
Endowment funds:			
Freer Gallery of Art:			
Stocks and bonds	$6, 938, 020. 29		
Uninvested cash	13, 683. 51		
		6, 951, 703. 80	
Investments at book value other than Freer:			
Stocks and bonds	2, 431, 642. 64		
Real-estate and mortgage notes	6, 071. 00		
Uninvested cash	106, 872. 36		
Special deposit in U. S. Treasury at 6 percent interest	1, 000, 000. 00		
		3, 544, 586. 00	
			10, 496, 289. 80
			11, 625, 441. 68

UNEXPENDED FUNDS AND ENDOWMENTS

Unexpended funds:			
Income from Freer Gallery of Art endowment			$477, 020. 89
Income from other endowments:			
Restricted		$246, 696. 79	
General		126, 323. 90	
			373, 020. 69
Gifts and grants			279, 110. 30
			1, 129, 151. 88
Endowment funds:			
Freer Gallery of Art		$6, 951, 703. 80	
Other:			
Restricted	$1, 749, 305. 72		
General	1, 795, 280. 28		
		3, 544, 586. 00	
			10, 496, 289. 80
			11, 625, 441. 68

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 $871.17.

In many instances, 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 United States Treasury.

The foregoing report relates only to the private funds of the Institution.

The Institution gratefully acknowledges gifts from the following:

Brittain Thompson.
Laura D. Barney, additional gift for the Alice Pike Barney memorial fund.
Rose Banon.
Robert M. de Calry.
Guggenheim Foundation, grant for Honey Guide Bird Publication.
E. A. Link, Link Aviation Corporation, additional gift for historical research (marine archeology).
Dr. R. C. Moore, for illustrations fund for Foraminifera.
National Science Foundation, for research, Descriptive Flora of the Fiji Islands.
National Science Foundation, grant for foreign exchanges.
Edward W. Nelson, for biological studies.
National Geographic Society, for archeological work in Panama.
Research Corporation, for Canal Zone Biological Area.

The following appropriations were made by Congress for the Government bureaus under the administrative charge of the Smithsonian Institution for the fiscal year 1953:

Salaries and expenses	$2,419,500.00
National Zoological Park	615,000.00

In addition, funds were transferred from other departments of the Government for expenditure under the direction of the Smithsonian Institution as follows:

Working fund (transferred to the Smithsonian Institution by the Institute of Inter-American Affairs)	$24,287.37
Working funds, transferred from the National Park Service, Interior Department, for archeological investigations in river basins throughout the United States	122,700.00

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.

The report of the audit of the Smithsonian private funds follows:

WASHINGTON, D. C., *September 8, 1953.*

TO THE BOARD OF REGENTS,
Smithsonian Institution,
Washington 25, D. C.:

We have examined the accounts of the Smithsonian Institution relative to its private endowment funds and gifts (but excluding the National Gallery of Art and other departments, bureaus, or operations administered by the Institution under Federal appropriations) for the year ended June 30, 1953. Our examina-

tion 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.

The Institution maintains its accounts on a cash basis and does not accrue income and expenses. 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 financial statements present fairly the position of the private funds and the cash and investments thereof of the Smithsonian Institution at June 30, 1953 (excluding the National Gallery of Art and other departments, bureaus, or operations administered by the Institution under Federal appropriations) and the cash receipts and disbursements for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

PEAT, MARWICK, MITCHELL & CO.

Respectfully submitted.

ROBERT V. FLEMING,
VANNEVAR BUSH,
CLARENCE CANNON,
Executive Committee.

GENERAL APPENDIX

to the

SMITHSONIAN REPORT FOR 1953

284725—54——12

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 1953.

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.

Science, Art, and Education[1]

By R. E. Gibson

Director, Applied Physics Laboratory
The Johns Hopkins University

"The old order changeth, yielding place to new,
And God fulfills Himself in many ways,
Lest one good custom should corrupt the world."
Tennyson—*Morte d'Arthur.*

Extensive changes in the scope and character of scientific research have taken place during the past 75 years. Scientific research began as a private activity of interest to a few inquiring minds, pursuing knowledge for its own sake and their own esthetic satisfaction. It has grown to be an activity of widespread public interest cultivated for results that have an immediate and far-reaching effect on economic, social, political, and military thought and action. This change has proceeded at an ever-increasing rate. Its extent may be appreciated when we consider the large sums of money now devoted by the industries and government of this country to the support of scientific research, and remember that only 40 years ago Moseley thanked another college at Oxford for the loan of a vacuum pump that made possible his classical experiments in the X-ray spectra of the elements.

For reasons we shall explore later, it was inevitable that science and scientific research should emerge into a dominant role in modern technology and that concomitant changes should occur in the outlook of educational and research institutions. The enrichening effect of technology on our material civilization is unquestionable, and the continued extension of the role of science in technology is imperative, if we are to preserve ascendancy in a world of keen economic and military competition. We may, however, wonder about the increasing involvement of universities, of centers of original scientific thought, and of individual scientists in the maelstrom of practical affairs through the magnetic effect of the large financial support available from industrial and governmental sources. The study of science

[1] This paper is based on articles that appeared in the American Scientist, vol. 41, pp. 389–409, 1953, and the Armed Forces Chemical Journal for July 1953, and other unpublished lectures given by the author.

started as an intellectual pursuit, and it still offers to mankind contributions that transcend purely materialistic considerations. Herein lie its points of contact with the other esthetic and intellectual activities, and its disciplines and methods, whose value in cultivating discrimination and judgment in the average citizen constitutes one of the strongest educational assets of our time. It is possible that this side of science is being neglected and depleted by excessive preoccupation with material advances. This is one of the problems arising from the accelerating growth of scientific technology, and its solution demands the establishment of a balanced perspective in which to view the kaleidoscopic scene presented by our times.

In order to develop a background for considering the delicate balance between material progress on the one hand, and the search for new truths on the other, I propose to look again at the incentives and objectives of science and the useful arts and to sketch a simple pattern by which we may trace fundamentals through the maze of modern technology. To achieve this balanced perspective, we shall attempt to bring out resemblances and differences that exist between the sciences and the arts, and consider human attributes and relationships involved in their cultivation. This will lead us to the implications of the growth of scientific technology in education, and consequent expansion in the scope of universities and colleges. Finally, we shall note that the meager influence of scientific thought on the intellectual outlook of society at large suggests that there are ideas arising in the field of natural philosophy which might be profitably transplanted into the field of moral philosophy.

THE USEFUL ARTS

From earliest times, man has sought by the use of his intelligence and skill to adapt the resources of the physical world to the enhancement of his own welfare, comfort, and security. Thanks to his capacity for conceptual thought and his ability to communicate thought through true speech, man has been able to preserve the results of his efforts in a cumulative tradition. Thus, there arose over the centuries the practice of the "useful arts," an activity that has supplied all the material benefits which mankind has enjoyed and on which its very existence depends. "Art" is a word used in a variety of senses, but I suggest that in its principal connotation it refers to the reduction of a complex of ideas to a form that appeals directly to the emotions of man. This is a definition that covers the art of the painter, the musician, the actor, and the poet, as well as that of the weaver or designer, the silversmith, the engineer, and the physician. The incentives of the useful arts lay in a realization of the needs or wants of society, of possible markets, and of military or economic problems. The methods used by artists and artisans were purely empirical, based

on individual training, skill, ingenuity, or experience. Imaginative ability to perceive, weigh, and integrate intuitively the many elements of a complex phenomenon and to express the results of this intuition in tangible form or communicable pattern is an essential trait of the successful artist. By these attributes, artists through the centuries have been able to reduce to readily apprehended or useful forms complexes of ideas they did not understand explicitly, by rules or practices learned by empirical cut-and-try methods. Thus, the useful arts and industries were founded on complex rules and procedures of purely local or specific application which were often the result of years of patient and groping search. Frequently these rules and procedures were so specific in their application that a slight departure from standard practice resulted in failure. It is not surprising, therefore, that trade secrets were one of the most highly valued possessions of each art or craft. Teamwork was not a characteristic of the arts. Departures from standard practice were discouraged, and the extension of an art or the creation of a new one depended on chance or on individual intuition.

In the intensely competitive atmosphere of the modern world, the traditional methods of the arts with their reliance on the expert and his rules have proved to be inadequate and uncertain. Industries have turned more and more to science for assistance in advancing the arts on which they depend.

NATURAL PHILOSOPHY

"Science," says C. N. Hinshelwood, "is not the mere collection of facts, which are infinitely numerous and mostly uninteresting, but the attempt of the human mind to order these facts into satisfying patterns . . . The imposition of design on nature is in fact an act of artistic creation on the part of the man of science, though it is subject to a discipline more exacting than of poetry or painting."[2] I subscribe without reservation to this statement, which places as the principal objectives of science the study of human experience, the establishment of the validity of this experience, and the fitting of valid experiences into satisfying patterns or structures, which can be communicated unambiguously to others. The great contribution of Newton was not the observation that apples fall, but the fitting of this fact into the same pattern that describes the motion of the planets in their orbits and the expression of this pattern by a general formula.

Thus, while the byproducts of scientific research may be items of such importance as new instruments, new materials, new machines, the amassing of data—or even the creation of new sciences such as electronics or nucleonics—its unique objective is the systematization

[2] Hinshelwood, C. N., The structure of physical chemistry. Oxford, 1951.

of valid human experience in satisfying patterns that can be described exactly. This attempt to fit valid experiences or facts into satisfying patterns with the help of the cohesive bond of a system of logic is important from three points of view. In the first place, it facilitates comprehension. An established pattern is an excellent aid to memory; we can carry around a great deal of knowledge merely by remembering the pattern and not overburdening ourselves with isolated facts. This increases the power of the human mind to comprehend its cumulative experience; I need hardly remind you that such a pattern is exemplified by the laws of thermodynamics and the theory that makes possible rigorous deductions from them. This pattern embraces a large fraction of the experience of chemistry and engineering. In the second place, a pattern gives us a basis for understanding by bringing out relationships among isolated facts or events. We understand new experiences when we can express them in terms of experiences already familiar to us. In the third place, a satisfying pattern always suggests extensions of itself and, thereby, gives a sound and fertile foundation for the prediction of new facts or events. In short, a satisfying pattern (or theory) enables us to mobilize knowledge for immediate use, not only in the domain of pure science but also in the domain of applied science.

Over the course of three centuries this quest for understanding has developed a natural philosophy whose foundations have become progressively simpler and whose logic has grown more powerful. The elements of the satisfying pattern have become simpler, its design more apparent. Its realm of application has broadened from the simple mechanics of Newton to cover the various branches of modern physics, chemistry, and engineering, and it is rapidly embracing the more chaotic experience of biology and medicine. Indeed, the pattern has become more than satisfying; it has become compelling. When our experience does not fit the pattern, our first reaction is to make sure that the experience is valid and not vitiated by some instrumental error or oversimplification of the conditions of observation. Sometimes the pattern itself must be changed radically, as occurred with the introduction of the relativity theories and quantum mechanics, but these changes merely enlarged the whole pattern, requiring the rearrangement but not the abandonment of the existing elements of design. Like a piece of fine tapestry, the pattern of natural philosophy is made up of numerous smaller patterns, each of which has an artistic consistency in itself and in its relation to others. As scientific knowledge has grown, broader patterns have become apparent; the detailed design has merged into a consistent whole without loss of individual identity.

The foregoing discussion is summarized graphically in figure 1, where the incentives and objectives of the sciences and the arts are given. The right-hand column represents the useful arts, whose incentives are the realization of a need or a market, the desirability of a new luxury, or the urgency of a new weapon of defense. Its methods are purely empirical, the work of the expert and the inventor. Its objectives are commodities or other tangible products for use or ornament that appeal directly to the emotions. The byproducts of the arts are new facts, new materials or techniques, or new problems. The practice of useful arts is a clear-cut human activity whose utility is apparent and whose definition is relatively easy. On the left-hand side is a column representing pure science, a private activity whose

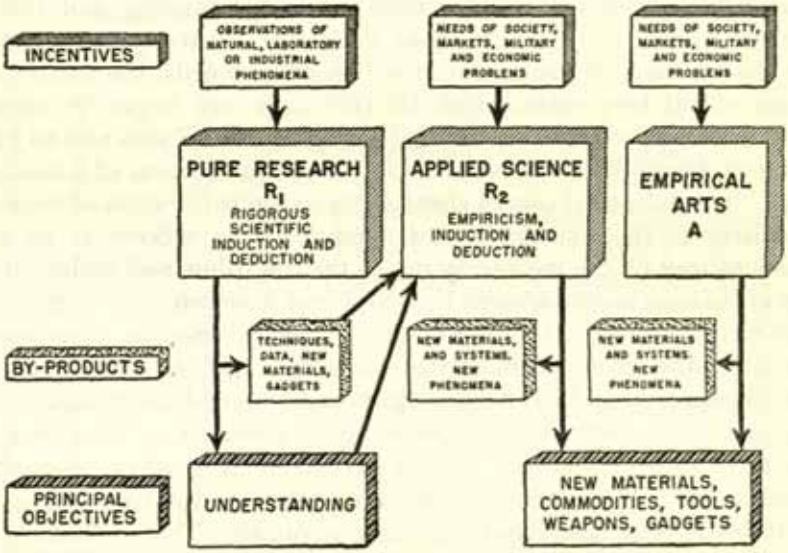

FIGURE 1.—Relationship between pure and applied science and the arts.

incentives lie in the desires of individuals to widen human experience by the collection of new facts or in the curiosity of individuals to explain new phenomena. Its chief product is understanding. The methods of pure scientific research involve, first, the establishment of the validity of the experience involved, i. e., the establishment of scientific facts, and second, the fitting of these facts into satisfying patterns (theories) to achieve comprehension, understanding, and power of prediction.

Although I have labeled new substances, new instruments, new techniques, etc., as "byproducts" in order to simplify our definitions, I do not underestimate their importance. Indeed, they are part of a very important closed circuit. In order to extend and integrate their patterns, to make them more and more satisfying, scientists have

found it necessary to explore into every region susceptible to precise observation. The history of natural philosophy has been marked by milestones, each indicating the discovery of a new device or technique which opened up to human experience regions that were hitherto inaccessible. These devices were means to an end, but the end would never have been achieved without the means. Telescopes, microscopes, X-ray diffraction apparatus, chemical analysis, cyclotrons, and rockets have all been means of opening up new areas for valid experiences—there are more to come.

APPLIED SCIENCE

About one hundred years ago, natural philosophy reached a stage where it could make significant contributions to the useful arts by providing for them a broader basis for understanding and consequently making predictions about the processes and products that are the business of the useful arts. In other words, the satisfying patterns had been extended so far that they now began to accommodate the experiences already gained in the useful arts and to predict new possibilities for application in the production of commodities. The industrial uses of electricity and the application of organic chemistry to the manufacture of synthetic dyes ushered in an era characterized by the increasing use of the discipline and understanding of science to supplement the empirical knowledge and intuitive skill characteristic of the useful arts. This has resulted in an acceleration of the development of the new technologies on which modern life depends. Practical technologists have sought more and more to broaden the basis of their operations by drawing on the power of the satisfying patterns of human experience to predict promising directions for advancement of their arts and for the cure of the inevitable troubles associated with new advances. This admixture of thought and action, of understanding and practical knowledge, known as applied research, is now the basis of all progressive technology either in peace or in war; however, its organization, direction, objectives, and even its meaning are subject to considerable argument.

In figure 1, I have indicated applied research in the center column as having the same incentives and objectives as the useful arts; however, the methods are different. In figure 2, an attempt is made to illustrate in more detail the place of applied research in the over-all scientific and technological scheme of things. The realism of this diagram depends on the use of closed loops or circuits, rather than straight-line flow patterns, to depict the interrelationships. The idea of closed-loop relations is borrowed from the technical fields of electronics and automatic control (although it dates far back in organic evolution). It requires little imagination to see that any organization designed to make the best use of collective human intelligence

must involve a complex network of feedback loops in which ideas are generated and regenerated by their transfer from one field to another.

On the left side of figure 2 we see a "red" circuit involving pure research—the step between curiosity and understanding. Since understanding leads to keener, more intelligent, and more powerful observations, a positive feedback exists in this circuit and ideas build up rapidly. The growth of centers of research and the tremendous increase in the size and number of scientific journals bears eloquent testimony to the effectiveness of this feedback. On the right, the useful arts are represented by their modern counterpart, development

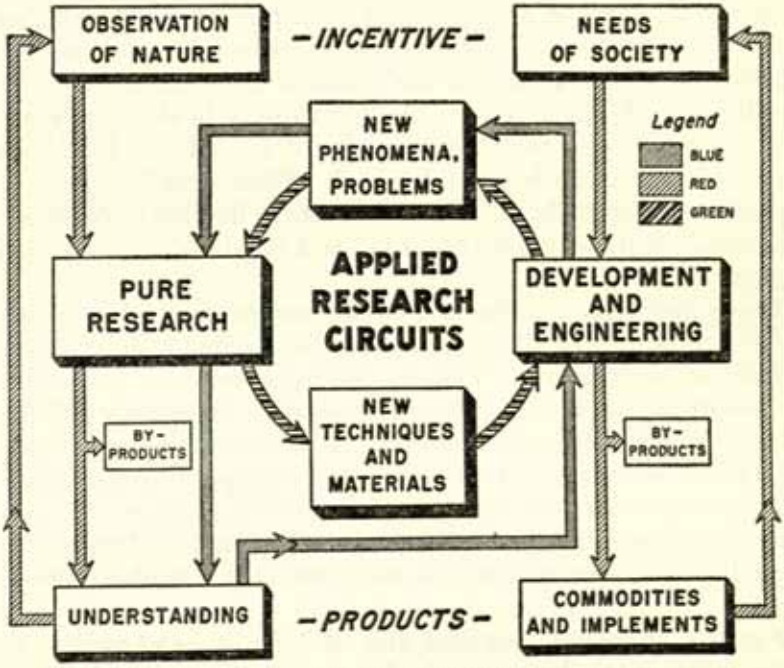

FIGURE 2.—Regenerative circuits in science and technology.

and engineering, the step leading from the awareness of a need or market to a commodity to supply the need. New products stimulate the desire for newer products and a positive feedback exists in this circuit also—a feedback fortified by competition and profit motives. In the military field, this positive feedback is particularly pronounced. The development of a new weapon of offense demands immediate advances in weapons of defense and vice versa. We can expect the amplitude of the current in this circuit to build up at ever-increasing rates, and the history of technological output of this country in the past 20 years is ample evidence of this buildup. In between the two extremes, represented by the red circuits, lies the region of applied

research, the region in which most of our larger research institutions now operate. I have purposely refrained from representing applied research by a block with special incentives and objectives but have used, instead, two circuits to typify its functions.

The "blue" arrow indicates the demands of development and engineering for understanding. In the course of a development, new phenomena may be encountered or problems arise that require elucidation from a broad point of view. If brought to his attention, these stimulate the interest of the scientist, and the understanding resulting from his researches feeds back to broaden the basis on which the development rests, to predict promising modifications, or suggest remedies for troubles. The development of high-performance jet engines furnishes an excellent example of the working of the "blue" circuit. These engines depend on combustion reactions in gases moving at relatively high speeds, and in the course of their development many significant problems have been brought to light in chemical kinetics, fluid dynamics, and thermodynamics—the need for a fundamental theory of flames has been accentuated. These problems have challenged the research physicists and chemists to develop understanding, and already their results are being fed back into the design of practical engines.

The "green" arrow indicates a circuit energized by what are essentially byproducts in the quest for understanding, new substances, techniques, or principles. The outstanding example of this circuit is the use of atomic energy, which applies on a large scale substances and techniques that were completely in the domain of pure research only a few years ago. Another current example is a byproduct of solid-state physics (one of the more academic subjects in modern physics), namely, transistors. The "green" circuit has already started to oscillate in the transistor field, and a revolution in electronics is in process.

Figure 2 presents a simplified and unified picture of modern technology, the interlocking world of technical thought and action in which the professional scientist works and for which he must be educated. It suggests several interesting points: (1) The intrinsic place of pure research as a necessity and not a luxury in the integral scheme of technology is brought out; pure research is the source of understanding, the catalyst of technological progress. (2) The diagram is noteworthy for the absence of any mechanism for negative feedback or automatic volume control in any of the circuits. In the long run negative feedback may be needed for stability, but in the meantime explosive buildup in any of the circuits is inhibited by such attenuation or friction-damping factors as the shortage of well-

trained, imaginative men, impedances in communications, or limitations on capital for extension of facilities. (3) The diagram emphasizes the need for good communications between fundamental research and engineering if we are to realize and use most effectively the catalytic effect of understanding so necessary in a world dominated by intense economic and military competition. This part will be enlarged upon later.

Figure 2 also suggests a reason why it is so difficult to define or classify applied research in terms of conventional organizational concepts. The incentives of applied research are varied, for they may be either the realization of a need or a market, or the conviction that a new idea may, upon conversion to practice, create a need or a market. The chief products of applied research are commodities, but understanding is a byproduct. Applied research bridges the gap between activities carried out for intellectual satisfaction and those whose aims are materialistic. Nor is it remarkable that such an activity eludes simple definition and organization; applied research can perhaps best be described as teamwork between those who think and those who do.

Perhaps the outstanding contribution of the Western nations to civilization is the application of natural philosophy to accelerate and extend the progress of the useful arts. The increase in the productive capacity of the individual worker, achieved in these nations through technology, has made possible for the majority of their populations a standard of material welfare unequaled in the history of man.

SCIENCE AND CREATIVE ART

Art and science have come to be regarded as entirely separate and even antagonistic human activities. Indeed, there has grown up a legend which represents the scientist as a cold-blooded, objective dealer in facts and figures, whose imagination, if any, is narrow and distorted, a man with whom esthetic sensibilities are not associated, and who possesses a "scientific mind," a relentless logical machine endowed with undefined mental characteristics beyond the reach of ordinary humanity. At the same time, the artist is associated with loose living and looser thinking, a genius dealing with abstractions from the penumbra of human experience, whose creations are entirely subjective in meaning, luxuries rather than necessities in the world of reality. I need hardly add that both these legends are quite misleading.

A very significant change is in progress; the kinship between the creative artist and the scientist is being rediscovered and reaffirmed, and scientists, it seems, are taking the initiative in this movement.

The quotation I made from Hinshelwood's "Structure of Physical Chemistry" is an example. I should like to quote two other passages expressing the same thought:

> We have a paradox in the method of science. The research man may often think and work like an artist, but he has to talk like a bookkeeper in terms of facts, figures and logical sequence of thought. [H. D. Smyth, quoted by Gerald Nolton in American Scientist, vol. 41, p. 93, 1953.]

> The great scientist must be regarded as a creative artist and it is quite false to think of the scientist as a man who merely follows rules of logic and experiment. [W. I. B. Beveridge, "The Art of Scientific Investigation," 1952.]

It has been realized for a long time that the choice of a fruitful research problem, the selection of a fertile hypothesis, and the genesis of a brilliant theory are decisions whose quality differentiates the greater scientist from the lesser. They are decisions for which no rules of logic exist but in which the imagination and the intuition of the investigator play the dominant part. In this sense the great scientist is also an artist, and his imposing of a pattern on nature is definitely an artistic creation.

However, we may go further in establishing an affinity between art and science along lines that were laid down by Martin Johnson a few years ago in an interesting book entitled "Art and Scientific Thought—Historical Studies Toward a Modern Revision of Their Antagonism." The creative artist is one whose imagination gives him a penetrating insight into the significance of human experience, and whose craftsmanship enables him to build this insight into a pattern or structure by which it is communicated to sophisticated observers. In a disciplined art imagination does not become fantastic but weaves ideas into a pattern that awakens the observer to a transcending realization of some truth or experience. The actual ideas conjured up in the mind of one observer may, however, differ in detail from those of the artist or those of some other observer, depending on their past experiences. Compare this with the work of the creative scientist whose imagination sees the significant facts in certain phenomena and leads him to weave these facts into a satisfying pattern that he can communicate to others. The resemblance is obvious, but there is one important difference; the patterns (theories) of the scientist must be communicable to his audience in such a way that formal deductions and interpretations made by each individual agree exactly with those of any other individual and with those of the author. This quantitative communicability of patterns of fact is the characteristic that differentiates science from art and, even more, that provides the only criterion for the validity of the scientist's facts and patterns. As Martin Johnson remarks,[3]

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[3] Art and scientific thought, p. 42. New York, 1949.

. . . the work of scientist and artist alike is the presentation of Form, Pattern, Structure, in material or in mental images. For the work of either to fulfill its function it must be communicable; the hearer, reader, or beholder of the work of art must in the end find coherence and feeling from the images aroused in his own mind, and the verifier of the scientific theory must be able to reproduce in his own mathematics and experiments the measurable facts communicated. The most obvious divergence between art and science is that any number of responding personalities to a work of art will find themselves creating any number of differing emotional patterns: on the other hand, the numerical verification of a scientific theory is unique, all the different scientific minds converging upon identity. They invoke this identity as the only test that the communication of the pattern of electrons or atoms or time and space measurements is valid. The identity is possible because the subject of physical science is confined to the measurable, whereas the subject of the arts is qualitative, not quantitative. With this distinction guarded, the physicist and the imaginative artist might learn to see in one another the reflection each of his own aim, discipline, and method.

Aside from establishing a basis for interaction between two great human activities, and thereby strengthening both, the foregoing considerations have implications of great interest in science. In the first place, they point up the need for a constant flow of imaginative workers into the fields of basic and creative research. A liberal education in school and college is the best vehicle we have today for cultivating both imagination and powers of communication. A feeling that the physical sciences are an integral part of human knowledge and experience, and not the specialized preoccupation of a few odd characters, promotes the formation of a climate in which imaginative men wish to devote their lives to research. This subject will be discussed in more detail later.

In the second place, these considerations suggest that quantitative communicability of facts and patterns is a fundamental, if not *the* fundamental, characteristic of science. Imagination enters into the ordering of the facts into satisfyinig patterns or theories and in the perception of the implications of the patterns but not into the interpretations of the communications the listener receives from the author. Results are valid scientifically only when they can be communicated to any serious and intelligent listener, conveying to him a meaning which is exactly that intended by the author—a quantitative description of experience that the listener can verify independently. The scientist must have the power of exact expression—nowadays this generally means a facility with mathematics, but this is not all; the pattern he wishes to communicate must also be capable of exact and unambiguous expression and interpretation.

There are three further interesting implications of the requirement for exact and quantitative communicability in science:

(1) It has placed severe limitations on the subjects available up to now for scientific study. These subjects must be so simple that all

the significant variables can be isolated, expressed quantitatively, and related by some logic such as mathematics. As the patterns of science are extended, their ability to include more complex subjects grows exponentially and the limits of their application are still far away. Indeed, if we follow H. Dingle and use the term "valid human experiences" rather than "facts," we see that the application of sciences may extend beyond the physical world of the Victorians. In the meantime, however, there are areas of such complexity and haziness that they are currently beyond the reach of exact science and must, as yet, be left to the artist.

(2) The requirement for quantitative communicability has led to a steady monotonic progress of science from one generation to another, knowledge fulfilling this requirement being immune to the vagaries of fashion which cause periodic fluctuations of value in the creations of the artist. The young scientist of today sees the universe from a vantage point on the shoulders of the giants of the past, the inheritor of a cumulative tradition which enables him to attack problems that were impossible in bygone years. The steady progress of science, contrasted with the cycles of opinion in the arts, is the reward the scientist receives for confining his attention to simple subjects and avoiding the siren call of the colorful wildernesses of human experiences. The steady progress of science over the last 300 years, contrasted with the changing natural philosophies of the previous millennia, leads us to speculate about natural selection in the survival of systems of knowledge. Was it a happy accident that Galileo, Newton, and others stumbled on a pattern that has been capable of continuous extension, that accommodates such a range of valid experiences, and that had the property of quantitative communicability?

(3) In regions simple enough for the application of science, consistent patterns of knowledge and quantitative communicability give to the inexperienced and even mediocre practitioner powers that otherwise are gained only after long experience by the highly accomplished expert. For example, the brilliant and experienced surgeon may look at a patient and with unerring intuition decide that he needs a blood transfusion, but he cannot communicate exactly to his students the complex integration of observations that leads him to this conclusion; they must have experiences similar to his before such communication is possible. If, however, the problem is simplified by systematic study to a point where the necessity for a transfusion can be correlated exactly with the presence or absence of definite amounts of identifiable substances in the blood, and methods for measuring these are devised, then a pattern that is exactly communicable is developed which even the novice can completely apprehend and apply with confidence.

Up to this point we have discussed science, the creative arts, and the useful arts and shown, I think, that these have much in common, all containing the elements of pattern and communicability. In science and the useful arts, the pattern and its elements (facts) must be susceptible to quantitative and exact communication so that the reader develops identically the meaning the author tries to give. Perhaps the chief difference between science and the useful arts is that the former strives toward patterns of general and even universal comprehensiveness, whereas the latter is content with patterns of very local application. The creative arts strive for patterns of universal comprehensiveness, but their communicability is qualitative rather than quantitative.

In the light of these thoughts, the quotation from H. D. Smyth takes on a meaning that was not apparent before; the scientist works like an artist in making his patterns and like a bookkeeper in his communications.

ATTRIBUTES OF MIND IN RESEARCH

In commenting on figure 2, we noted the integrated role played by pure, or basic, scientific research in developing patterns of understanding to catalyze technological advances. This role is being realized more and more, but it is by no means ingrained deeply in the minds of those who have power to affect the research and development policies of universities, industrial firms, and nations. There is at present grave concern that there is a shortage of basic research in this country, that the applied sciences with their greater material rewards are draining away the remaining resources that are available for the cultivation of pure science, and that we face a bankruptcy of ideas for future developments. A real problem exists. It is a problem whose ramifications extend much further than the need of understanding on which to build tomorrow's technologies and whose roots lie in the substratum of philosophy. Its solution involves much more than short-range material considerations. In discussing this subject let us first consider the attributes of mind and the education of the research scientists who are the effective agents in producing oscillations in the pure-research circuit.

If we take a cross section of productive research workers in this country, perhaps by studying the authors of articles in the better journals, we find represented several kinds of minds which may be classified as: (a) the Promethean, (b) the critical or analytical, (c) the cumulative and inductive, (d) the cumulative and descriptive, (e) the meticulous, (f) the routine-industrious. It is evident that more than one of these attributes may be found in any given individual, although one will generally predominate. (a) The Promethean

mind tries to inject something radically new into anything it does. It may provide the flash of genius that shows up a new continent of knowledge or gives rise to a new all-embracing theory. It may throw new light on old tough problems. It may just invent an easier and better way of performing an experiment or making a commodity. It is a mind that transmutes ideas from one field of experience to another. (b) The critical or analytical mind takes nothing for granted, but examines keenly all statements presented to it, probing deeply into their consequences for consistency and rigor. It is the questioning mind so needed for clarification of complex situations and for establishing the validity of experience. (c) The cumulative-inductive mind ranges in the literature and in experiment, collecting facts and attempting to put them roughly in order. It is a type of mind that has contributed, for example, largely to physical chemistry. It is a type of mind that makes local elements of pattern. (d) The cumulative and descriptive mind is that of the trained and keen observer who remembers what he sees and describes it clearly for others to read. It is the mind that has laid the foundations of the complex sciences of astronomy, geology, and natural history. It is always evident on the frontiers of knowledge and is the stock-in-trade of the effective teacher. (e) The meticulous mind is concerned about the correctness of all details in observation, procedure, and processes. It is concerned with the search for accuracy and precision. (f) Finally, we have the routine-industrious mind that follows through relentlessly, especially where many experiments are needed to establish one fact and where repetitive processes are of the essence.

History has shown that all these mental attributes have important roles to play in the sound and steady growth of all branches of science and engineering, and we should be guilty of crass intellectual snobbery if we discounted any one of them. The meticulous worker who spends years establishing the real facts in a complex phenomenon or in perfecting a technique, or the routine-industrious man who explores an area thoroughly by a long series of measurements, provides means and materials for the inductive thinker and the creative artist, materials they might not be able to get for themselves. The critical mind keeps thought and observations on the track, saving costly detours along false trails. Each has his place, and the secret of the efficient use of manpower either on a laboratory scale or on a nation-wide basis lies in assigning to each mind a job suited to its attributes and carrying with it recognition of contributons to a worthwhile objective.

Throughout the centuries, the progress of science has depended on teamwork. Although each investigator planned and carried out his work in a very private manner, he took care to make his results public

as soon as possible through communications to colleagues in various parts of the world or through articles in journals. As a result, the work of any investigator became available to others for criticism and extension; in short, all attributes of mind could be brought to bear on a scientific topic once it had been formulated and exposed by an investigator. An unorganized, but none the less effective, team made up of men from all nations quarried and polished the stones of which the structure of science is built.

Two thoughts prompted by the previous paragraph may be mentioned in passing: (1) In areas of work where national safety requires a high security classification, it is impossible to use the method of publication to enlist the services of all the attributes of mind necessary on a team. Special efforts should be made, therefore, to ensure that all security-classified fields of work are furnished with teams diversified enough to have within themselves all the attributes of mind necessary for a sound and critical program of research and development. (2) Problems in the distribution and employment of manpower might be approached more realistically on the basis of the mental attributes of scientists and engineers (similar to those I have enumerated) rather than on the basis of their professional training alone. There are many examples of chemists who do excellent jobs as engineers or administrators and still retain their interests in chemistry, but if Promethean minds are set to work on routine problems, or if routine-industrious minds are given problems that depend on creative ability even in the field of their own training, frustration of the men, mediocrity of the product, and a general waste of manpower are the results.

Returning to our main theme, I should like to suggest that the alleged shortage of basic research in this country really means that we need more creative and imaginative minds in our national portfolio of scientific assets. The catalytic effect of a creative piece of work in providing new and speedier channels along which men with other attributes of mind can effectively devote their efforts is a phenomenon that has been demonstrated time after time in the history of pure science. I recognize fully the importance of all attributes of mind in the development of science, and of fundamental training in scientific discipline, of the acquisition of habits of careful observation and critical reasoning together with the cultivation of experimental skill as ingredients in the education of a research scientist. However, an alert mind and a fertile but disciplined imagination are characteristics that are indispensable to the scientist whose work is to rise above mediocrity and blaze trails for others to follow. I also wish to emphasize that we need more young imaginative workers who can sense the significant problems, plan original methods for their solution,

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and point out ways in which the patterns of knowledge may be fruitfully extended or enriched if our national scientific effort is to be more than pedestrian.

The place of imagination in science was emphasized by Francis Bacon in the Novum Organum:

> Those who have treated of the sciences have been either empirics or dogmatical. The former, like ants, only heap up and use their store; the latter, like spiders, spin out their own webs. The bee, the mean of both, extracts matter from the flowers of the garden and the field, but works and fashions it by its own efforts. The true labor of philosophy resembles her, for it neither relies entirely or principally on the powers of the mind nor yet lays up in the memory the matter afforded by the experiments of natural history or mechanics in the raw state, *but changes and works it in the understanding.* [The italics are mine.—R. E. G.]

Bacon's contributions to the techniques of acquiring knowledge arose from his realization that in matters relating to problems of fact the function of the mind is one of transmutation. Ideas culled from one set of experiences may be digested by the mind, transformed, and applied with creative results to problems presented by another set of experiences. In the isolated mind, ideas are neither created nor destroyed.

The history of science is full of illuminating examples; I shall mention one to illustrate a point I wish to make. In the last half of the nineteenth century, organic chemistry was changed from an unwieldy collection of facts into an esthetically satisfying science by the systematic application of a few hypotheses concerning the nature of the carbon atom, its valency, and its ability to join with itself and other atoms to form geometric structures. The name of August Kekule is permanently associated with this major scientific advance. In early life, Kekule set out to be an architect and studied this subject at the University of Giessen. Under Liebig's influence, he became interested in organic chemistry, but instead of following the usual routine of student, assistant, *privat docent*, and so forth, at Giessen, he left the University after finishing his course and wandered around the scientific centers in Paris and London. Here he met the foremost thinkers of his time and, to quote his own words: "Originaly a pupil of Liebig, I had become a pupil of Dumas, Gerhardt, and Williamson. I no longer belonged to any school." Kekule's reveries on top of a London bus or before the fire in his study at Ghent are well known. In these dreams, the ideas of form and structure, gathered from his experience as an architect, were interwoven with the ideas and problems arising in his chemical studies. He saw atoms dance before his eyes, arranging themselves in structures and manifold conformations. He awoke and spent the night writing down the substance of his reveries. This was the beginning of the theory of the structure

of molecules. In describing the reveries that led him to the hypothesis of the structure of benzene, he closes with the remark: "Let us learn to dream, gentlemen, then perhaps we shall find the truth, but let us beware of publishing our dreams before they have been put to the proof of our waking understanding." Let us also beware of trying to dream like Kekule before we have had his experience; the mental inventory of the research worker determines whether he is a day dreamer or the possessor of a fertile imagination.

In my opinion, this example bears directly on the problem of the shortage of basic research. The present situation will not be remedied by turning out more highly skilled but unimaginative technical men from the colleges, nor by pouring more funds into the support of mediocre institutions where they work. At most, the returns will be small compared with the effort expended. The remedy lies in providing embryo research scientists with an education calculated to sharpen the alertness of their minds and strengthen their imaginations. This is, of course, easier said than done, but a few suggestions for possible action may be developed from the foregoing discussion.

EDUCATION AND IMAGINATIVE RESEARCH

In the first place, we should recognize that imagination flourishes only in minds stocked with a choice and varied inventory of knowledge. On the average, the graduates of our universities have an excellent store of knowledge in one or two technical fields, but all too often their education is confined to these fields only. Although their capacity for imaginative thinking may be great, they have no extensive background in literature, the humanities, the fine arts, or other branches of human activity from which to generate novel ideas for transplantation into scientific fields. A number of colleges have recognized this need and are attempting to broaden the education of their students. This is a step in the right direction, but at the college level the acquisition of fundamental training in the methods and discipline of the sciences and of the specialized knowledge necessary to begin research work requires almost the full attention of the student. In my opinion, survey courses have little of real value to offer, although they might serve as dessert in the nutrition of the young imagination.

Breadth of knowledge should first be cultivated at the grammar-school or high-school level where attention can be given to enlarging the intellectual repertoire of the better students without overworking them. Experience in the British and European schools indicates that facility in the use of language and logic and a wide permanent knowledge of literature, history, and the arts can be attained by a student at the age of 18. The average intellectual development of a British

or French student on leaving a secondary school is comparable to that of a student entering his junior year at college in this country. Now the task of making a radical change in a body whose inertia is as great as that of our public-school system is one which no one can face lightly. However, our requirements do not call for thousands of highly educated scientists but only for scores or, at most, hundreds.

Realizing that in education the private schools and universities are the pacemakers in setting new standards, I suggest that the problem might be approached by arousing the interest of a few forward-looking schools and encouraging them by financial help to adjust their curricula to meet the objectives just outlined. Such a program should be supported by scholarships in order to prevent economic circumstances from limiting unduly the sources from which students could be selected. An expenditure of half a million dollars a year would support 250 boys and girls on full scholarships and give 25 schools somewhat less than $10,000 a year to strengthen their staffs in order to meet the new requirements. Half a million dollars a year is less than one two-thousandths of the Nation's budget for research and development. The experiment would not be a costly one over a period of 10 years—the least to be expected would be an increase by a hundred or so in our supply of well-educated research scientists, and a reasonable expectation would be the gradual spread of higher standards of secondary education with special emphasis on the intellectual training of the promising youngster.

Another method of increasing the supply of imaginative young scientists and engineers is the introduction into the high schools and colleges of some courses in the history of science and technology for the purpose of inspiring imaginative youngsters who might normally seek other vocations to take up a career in science. This also has its difficulties because adequate textbooks have not been written. The historians of science have generally been interested in the growth of ideas, and their works cannot be properly appreciated without a fairly thorough knowledge of the content of the various sciences. However, this challenge could be met successfully by a teacher who is interested in tracing the influence of technological advances on the general history of the nations, and in exploring the circumstances leading up to these technological advances right back through the development and research stages to the methods and characters of the men who originated the basic ideas. In such a book the scientific background could be supplied in a general way without misleading the reader or disturbing the emphasis. A knowledge of the difficulties encountered and the successes achieved by men in past generations, together with a realization of the consequences of their labors as seen from the vantage point of the historian, has a moulding and inspirational influence on young minds that cannot be overestimated.

Finally, the example of Kekule leads me to suggest a less fundamental but much easier step that can be taken to develop the imaginative powers of our scientists, namely the revival of the *Wanderjahr*. "Free yourselves from the spirit of the school," says Kekule; "you will then be capable of doing something of your own." In these days when fellowships are numerous, the obstacles to a young Ph. D. taking a year off to wander around the centers of learning are not insuperable. What is needed to facilitate such travel is a clearer realization by his professors, or by those in a position to award fellowships, that the ideas planted in the student's mind during a year of leisurely and aimless wandering may bear abundant fruit later on, fruit whose value in terms of original contributions to understanding may far transcend that of a few routine papers laboriously ground out during the tenure of a fellowship. It would simplify matters if one could differentiate beforehand between those who could profit by a *Wanderjahr* and those who would only waste it. We are not yet in this happy position, but I feel that university professors have a real responsibility in advising such a course to men who, in their judgment, are promising. Even with a high percentage of failures, we would still profit by granting fellowships for this purpose.

EDUCATIONAL INSTITUTIONS AND SCIENTIFIC RESEARCH

Now let us consider the habitat of basic scientific research with special reference to the objectives, scope, and quality of basic scientific research in educational and in technological organizations. In spite of a prevailing impression to the contrary, pure scientific research is not indigenous to the universities, although it has been one of their prominent activities during the past five or six decades. In the early days scientific inquiry was fostered by societies and carried on largely by wealthy amateurs or by enthusiasts who could enlist the support of a patron. We have only to recall such names as Bacon, Gilbert, Boyle, Cavendish, Rumford, Franklin, Lavoisier, Priestley, Davy, Faraday, Joule, Hooke, Napier, and Jeans, none of whom worked in a university, to realize the truth of this statement. From the earliest times, the primary objective of universities and colleges has been the preparation of the youth for intellectual leadership in meeting the problems of their day and generation. In striving toward this objective, the universities have properly followed a conservative policy, introducing changes only when the educational value of new subjects had been proved, or when problems of the day called urgently for extension of the classical curriculum. Pioneering into new and untrodden regions of thought and experience has not been a dominant characteristic of the universities, although from time to time exceptional individuals associated with them have blazed new trails. In-

deed, the proportion of pioneers and prophets on the faculties of colleges and universities has not been higher than that found in other portions of the population, and recognition of the significance of radically new and fruitful ideas has all too often been quite accidental. To support this statement, I quote from Sir James Walker's Memorial Lecture on J. H. van't Hoff:

> In order to obtain his doctor's degree, van't Hoff rematriculated in the University of Utrecht in October 1874, and was prompted to his doctorate in December of the same year. His dissertation was entitled, "A Contribution to Our Knowledge of Cyanacetic Acid and Malonic Acid." It was of a routine character, and contained nothing beyond the powers of an ordinary advanced laboratory student. This is at first sight surprising, for van't Hoff had in the preceding September issued as a pamphlet his famous paper on space-formulae. The original pamphlet was in Dutch, and bore the title, "An attempt to extend to space the present structural chemical formulae, with an observation on the relation between optical activity and the chemical constitution of organic compounds." It argues well for the sound common sense of the young van't Hoff that he presented a humdrum piece of practical work for his dissertation rather than the startling innovation contained in his pamphlet, for the latter might have had an even worse fate than the equally famous thesis of Arrhenius, containing the first statement of the theory of electrolytic dissociation.

However, once a field of knowledge has been opened up and its implications for society made evident, the universities have not been slow in admitting it to their territories, cultivating it, and teaching it systematically to their students. In the seventeenth and the early part of the eighteenth century scientific research was really a pioneering activity maintained by a few individuals who wandered far beyond the frontiers of then current knowledge. As these pioneers progressed, the results of their work became important additions to the store of existing knowledge. Professors of natural philosophy and, much later, professors of chemistry and of biology were accepted into the academic world. In teaching such subjects as physics, chemistry, or biology to students, the professors encountered many problems that could be answered only by recourse to theoretical or experimental research. Thus to do a thorough job of advanced teaching, a professor became a research man and devoted a considerable portion of his time to the discovery of new knowledge as well as to imparting the old. Like their predecessors, the amateurs, the professors acquired a passionate interest in searching for new facts about their subjects and in ordering these facts into satisfying patterns that could be communicated to their collaborators and to their students. Slowly but surely research became recognized as one of the fundamental and, later, one of the characteristic features of universities. During this era, which extended from the latter half of the eighteenth century to the latter half of the nineteenth, students of the sciences were not numerous

and most of them went on to careers in medicine or pharmacy. A few advanced students went into professional careers, and the most brilliant became teachers and research leaders in schools or universities; very few found careers in industry, and privately endowed research institutions were extremely rare.

The coming of this century saw the beginning of another major change; the impact of scientific research on the useful arts had begun. Scientists, particularly chemists and chemical engineers, entered industry, and the demand for more such men placed on the universities as well as the technical schools another obligation, that of training men who could take part in industry not merely as adjuncts to product and process control, but as creators of new processes and products. New vistas for intellectual leadership were opened up and the universities responded to the new challenges. Members of the faculties of science and engineering found that they needed to establish direct contact with the rapidly changing problems of industry in order to provide realistic courses of study for an increasing number of students destined for careers in industry. Closer relations between university scientists and the industries developed, schools of chemical engineering and other applied sciences were established, and, as consultants, many professors of chemistry, physics, and other sciences not only realized the power of their disciplines to solve problems that had baffled the empirical technologists, but also brought to their students experience and fertile lines of research which prepared them admirably for leadership in their chosen fields. This relationship between the universities and industry was established in Germany 25 years before it became effective in this country. A conservative course, charted according to their traditional objectives, brought about gradual but deep-seated changes in the universities. It should be noted that in these changes the better universities did not attempt to compete with technical schools in producing technicians. Industry called for and received well-trained scientists to solve its problems and spearhead new advances in its growing laboratories.

During this same period the increasing appreciation of scientific research by the general public was marked by the endowment and establishment of private research institutions and by the rapid growth of large government laboratories devoted to research and development in fields such as agriculture, mining, and scientific standards that were vital to the country's economic growth. To summarize, the half century from 1890 to 1940 saw an increasing dependence of the industrial and economic life of the country on the application of science. This was recognized to be a fundamental and stable trend, and the universities reflected this realization in changing their curricula to provide men educated for leadership in the new order.

The onslaught of World War II, with its urgent demands for an all-out mobilization, presented another severe challenge to the universities. The design of the weapons and equipment needed to support our Armed Forces had not kept pace with advancing technology. To meet the emergency the best scientific and engineering minds of the country were requisitioned to set up and conduct research, development, and engineering programs aimed at the solution of urgent military problems. Not only were the faculties and graduate students of our universities drawn into this effort on a large scale, but the universities themselves undertook the sponsorship of development and engineering projects of unprecedented magnitude. The success of these enterprises in providing our troops with superior weapons and equipment, such as radar, proximity fuzes, and rockets, is a matter of history.

At the close of hostilities the relationship between the armed services and the universities had undergone a profound change—a new mutual respect had developed. On the one hand, the armed services recognized our universities and technical schools to be highly significant assets in the preservation of national security not only for their capacity to train leaders in science, engineering, medicine, and other walks of life, but also for their capacity to bring to bear a powerful combination of science and art to develop imaginative and effective solutions of complex military problems. The Armed Forces have learned to rely more and more on universities and other nonprofit research institutions to operate teams of creative workers in science and engineering to provide the weapons and equipment that can make the American fighting man superior to four or five of his adversaries. In this effort, a working concept of the unity of technology, as shown in figure 2, and unimpeded flow in the "green" and "blue" circuits, were found to be of paramount importance. The long-range implications of pure scientific research acquired new respect in the minds of those concerned with national security, a respect that has been demonstrated in a very substantial and intelligent way during the last seven years, particularly by the Office of Naval Research and by other agencies charged with the supply of weapons and equipment to the Armed Forces. Of the latter, an outstanding example is the Bureau of Ordnance of the Department of the Navy.

Secondly, a very large number of research scientists, many of them steeped in the true academic tradition, learned for the first time that the tactical and technical problems encountered by the armed services can present the scientist or engineer with research problems that are as challenging and stimulating as those encountered in teaching or in industry. The degree of this challenge is understandable when one remembers that the technological ascendancy needed to maintain

superiority over an enemy requires that the development of new weapons and equipment be based on the newest ideas available. The research investigator in this area must be in the forefront of knowledge. Hence, aside from patriotic motives and aside from the attractions of substantial financial support, many research men found themselves thoroughly interested from a purely scientific point of view in the research problems raised by military needs, and continued to study them when they returned to their universities.

A number of universities, furthermore, undertook to continue the operation of laboratories that had been fledged during the war by placing them after 1945 on a continuing basis as independent divisions of the university organization. Other universities, which had discontinued the operation of laboratories set up during the war, undertook responsibility for the operation of new ones, when the emergency of 1950 demanded a greater defense effort in this country. The realization that a long period of preparedness for an emergency now lies ahead of us places a continuing and inescapable demand for the services of such groups. Geography no longer provides convenient protection for a powerful nation to exert a powerful voice in world councils; this protection must be sought in strength through technology.

Universities have changed greatly from what they were 150 years ago, when the classics, literature, moral and natural philosophy, logic, metaphysics, law, medicine, and theology marked the extent of their curricula; when most learning was derived from books; and when the idea of even a small chemistry or physics laboratory would have been far more shocking to their faculties than are today such organizations as the Argonne Laboratory of the University of Chicago, Project Lincoln of Massachusetts Institute of Technology, the Applied Physics Laboratory of The Johns Hopkins University, or Los Alamos of the University of California. This change has come about naturally through the intrinsic interest of the universities in all forms of human knowledge; through their avowed mission to serve their day and generation by educating the youth for intellectual leadership in meeting the problems of their age, stimulated by the stupendous consequences of scientific research in the progress of the useful arts and those phases of modern life—such as economic and national security—that now depend upon them.

All these changes have brought problems with them, some of which are the results of the usual reaction of conservatives to an innovation; others arise from adjustments within the universities which are necessary in order to achieve equilibrium with their environment. We can only consider here problems that affect the prosecution of basic research. A serious problem was first encountered in the late 1920's

when the rapidly growing recognition of the importance of research to the future of industry brought about a strong demand for well-trained and able research workers. The differential in salaries between industries and the universities was great enough to attract away from the latter too many of the promising postgraduates and younger faculty members whose continued presence in the universities was essential for the preservation of high standards of teaching and research. At that time the condition was especially true in chemistry; it is now true in physics. It can safely be said that the universities have not completely restored the former balance, although the wealthier universities are now able to attract and keep the best men.

Since the end of World War II the additional governmental requirements for men with sound scientific training and good technical judgment have caused new inroads on the staffs of universities as well as of industrial laboratories. Many productive investigators have spent much time as consultants to, or full-time participants in, Government organizations. The importance of this participation in national affairs is unquestionable; it is a service that the universities are uniquely fitted to render to the nation. It does, however, withdraw keymen from teaching and research. Furthermore, the needs of the Defense Establishment, backed by large budgets, have brought contracts for research and development into the departments of many of our universities and colleges. Many of these projects fall more in the class of development than that of research, and their value in promoting sound training for scientists or in leading men into habits of imaginative research is open to question. Indeed, a number of serious thinkers have expressed concern—for example, the *New York Times* recently quoted G. B. Kistiakowsky as saying to a conference at Mount Holyoke:

> I see ourselves threatened with a generation of scientific workers who know how to carry out instructions and to follow in the footsteps of others, but who have not learned how to discover a rewarding research problem, how to plan the attack on it and how to solve it. And whether we are training the students for industrial leadership or perchance for a life of a college scientist, we are not doing a good job this way.

Altogether, it might appear that pure research is in danger of being smothered or starved by its own aggressive and powerful offspring. In passing, however, we may note that much more serious problems would have faced the world of science had these offspring been weak and sickly.

PROMOTION OF BASIC RESEARCH

In discussing figure 2, I stated that the incentive for pure research was curiosity aroused by some phenomenon, and that its objective

was an understanding of the phenomenon—that is to say, the fitting of it, together with previously known facts, into a satisfying pattern. The source of the research problem is not mentioned and is immaterial; it may come from a man's communing with nature, from his realization of an inconsistency or a hiatus in the subject he is teaching, from difficulties encountered in an industrial process, or from the knowledge of an urgent military problem. As long as good judgment, fortified by training and experience, is exercised to ascertain the significance of the problem,[4] its source need not prejudice its value for mental discipline or instruction. The objective, however, is important; the investigator must set out to *understand* the phenomenon he is to investigate, and this objective will determine how the work is to be conducted. It will constrain him to isolate the variables and to determine the facts quantitatively, to advance hypotheses and plan critical experiments or theoretical studies, to plan auxiliary investigations or explore side lines, and, above all, to use his imagination fortified by reading and study of related phenomena.

In undertaking a problem from any source whatever, the professor in a scientific department of a university has the right and obligation to inquire into its significance and, having satisfied himself in the light of his knowledge and intuition that it is not trivial, to set as an objective the understanding of something of putative significance before assigning the formulation and prosecution of the problem's subdivisions to graduate students. If, in the professor's judgment, the problem cannot be judged significant in this sense, he has the obligation of refusing to accept it. Under such initial conditions, it is highly probable that the work accepted will become a piece of basic research that is intrinsically valuable for its results and for the training it affords a student no matter what its subsequent application may be.

When the role of the university in local or national affairs requires it to sponsor larger problems in which development and objectives other than understanding are important, it is advisable to set up an organization sufficiently separated from regular university activities to avoid the distractions that arise from full-time efforts with programmed time scales, the influx of a number and variety of new

[4] The reader may ask for a definition of a *significant* problem. An answer is extremely hard to give, since the significance of an investigation often depends on the peculiar quality of the imagination and creative ability that the investigator can bring to its prosecution. Conventional and contemporary opinions do not give sufficient basis for determining the significance of a problem; it must be judged in the light of its challenge, its possibility of opening up new vistas, and the ability of the current state of science to provide a background for understanding it. A problem is really a springboard for a leap into the unknown.

workers, sizable budgets, and business operations. There is ample precedent for this procedure in the agricultural experiment stations and in the hospitals which are now traditionally a part of almost every large university. Such hospitals are usually separate or related organizations integrated into the whole university structure only at the policy levels.

However, this country no longer depends entirely on the universities for basic research, and we may now consider another means of providing for this fundamental activity. Through the establishment of the Research Society of America,[5] the Society of Sigma Xi has deliberately served notice that the band of Companions in Zealous Research has been extended beyond the academic halls to scientists in the laboratories of the Government and industry. In terms of figure 2, the "blue" circuit is endorsed as a means of increasing our store of understanding of the physical world. The industrial and Government laboratories have a wonderful source of problems in the phenomena encountered in the development and engineering phases of the useful arts. They also have on their staffs men whose curiosity can be effectively challenged to seek an understanding of these phenomena. In other words, all the elements of the "blue" circuit are in place. However, severe impedances exist. The communication of ideas between development engineers and research scientists is still hampered by a lack of common language and standards. Furthermore, those charged with the responsibility of determining the policies of these laboratories have not often taken the step of specifically allocating their funds in such a way as to broaden and deepen the scientific understanding of phenomena encountered in industrial work. As a result, the current in the circuit is frequently shunted or even cut off just as it starts to build up. The day-to-day pressures generated by the "red" development loop sap the blue circuit so that the circulation of understanding, which could bring intellectual satisfaction and perhaps the foundations of a future development, is severely attenuated. May I suggest that RESA is in a good position to remedy this situation, and that one of its objectives might well be the promotion of the idea that industrial and Government laboratories have the responsibility of allocating a part of their vast resources to the pursuit of understanding. All that is needed is a firmly rooted conviction that the "blue" circuit in figure 2 not only spans the gap between the universities and industry, but also has all its elements present within the framework of many industrial laboratories. Attention to these internal circuits will radiate some of the imaginative and creative basic research we so badly need.

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[5] A substantial portion of this paper was delivered on the occasion of the founding of a branch of RESA at the Burroughs Adding Machine Co. in Philadelphia, Pa., November 1952.

It is hardly necessary to state that there are outstanding examples of industrial and Government laboratories where this principle is already developed and operating. An extension of the idea to more and more organizations is required.

COMMUNICATIONS IN TECHNICAL TEAMS

Returning to figure 2, I should recall that an important province of the professional scientist is that labeled "Applied Research Circuits," and the success of his effort in this field will depend on the ease and certainty with which ideas circulate in the "green" and "blue" circuits. Portentous ideas may be generated or regenerated in either main block, pure research or engineering, and the transmission of ideas depends on the facility of scientists and engineers to communicate with each other. Although conditions have improved enormously since 1940, the impedances in these circuits are still too high and the circuits themselves are "noisy," with the result that transmission of ideas is neither speedy nor certain. The establishment of communications in a technological team involves many personal and other problems that are hard to generalize. There is, however, one fundamental aspect of the subject that does permit of general discussion and deserves attention here. I think we can safely say, as a matter of experience, that communications flow most rapidly and effectively in a group where all the members share a common point of view, or perhaps I might say, a common set of standards of validity. Thornton Page has advanced this thought[6] and pointed out how a common viewpoint provides a basis within which men trained in radically different disciplines can talk together intelligently.

In a technical team, this common point of view, this common set of standards of validity, is compounded of a thoroughgoing belief in the value of satisfying patterns of facts that fulfill the requirement of quantitative communicability, together with a realistic knowledge of the limitations of current satisfying patterns. In other words, it contains a balanced admixture of science and art. With this viewpoint, a man strives to fit valid facts into a consistent theory as a necessary step in developing knowledge and understanding, is discontented with facts or tests treated as isolated events, and is disgusted with speculation on strange phenomena or events without any reference to theory or even examination of the facts. At the same time, he realizes that patterns or theories are constantly growing and will never be perfect until we know and understand everything. Thus, he expects every scientific or engineering project to have its groping, unpredictable, empirical phases, but he makes the best and fullest

[6] Team work in research, edited by G. P. Bush and L. H. Hattery, ch. 7, p. 55, 1953.

use of current patterns of science where they can be applied, and supplements them by the skills of the arts. He is well aware of the fact that empirical results are not really valid until they are related to other experiences in a satisfying pattern, and at the same time he fully knows that the practical applications based on predictions from theory require for their full development the proper economic and technological climate.

Physicists, chemists, and, to some extent, biologists who have been well trained in graduate schools have, in general, an innate appreciation of the use and value of satisfying patterns of valid facts. This appreciation motivates their approach to all problems, setting before them always the objective of developing theoretically the field in which they work. However, many engineers and other professional men who have had elementary and even advanced undergraduate courses in physics and chemistry and mathematics do not have this viewpoint. No lasting appreciation of the need for consistent theories to guide their work has been imparted to them by undergraduate science courses. If this seems exaggerated, note a statement made in a responsible publication by an authority on the administration of industrial research: "The process of research of whatever type and regardless of when, where or to what applied is nothing more or less than an *organized, diligent investigation to discover facts.*" When such views are held by leaders, it is small wonder that the followers are confused.

On the other hand, engineers have an innate appreciation of the practical value of quantitative communicability which is the result of training, reinforced by experience. In this respect, they are ahead of the average physicist and chemist. In expressing his results, the engineer uses drawings and specifications in which all details are expressed not only quantitatively, but also with tolerances that indicate the permissible compromises between the exigencies of design for performance and the limitations of the skills and techniques of artisans to realize these in practical working devices.

The establishment of a common viewpoint or common standard of values among technical men and the consequent improvement of communications among them are matters of real concern in university education at all levels. We need to devise methods for impressing more deeply on all students of science that quantitative communications, clear, concise, and exact expression of ideas, results, and patterns of facts, are an intrinsic part of science without which it is no longer science but art. Furthermore, we need to impart to all students of science and technology a lasting feeling of the practical importance and the esthetic appeal of consistent patterns of valid human experiences, the essential place of theoretical development in

modern thought. The disciplines of the pure sciences are ideal vehicles for this type of education, but the teaching of these disciplines will become effective only when professors of the pure sciences take stock of the essentials of their subjects and devise courses which bring to students the spirit as well as the results of basic scientific research.

COMMUNICATIONS WITH SOCIETY—COMMON SENSE

A very disturbing symptom of the postwar era, resplendent as it is with spectacular technological advances, is the evident ignorance among even educated people concerning the attitudes of mind and the disciplines of thought that underlie these advances. The impact on the general public of guided missiles, rockets, radar, television, and, above all, the large-scale release of atomic energy has been one of inducing paralysis in the centers of higher thought and discrimination. There has been an abandonment of all restraints on imagination and credulity. After these spectacular advances, people are willing to believe anything and unwilling to accept any of the discipline which established scientific theory or sound engineering practice must impose on the trained mind. This is becoming an age of unbridled fantasy and superstition, an age devoid of critical discrimination.

Thus, we have "flying saucers." I shall not venture any opinion or possible explanation of these alleged phenomena, but I can state that the credence placed on so-called "reliable observers," who from one visual observation can give the size, speed, and the distance of an unknown and remote object, implies a complete disregard for the most elementary principles upon which scientists and engineers have built so surely and successfully for hundreds of years. This is but one example of the tendency to accept any story, however improbable, without critical review or reference to some standards of credulity. It points up a region where communications between the scientist and society at large are woefully inadequate, a situation fraught with considerable danger. The scientist is running the risk of becoming separated from society, misunderstood as to his motives, and distrusted as to his intent.

Earlier I directed your attention to the place of satisfying patterns of valid experiences, of qualitative and quantitative communications, and of common viewpoints or common standards of validity in art, science, and technology. These ideas are, of course, not confined to these sophisticated human activities but are to be found in the mental equipment of every rational man or woman. From infancy, the normal human being attempts to order his experiences into rational patterns which he conjures up to orient himself in encounters with new and strange phenomena or events. This is referred to colloquially as "making sense" of something new. Since the experiences of large

groups of people are fundamentally quite similar, there have grown up widespread patterns of experiences to which the general name "common sense" is given. These patterns represent the common viewpoint upon which the majority of human beings communicate with each other. The patterns of common sense differ from those of science and art in being haphazard and fragmentary rather than systematic and integrated, little critical effort being made to establish the validity of the experiences they encompass, and no emphasis being placed on unambiguity of communication. Furthermore, their growth and transmission are subject to individual and local fashions and prejudices. It is obvious that common sense changes from generation to generation and is strongly influenced by a group's background.

Since the results of science and art seep into the consciousness of all civilized groups, it can be expected that the progress of common sense follows that of the arts and sciences with an indeterminate time lag. I have emphasized the acceleration in the advances of science that arises from its very nature, it being a regenerative circuit. In an era when this acceleration is high, it can be supposed that common sense lags far behind science unless the coupling is tight. We may imagine the accelerating advance of science as a rocket towing behind it, by means of a spring, a car labeled "common sense," the spring representing the communication between the analyzed patterns of scientific fact and the haphazard patterns of common sense. When the rocket is accelerating rapidly and the spring is weak, the towed car lags far behind and confusion reigns. If we are to preserve the material benefits of rapidly advancing technology and avoid confusion of public thought, the spring must be tightened, the communications between science and the public must reflect the methods—particularly the discipline of scientific thinking—as well as the results of scientific research.

I have presented this discussion on common sense because it represents the background against which the average man judges new things. We have all been asked about a scientific theory, "What is the common-sense explanation?" Furthermore, this background is fairly well set early in life, and efforts to popularize science in the press, in books, or on radio and television have only a superficial effect upon it. From what I said earlier, it seems that after 25 years of popularization of science, we still have a very unscientific common sense. It is clear that this state of affairs can be remedied only by enlightened effort in secondary school and undergraduate education and, here again, all teachers, especially the teachers of the pure sciences, have an important part to play in giving to all who pass through their hands a balanced picture of the satisfying patterns of facts and the disciplined methods by which human experiences are

analyzed and fitted into structures that may be communicated exactly to others.

INTEGRATION OF SCIENCE AND SOCIETY

In the foregoing discussions we have devoted much of our attention to the far-reaching consequences of the growth of natural philosophy on the material aspects of human life. It has increased beyond measure our ability to control and use the physical world. In this direction, the history of the last three centuries has been one of accelerating and inspiring progress. However, we have also noted certain elements which indicate that this progress has not been completely satisfying. The modern search for the kinship of science and the creative arts, the real concern that universities and other centers of scientific thought are becoming excessively preoccupied with the applications of science, and the consciousness that the communications between science and the general public require strengthening, all point to a feeling of uneasiness, of dissatisfaction with the purely material objectives of science. When we link such considerations with the present chaotic state of human and international relations, we are convinced that our progress in understanding and using the physical world is out of phase with other aspects of intellectual and spiritual development. It is perhaps timely to survey the scene from a mountaintop and readjust our perspective.

Deeply ingrained in all religions, and in most systems of philosophy, is the concept of the dual nature of man. He is a material being who must derive his security and comfort from mastery of the physical world; he also has a spiritual and intellectual nature which tirelessly seeks to transcend material things, which seeks to know why things are as they are and which seeks to create a world in its own image. The interdependence of the material and the transcendental is one of the baffling complexities in philosophy. Now it is also agreed by all religions and most philosophies that, if man is to fulfill his destiny, he must place his primary emphasis on reaching out for the transcendental and his secondary emphasis on concern for the material welfare of his fellows and himself. This is expressed clearly by the order of the Ten Commandments and by the Christian epitome of the Law and the Prophets, "Thou shalt love the Lord thy God with all thy heart, with all thy soul, and with all thy mind, and with all thy strength. This is the first and great commandment and the second is like unto it, thou shalt love they neighbor as thyself."

Being a human activity, science reflects this duality in the nature of man, and the scientist can approach the problems of the physical world with two objectives in mind. He can give his allegiance to the transcendental and, in order to satisfy his intellectual and esthetic

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longings, seek to understand why things happen; or he can seek to improve the material welfare of mankind by asking how things happen so that he can utilize the knowledge to make tools or commodities. In his last work on Cosmology, E. A. Milne quoted the song of the angels, "Glory to God in the highest and on earth peace to men of good will," as the definition of these two objectives of science.[7]

Although the advances of science toward the second objective are those that have caught the popular imagination by raising our material standards of life to unprecedented heights, it is the paradox of history that those who sought the first objective, who labored to find understanding, have, in the long run, done more to enrich the material as well as the esthetic phases of human life than those who set out directly to supply immediate material needs. Thus, in science, as in other phases of human life, the first and great commandment exhorts devotion to the unseen, to that which transcends current understanding. The uneasiness we have noted springs, therefore, from very profound sources; it is the reaction of a corporate conscience to the realization that the major commandment is being transgressed. All our deep-rooted instincts demand that we must nurture scientific research for reasons that transcend material considerations. The universities and the privately endowed institutions have inherited the privilege and the responsibility of cultivating pure science as an intellectual pursuit, the quest for understanding. This is a responsibility they must and can discharge regardless of what other activities they must foster in the service of their generation. If they fail, a new dark age will be the result, an age described by Isaiah, "It is a people of no understanding; therefore, He that made them will not have mercy on them, and He that formed them will show them no favor." If the universities discharge these responsibilities with the breadth and liberality of true education, we can expect generations of research scientists, scholars, and professional men who are imbued with a thirst for intellectual satisfaction that leads them to extend the range of valid human experiences, and order them in patterns that make the mysteries of nature communicable to all who wish to know them; that will, in short, inspire them to search for truth. In this spirit, the quest for understanding through basic scientific research results in much more than the foundation of tomorrow's technologies; it becomes a discipline fundamental to civilized life.

Even in the realm of problems of value, in moral philosophy, we may apply the ideas of circuits or closed loops which we have used in describing natural philosophy. In figure 3, I show the basic reciprocal relations between truth, freedom, civilization, and the

[7] An interesting review of this work is given by G. E. Hutchinson in American Scientist, vol. 40, p. 509, 1952.

liberal arts and sciences. Truth, a public basis for agreement which is open to anyone who takes the trouble to look for it, as opposed to bases of agreement laid down by authoritarian dogma, leads to freedom, which in turn is a necessary condition for civilization. Under civilization and free inquiry, there flourish the arts, sciences, and humanities whereby men can broaden and deepen their search for truth. When this circuit is in stable oscillation with intangible products of the mind and spirit flowing in the directions shown by the arrows, a state of healthy moral values exists. Realism, however, dictates that in the world as it has been up to now, and as it will con-

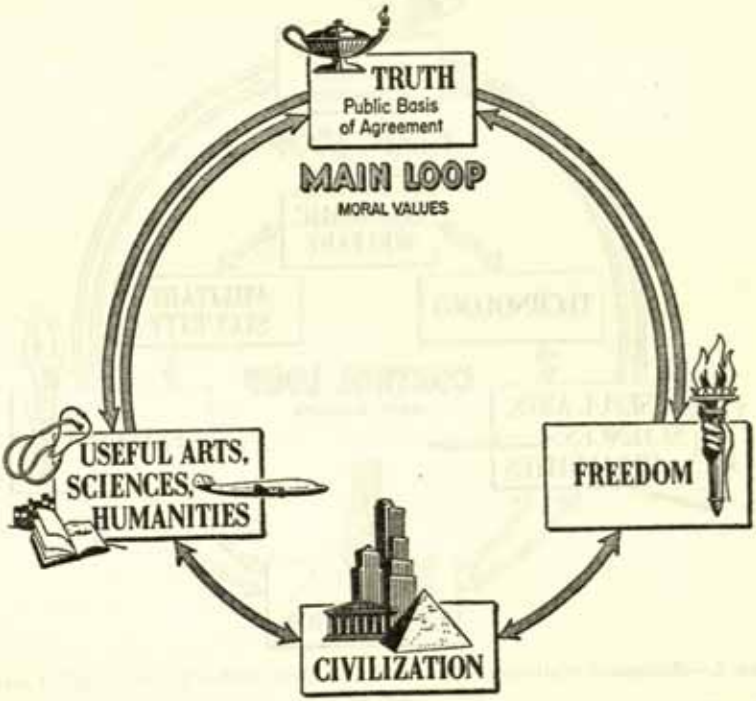

FIGURE 3.—Reciprocal relations between truth, freedom, civilization, and the liberal arts.

tinue to be because of man's continual desire for personal power and his lust to impose his will on others, we must add a stabilizing circuit as is shown in the next diagram, figure 4. In this circuit, the arts and sciences lead to technology, which in turn provides economic welfare, which in turn leads to military security which protects the peaceful institutions that support civilization and promote freedom. Stable oscillations of this group radiate material welfare.

These diagrams suggest some interesting thoughts. In the first place they depict a dynamic relation; it is the flow and regeneration of intellectual ideas and spiritual values in the circuits that give vitality to the elements depicted in the boxes. If the circuit is cut,

blocked, or shunted at any point, the elements such as truth, freedom, or civilization atrophy. Institutions without the dynamic current of the free but disciplined human spirit, one might almost say the divine spirit, become mausoleums, empty monuments to dead ideals. In the second place, this dynamic picture of human affairs, in which the surges and resurges of the intellect and spirit play the all-important role, reminds us that human affairs will not be studied profitably by the classical methods applicable to static systems—new methods for the dynamic study of human relations are needed. In the

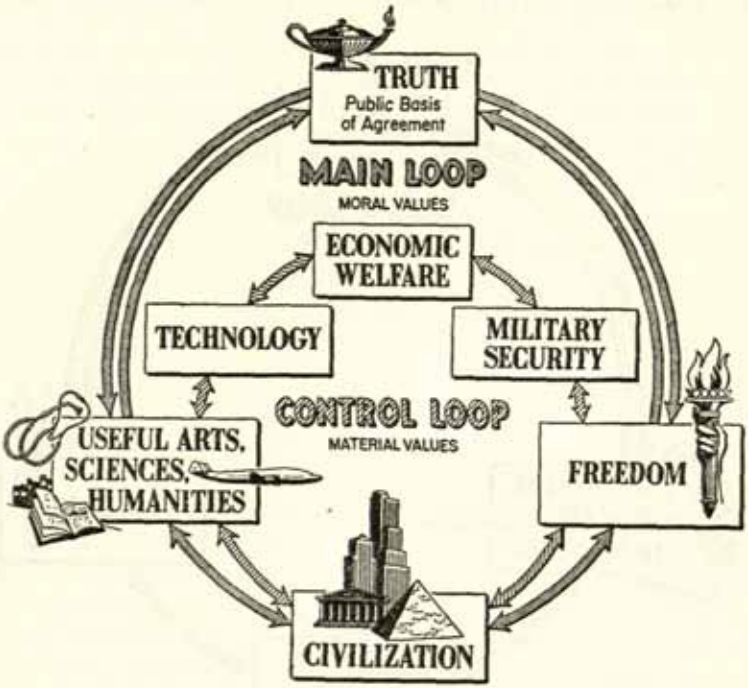

FIGURE 4.—Reciprocal relations as shown in figure 3, with added "control loop" of material values.

third place, these diagrams suggest that the circuits have no logical beginnings or endings, the spirit may start moving at any point, and none of the institutional elements can exist alone or have any absolute value of itself; they have value only in terms of the whole circuit.

Fourthly, figure 4 recalls the duality in the nature of man and his activities by two interlocking circuits, the outer loop representing the transcendental world of ideas, the inner loop representing the world of material things. The figure suggests that the inner loop is a control one which preserves in a world ridden with forces of destruction the freedoms and institutions hard won by forces of construction. It is a stabilizing loop, but only a stabilizing one. The

ultimate destiny of man depends on the promotion of stable and healthy flow of current in the outer or "main" circuit.

We live in an age when the current in the material circuit is flowing with an amplitude unequaled in the history of the world. However, few will contend that the oscillations in the moral loop are equally strong and healthy. Indeed, it seems that our appreciation of and respect for truth are becoming weaker as the twentieth century rolls on. The two circuits are out of phase, the coupling is poor. To return to a figure of speech we have used a great deal in this paper, this poor coupling means that our over-all patterns of human experience are fragmented, inconsistent, and unsatisfying. The suggestion of a remedy for this state of affairs is far beyond the scope of this paper. We can only indicate that it constitutes the chief challenge to science, art, and education for generations to come. It is the challenge to separate the gold from the dross in human experience, to weave the gold into satisfying and consistent patterns, and to display this tapestry before all mankind through clear-cut, simple, and direct communication so that all life on this earth may be enriched. Then the world will realize more fully the truth spoken by the writer of Proverbs:

> Happy is the man that findeth wisdom and the man that getteth understanding.

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Recent Progress in Astronomical Photography[1]

By C. E. Kenneth Mees

Director, Research Laboratories
Eastman Kodak Co.

[With 6 plates]

In the great epic poem which has come down to us under the name of the Book of Job, God issues a challenge to man in which he sets forth the wonders of the universe and asks whether the mind of man is such that he can comprehend them. Turning to the stars, he says, "Canst thou loose the bands of Orion? Knowest thou the ordinances of heaven?" And as if to make a suggestion for the meeting of the challenge, he asks, "Where is the way where light dwelleth?"

All that we know of the universe, apart from that small portion of the earth which appeals to our other senses, we obtain through our eyes by the medium of light. Long before the Book of Job was written, the apparent motion of the heavenly bodies had been studied and mapped, primarily with a view to the measurement of time, since the rotation of the earth on its axis and its revolution in its orbit form the primary clock by which time is measured. The earliest dates that we know definitely are determined from the record that Sirius, the brightest star in the northern sky, rose at the same time as the sun. This enables us to compute approximately the year in which that event occurred, since it can recur only at intervals of 1,400 years.

But the desire to know, which is at the root of all scientific progress, led men not only to measure the apparent motion of the heavenly bodies but to make maps showing the positions of the stars. The stars were observed one at a time, their positions in the heavens were plotted and maps drawn from which the positions of the stars could be identified. It was as a result of the patient work of Tycho Brahe, in the latter half of the sixteenth century, that Kepler was able to

[1] Twentieth James Arthur lecture, given under the auspices of the Smithsonian Institution on May 21, 1953.

formulate the laws from which Newton deduced the general laws of motion.

Today the time at which the stars pass an indicating point in a fixed telescope is observed in order to check our computation of time, and studies have been made even recently of minute differences in the observed and calculated movement of the planets. Observations of the movements of the stars themselves are still being continued, but all this is now a small portion of astronomical work, which is concerned primarily with the study of the probable composition of the stars and of their life history, their probable origin, and their eventual fate. The popular picture of an astronomer is perhaps still that of an oldish man looking through a large telescope and noting down the readings that he makes of the positions of the stars. Many years ago, however, such recordings by the astronomer were replaced by a young lady measuring a photographic plate under a micrometer, for today all the observing is recorded by photography, and the really painstaking work is done by the computer, who measures the plates and reduces the observations to tables. A telescope today is a camera, and for all scientific purposes the eye has been replaced by the photographic plate.

Over 40 years ago, when I was still in England, I had a visit from F. H. Seares, the assistant, as he was then, to G. E. Hale at Mount Wilson Observatory. Dr. Seares told me of the importance to the astronomer of the quality of the photographic plates he used and said that Dr. Hale believed that the most important advance that could be made in astronomical practice was to increase the effective sensitivity of the plates available. He asked if I would be willing to come to Mount Wilson and try to make improved plates for astronomical work. I told him that I had just accepted Mr. Eastman's invitation to go to Rochester to found a research laboratory for the Eastman Kodak Co. and that I hoped that in my work at Rochester I might be able to develop improved photographic materials for astronomical use. This promise was not forgotten, and I kept in touch with the people at Mount Wilson after we started work at Rochester.

What astronomers want in general are plates that will take photographs in less time; that is, plates that are more sensitive to light. Unfortunately, however, those plates must have properties that are not easy to combine with increased speed. The astronomers want all the speed that can be obtained; they want the sharpest possible image; and they want the least possible graininess.

At first it might appear that the demand of astronomers for more sensitive plates does not differ from the requirements of other photographers. As the years have passed, the sensitivity of photographic materials has been increased, but everybody still wants more

sensitivity in their photographic materials. The news photographer, for instance, wants the highest speed that can be obtained, so that he can photograph at night with a minimum of flashlight. The motion-picture photographer wants to take pictures with a minimum of light. The aerial photographers, and especially those taking military pictures, want to give very short exposures and to work when the light is poor. Improvements in the quality of photographic materials are therefore valuable to all classes of photographer, but, as shown later, the astronomer has some additional requirements.

There is a relation between the sensitivity and the size of the grains of an emulsion since the larger the grains, the more effective the exposure of a grain in producing silver on development. It must be remembered that the unit of exposure is the silver-bromide grain. The most sensitive grains of a fast emulsion become developable when they absorb a few quanta of light. The sensitivity that can be obtained with grains that are not spontaneously developable without exposure seems to reach a limit, with a requirement of approximately 10 quanta per grain. Once exposed, the grains are completely developable.

The amount of silver produced by exposure is very small, but development produces at least a million times as much silver as is present in the exposed grain. The larger the grain, the more silver produced and the greater the multiplying factor introduced by development. Unfortunately, the use of larger grains, which give increased sensitivity, produces a granular appearance in the image and a limitation of sharpness and resolving power. The astronomer has always required, continues to require, and will always require an increase of sensitivity with no increase in granularity, and he has been telling me so for the last 40 years! It is even difficult to get him to answer the question that we put to him: "Would you rather have fineness of grain or sensitivity?" since his invariable answer is that he wants both. In practice, the choice between the two is one which has to be made by the astronomer, gently guided, let us say, by the manufacturer of the plates. Sometimes the same program, or what appears to a layman to be the same program of two different observatories, in one case demands plates having maximum sensitivity with whatever graininess is necessary to achieve it, while the other requires a moderate sensitivity accompanied by a decreased graininess and enhanced resolving power in the images.

As we continued to study the properties of photographic materials, we realized that there is a fundamental difference between the conditions under which most astronomical photographs are taken and those in which the photographic materials are exposed in other fields of photography. This is in the time of exposure. The greater number of ordinary photographic negatives, including those used for the

taking of motion pictures, are given exposures of the order of one-fiftieth of a second. Most astronomical photographs are taken with exposures of the order of an hour. There is thus a factor of about 10^5 between the two times of exposure.

W. deW. Abney first observed that photographic materials do not adhere to the reciprocity law of Bunsen and Roscoe; that is, if the brightness of the exposing light is diminished 100 times and a plate is exposed to it 100 times as long, exactly the same result is not obtained. The relation between the exposure and the photographic effect was measured for the range of astronomical levels by K. Schwarzschild in 1899, and he came to the conclusion that a constant effect is produced as long as the condition I, the intensity, multiplied by the time to a constant power is maintained constant; that is, effective exposure $=It^p$. For the materials he was using, Schwarzschild found the constant p to be about 0.8. It is now known that this is not a valid criterion for determining a constant photographic effect over very wide ranges of intensity. It holds fairly well over a limited range, and in astronomical photography the range is generally limited. But the relation between exposure and intensity is actually a curve of a catenary shape, and photographic emulsions can be made to have their maximum sensitivity at different levels of intensity. The plates which for so many years were standard in astronomical photography were those made primarily for use in portraiture, and such plates are made to have their maximum sensitivity under normal photographic working conditions; that is, for exposures of a fraction of a second. If, however, the emulsions are modified in manufacture, it is possible to increase the sensitivity appreciably at low intensity levels though a loss of sensitivity may be incurred for short exposures. For instance, two plates used today by astronomers are known as I–O and 103a–O. If we tested the speed of these two plates by practical exposure, we should find that the I–O plate is nearly twice as fast as the 103a–O when used by a press photographer; when used by an astronomer, the 103a–O plate would be about *three* times faster than the I–O.

The realization of the importance of this reciprocity failure led us to make special emulsions (of which 103a–O is an example) in which the reciprocity failure at low intensities was reduced to an absolute minimum and the plates were made essentially to be used for exposures of the order of hours. So successful has this experimental work been that I was told some years ago by W. S. Adams that our plates had made the 100-inch telescope at Mount Wilson effectively as useful in regard to exposure time as they had expected the 200-inch at Mount Palomar to be when it was completed. This does not mean, however, that the value of the 200-inch instrument is in any way less.

Though the improvement in sensitivity of photographic materials has depended upon a study of the general principles of emulsion making, great progress has been made in another direction. Before 1900, the photography by which the spectra of the stars was studied was confined almost entirely to a limited region of the spectrum. Ordinary photographic plates are sensitive to only the blue and violet and ultraviolet regions of the spectrum. Some 10 miles above the earth there is a layer that contains ozone, formed by the action of short-wave ultraviolet light upon the oxygen, in sufficient concentration to absorb practically all the ultraviolet of shorter wavelength than 3000 A. At the same time, the ordinary silver-bromide plate cannot record light of longer wavelength than 5000 A., and thus the astronomer's range of the spectrum was originally confined to the spectral regions between 3000 A. and 5000 A. In 1873 Heinrich Vogel discovered that silver bromide could be dyed and that some dyes made the bromide sensitive to the spectral regions corresponding to their absorption bands.

By the use of cyanine dyes made in Germany in the early years of this century, it was possible to sensitize photographic emulsions to the whole of the visible spectrum, and in 1906 commercial panchromatic plates were manufactured. They were very useful for the photography of spectra, and astronomers often sensitized their own plates by bathing them in solutions of dyes. Curiously, the German chemists who discovered these dyes did not determine their chemical structure, and it was not until 1922 that the general structure of the cyanine dyes was understood, largely as a result of work done in the chemical laboratories of Cambridge University. Many new dyes could be prepared, some of which were found to be excellent sensitizers. Photographic manufacturers in the United States, England, and Germany then started to prepare new sensitizing dyes belonging to, or related to, the cyanine series.

At this point there arose a problem which is frequently observed in the application of scientific research. It was comparatively easy to synthesize dyes of the cyanine type that would probably be sensitizers, but it was necessary to test the dyes adequately for their sensitizing power by adding them to emulsions of which coatings would have to be made. Different emulsions take dyes differently, so that it was desirable to test each dye in several emulsions. Moreover, it was soon observed that the behavior of the dyes when used together in the same emulsion was by no means additive. Some dyes greatly enhanced the sensitizing effect of others; some disagreed with their fellows. A well-organized study would require the trial of each dye with every other dye in pairs at least and for several emulsions; and, in some cases, the use of three or four dyes together. This presented

a tremendous experimental program, but it was possible to carry it out by the use of a special laboratory and equipment with which coatings could be made at the rate of more than 100 a day. The organic chemists of the Kodak Company alone have made over 7,000 dyes in the last 20 years, and though it has not been possible to test all the dyes in combination with all other dyes, an adequate testing program has been carried out by a process of selection and elimination.

From a photographic point of view, the spectrum may be divided into four regions: The region from the ultraviolet to 5000 A., which can be photographed on plates containing no dye sensitizers; the region from 5000 A. to 7000 A., which we may call the visible spectrum and which can be photographed on panchromatic materials with short exposures; the region from 7000 A. to 9000 A., the near infrared, which can be photographed on special materials with exposures greater, but not much greater, than those necessary for the visible spectrum; and the region beyond 9000 A.

The sensitizing dyes used for the photography of the spectrum above 5000 A. are cyanine dyes, in which two nuclei formed of rings of atoms and containing basic nitrogen atoms are joined to form a dye by a chain of methine, CH, groups. Heavier nuclei give dyes with absorptions and sensitizing maxima displaced toward longer wavelengths. Similarly, lengthening of the chain of methine groups joining the nuclei moves the absorptions toward longer wavelengths. The shortest chain consists of one methine group only, and the dyes are known simply as *cyanines*. The next chain has three methine groups, and the dyes were termed *carbocyanines* by W. H. Mills and W. J. Pope, who first analyzed the structure of the German dye pinacyanol, discovered by B. Homolka in 1904. Dyes with five methine groups in the chain are known as *dicarbocyanines;* those with seven methine groups as *tricarbocyanines;* with nine methine groups as *tetracarbocyanines;* and with eleven methine groups as *pentacarbocyanines* (fig. 1).

Figure 2 shows the progress which has been made in the extension of the spectral region for which photography can be employed in practice. At the top is the spectral region, including only the blue, violet, and ultraviolet, which could be photographed on silver-bromide plates without any sensitizer. Then the discovery of color sensitizing by Vogel and particularly the use of erythrosine made it comparatively easy to photograph through the green region of the spectrum and record wavelengths up to approximately 6000 A.

In 1904 the application of Homolka's pinacyanol to the production of panchromatic plates made it possible to photograph to the limit of the visible red, a region which may be roughly placed as just beyond 7000 A. In 1919 E. Q. Adams and H. L. Haller in Washington dis-

covered the dye *kryptocyanine*, a carbocyanine from lepidine, with which sensitivity could be obtained up to beyond 8000 A. In 1925 H. T. Clarke in our own laboratory found that in some kryptocyanine preparations another dye, which was named *neocyanine*, was formed, with which the photographic spectrum was extended to 9000 A. The discovery of the tricarbocyanines made it possible to make the tricar-

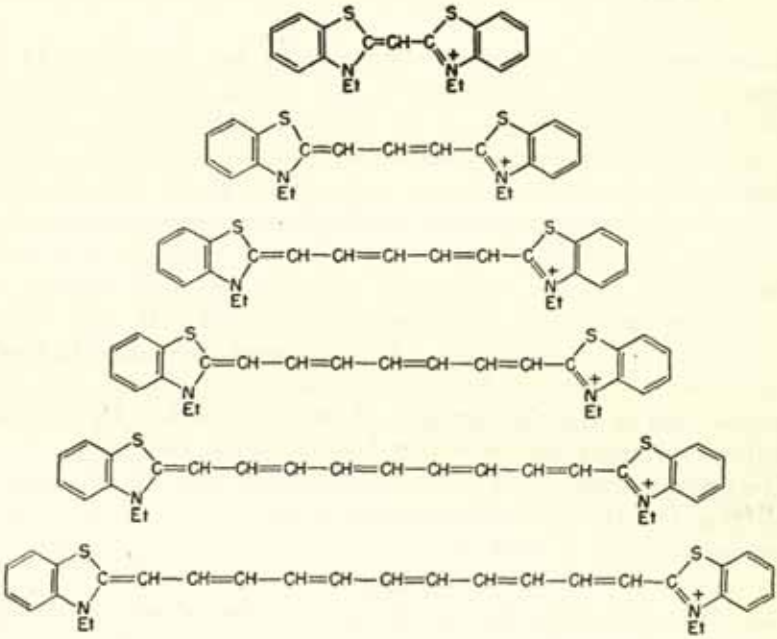


FIGURE 1.—Cyanine dyes with increasing chain-length structures.

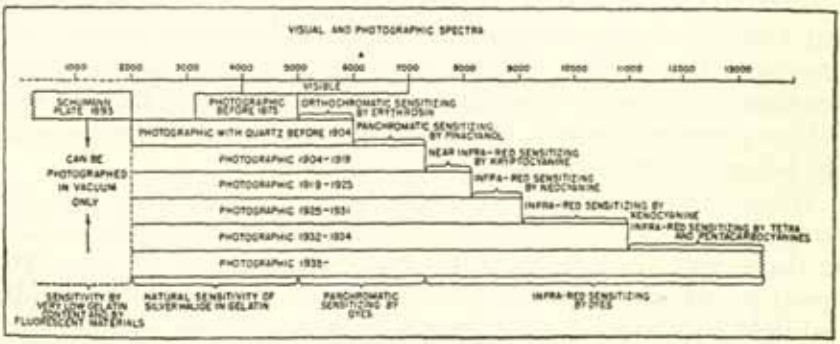


FIGURE 2.—Chart showing progress in the photography of the spectrum.

bocyanine from lepidine, and it was named *xenocyanine*. In 1932 it became possible with long exposures to extend the limit of the photographic spectrum to 11,000 A. In 1934 the tetracarbocyanines and pentacarbocyanines were made, with which the spectrum of the sun

could be photographed to somewhat beyond 13,000 A. Each of these steps of progress made it much easier, of course, to photograph the shorter wavelength portions of the infrared spectrum, so that at the present time photography in the infrared between 8000 A. and 9000 A. presents little more difficulty than photography in the visible spectrum. Only when it is necessary to stretch sensitivity as far as possible into the infrared is any difficulty encountered with the sensitizing dyes.

Quite recently an important improvement has been made in the preparation of dyes sensitizing in the region between 9000 and 12,000 A. For photography of the spectrum beyond 9000 A., the dyes available are the tetracarbocyanines and pentacarbocyanines. A typical pentacarbocyanine is shown at the bottom of figure 1, in which the two nuclei are connected by a conjugate chain containing no less than 11 methine groups. Unfortunately, this very long chain is easily broken, so that the dye is extremely unstable, and until recently the spectrum beyond 9000 A. could be photographed only with intense sources, such as that of the sun. It was almost impossible to photograph stellar spectra in this region, and little success had been achieved even in the photography of the solar surface by the spectroheliograph using the important helium line at λ10,830.

The organic chemists in our laboratory have now found a way of modifying the structure of a pentacarbocyanine dye to obtain greatly enhanced stability so that the dye can be purified and used in an essentially pure condition. Using plates made with this new dye, F. D. Miller has been able to obtain a number of spectra of late-type stars using an objective prism on a 24- to 36-inch Schmidt telescope. The infrared limit is somewhat beyond 11,000 A. A strong absorption band at 9300 A. is an atmospheric band due to water vapor, but a considerable group of absorption bands have been found in the spectra of N-type stars. Up to the present the molecules responsible for these bands have not been identified. It is believed that the new Z-type plates will make it possible to obtain spectroheliograms using the helium line at 10,830 A.

While the photographic spectrum has been extended by the discovery of new infrared sensitizers, there has also been a great increase in the sensitivity of photographic materials to the red region of the spectrum, which has made it possible to make stellar photographs by red light with exposures not greatly in excess of those required with the ordinary violet-sensitive materials. It will be recalled that the different classes of stars are of different colors, and though a number of stars are definitely bluer, a very large number of stars are distinctly redder than the sun. In the older photographs, taken on materials sensitive to only the blue and ultraviolet rays, these red stars were

recorded as much fainter than they appear to the eye, and consequently astronomical knowledge has been built up chiefly in reference to the brighter and bluer stars.

With the availability of the new types of panchromatic and red-sensitive plates, the exploration of the red stars of the universe is yielding very valuable results. The use of red-sensitive materials in astronomy has very definite advantages over the use of blue-sensitive materials. The scattered light from the night sky is largely of short wavelength because the scattering is selective, as is shown by the color of blue sky, and much more effective exposures can be made on stars before the scattered light from the sky buries the images in fog if the photographs are taken by red light. The limit of effective exposure by violet light, for instance, in the Mount Wilson telescopes is approximately 90 minutes, after which little is gained because of the fogging of the plate by scattered light. Using red-sensitive materials, the corresponding exposure can be more than five times as great. Also there are many regions of the sky which are obscured, and this obscuring material transmits red light much better than it transmits the blue light.

Plate 1 shows photographs of one of the most heavily obscured globular clusters, which is situated close to the center of our galaxy. Figure 1 was taken by W. Baade on a fast blue-sensitive plate with 50 minutes' exposure. Figure 2 shows the same cluster taken on a red-sensitive plate with 75 minutes' exposure through a yellow filter. These pictures show that the heavily obscured clusters are strongly reddened and that the reddening not only affects the clusters but the whole stellar field in which they are imbedded.

The greater penetrating power of the red-sensitive plate enables us to pass through the outer extensions of the hidden galactic nucleus when photographing regions near the galactic center, which are apparently little affected by obscuration. The new types of sensitizers have made it possible to photograph not only the visible red but to penetrate beyond it into the invisible infrared. J. J. Nassau, at the Warner and Swazey Observatory, has found that many very red stars, which are often variable, have absorption bands in the infrared. Much interesting information is being obtained as to the nature of these stars, especially as components of binaries and as to the part they play in the nearer galaxies external to our own Milky Way system. Moreover, the use of infrared spectra has given a good deal of information concerning the planets. It is possible to set an upper limit, for instance, to the concentration of water vapor in the atmosphere of Mars and to show the concentration of carbon dioxide in the atmosphere of Venus, and by means of their absorption lines ammonia and methane have been identified in the atmospheres of the outer planets.

Owing to its proximity, it is far easier to study the composition and structure of the sun than that of any other star. The information obtained from the sun can often be applied to other stars and thus can suggest explanations for phenomena which might otherwise remain obscure. Owing to the fortunate presence of the moon at a distance from the earth that enables it to eclipse exactly the solar disk when it happens to come between the earth and the sun, much knowledge of the atmosphere of the sun has come from the few moments when the bright disk is obscured and the thin atmosphere becomes visible. Plate 2, figure 1, shows a magnificent photograph of the solar corona taken by the Naval Research Laboratory expedition at Khartoum at the eclipse of February 25, 1952. Plate 2, figure 2, shows a large-scale photograph of a large sunspot taken recently at Mount Wilson. The detail in the spot and the so-called rice-grain structure of the sun's surface are well shown.

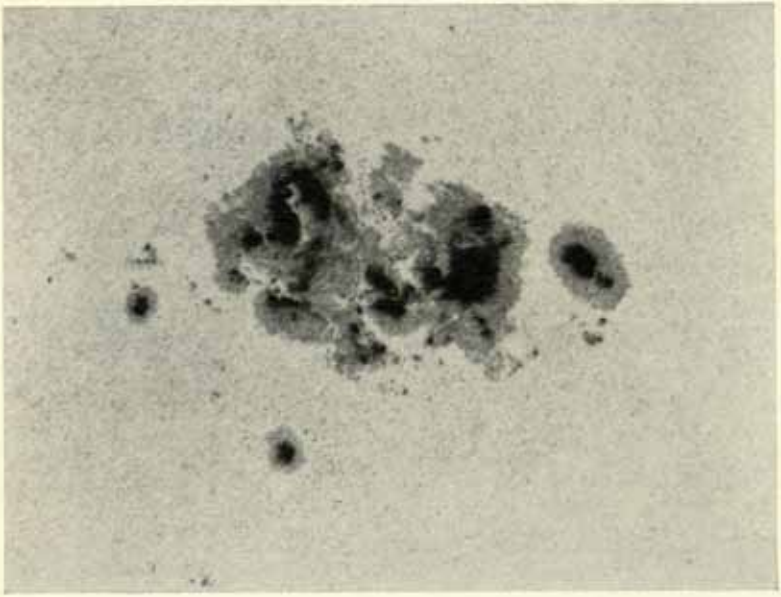
R. R. McMath and his associates, at the McMath-Hulbert Observatory of the University of Michigan, have combined a motion-picture camera with the spectrohelioscope designed by G. E. Hale. An image of the sun is formed on a slit of a large-grating spectroscope, and the dispersed image falls on another slit, which is adjusted to transmit only the position of an absorption line. With this instrument, the McMath-Hulbert Observatory staff have made beautiful photographs of solar eruptions.

Photographs of the solar prominences can also be made by the instrument known as a coronagraph, designed originally by B. Lyot of the Meudon Observatory in France. This coronagraph consists essentially of a simple telescope designed to give a minimum of scattered light and carefully trapped by baffles. The image of the sun is caught in a light trap so that only the area surrounding the sun is projected into the field of the instrument. By working at altitudes above 10,000 feet, where the scattered sky light is at a minimum, Lyot succeeded in photographing the outline of the corona. The instrument operated by Harvard and Colorado Observatories erected at Climax, Colo., has been used to take some very excellent photographs of the prominences, using film specially sensitized to the H-alpha line and a special filter by which the transmitted spectrum is confined to a very narrow band. Plate 3, figure 1, shows a huge arch prominence photographed in the light of H-alpha on June 4, 1946. A new solar phenomenon was discovered at Climax. The edge of the sun photographed by the light of the hydrogen red line near the North Pole shows a great number of tiny prominences, termed "spicules," which have an average life of only about 4 minutes. The spicules are always present in inactive regions and seem constantly

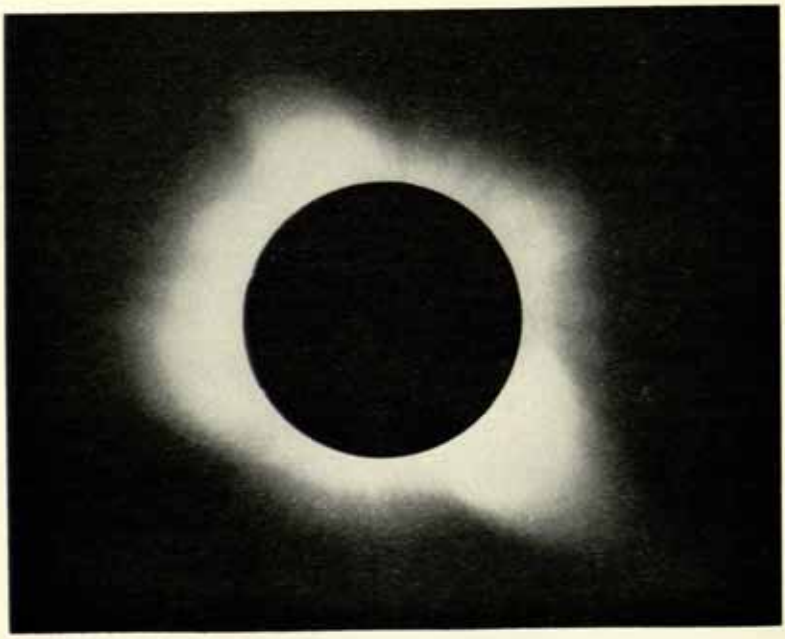
2. OBSCURED GLOBULAR CLUSTER ON RED-SENSITIVE PLATE.

1. OBSCURED GLOBULAR CLUSTER ON BLUE-SENSITIVE PLATE.

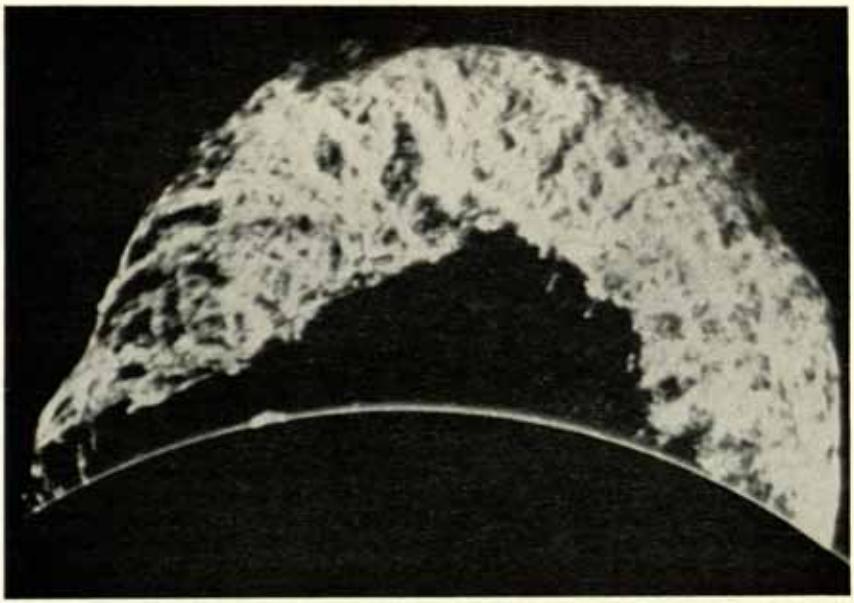
Photographs courtesy of Mount Wilson and Palomar Observatories.



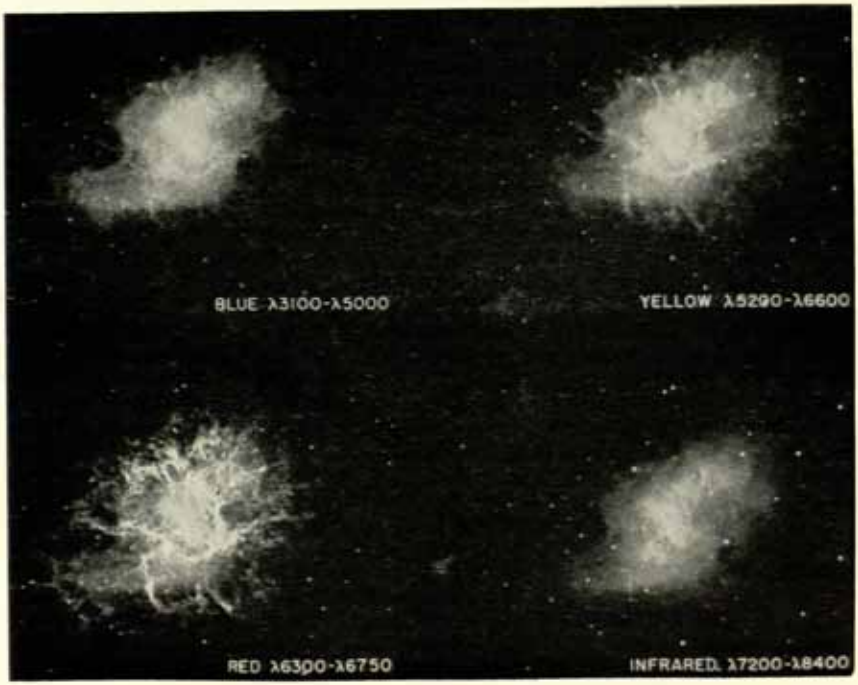
2. LARGE-SCALE PHOTOGRAPH OF SUNSPOT.
Photograph courtesy of Mount Wilson and Palomar Observatories.



1. SOLAR ECLIPSE, FEBRUARY 25, 1952, PHOTOGRAPHED AT KHARTOUM, SUDAN, BY D. S. HAWKINS.
Photograph courtesy of Naval Research Laboratory, U. S. Navy.



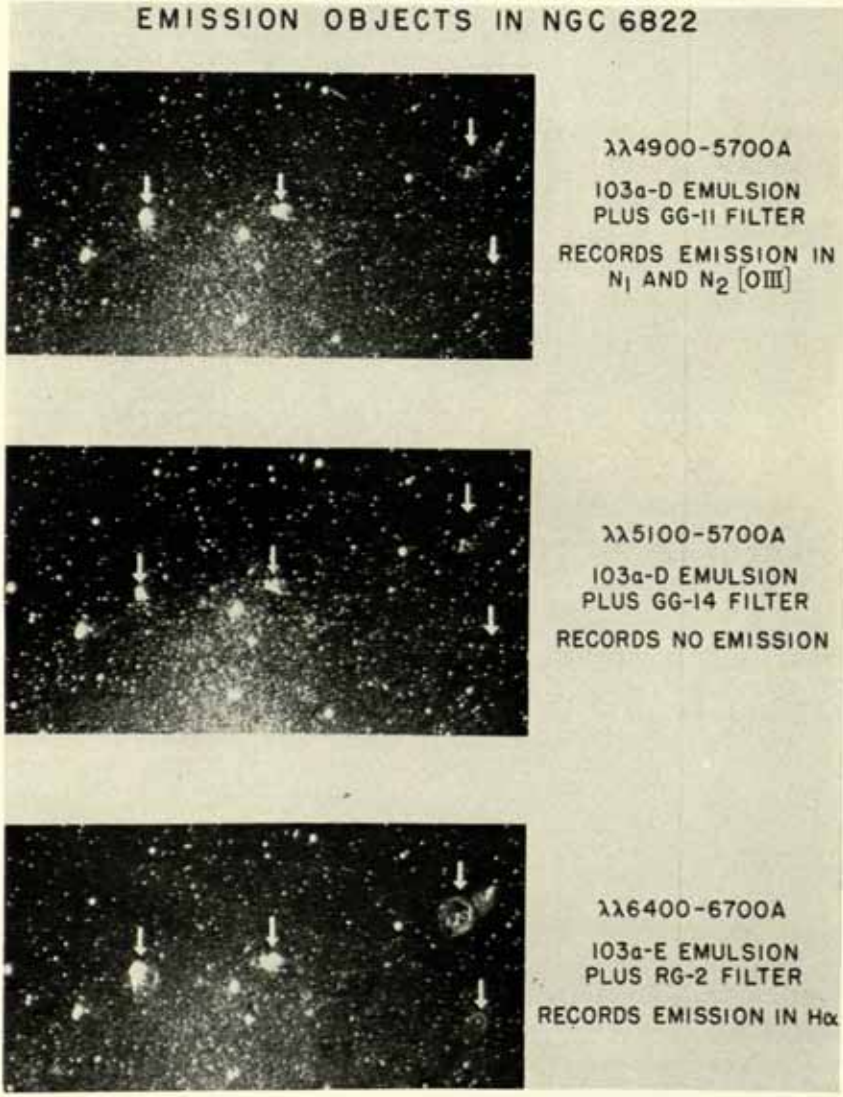
1. AN ARCH PROMINENCE PHOTOGRAPHED AT CLIMAX OBSERVATORY, COLORADO.
Photograph courtesy of Harvard University and University of Colorado.



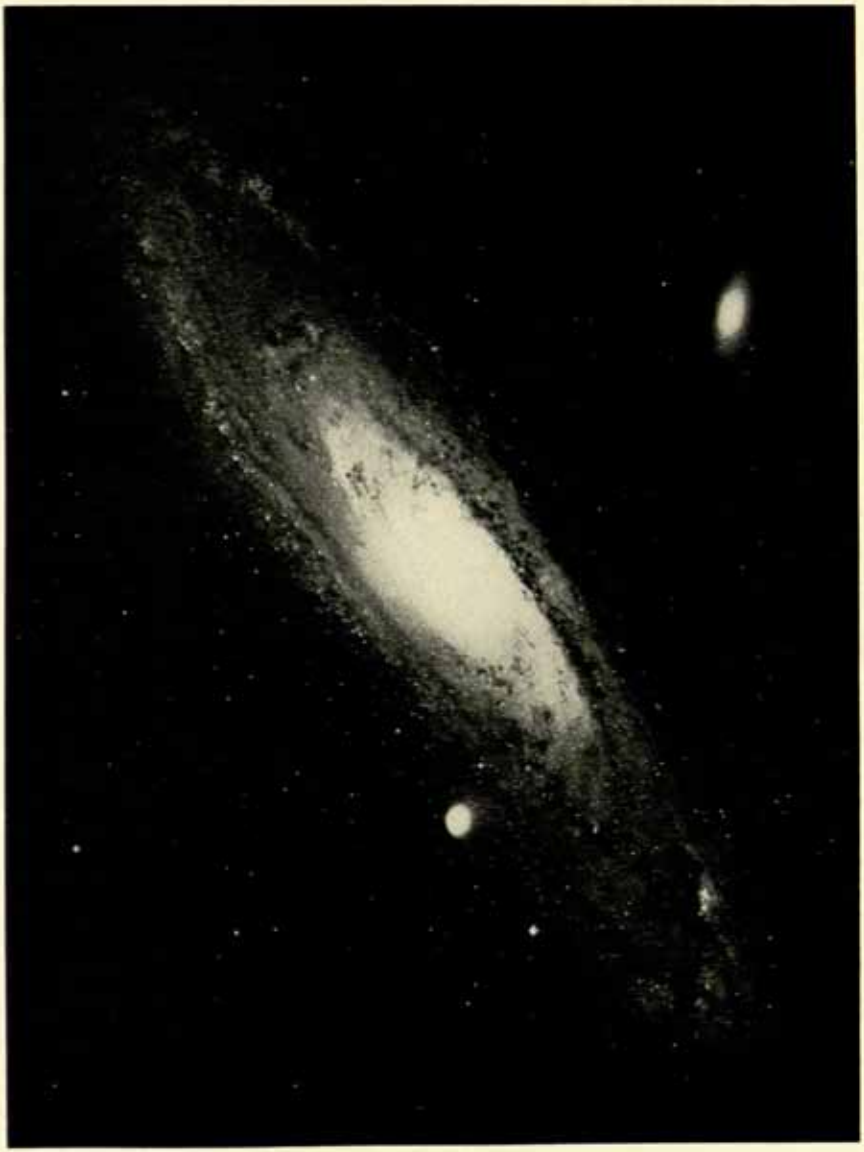
2. CRAB NEBULA PHOTOGRAPHED BY LIGHT OF DIFFERENT COLORS.
Photograph courtesy of Mount Wilson and Palomar Observatories.

HORSEHEAD NEBULA.

Photograph courtesy of Mount Wilson and Palomar Observatories.



EMISSION OBJECTS IN AN EXTRAGALACTIC STELLAR SYSTEM.
Photograph courtesy of Mount Wilson and Palomar Observatories.



ANDROMEDA NEBULA.

Photograph courtesy of Mount Wilson and Palomar Observatories.

to erupt radially from the sun in marked contrast to the general behavior of other prominences.

Now let us turn from the photography of the planets and the sun and celestial objects which are near us in space to the work that has been done on the very distant parts of the universe. Over a hundred years ago, Sir John Herschel called attention to the presence among the stars of what he called nebulae—little clouds—and as telescopes have grown in size and photographic materials have increased in sensitivity these nebulae have attracted more and more attention.

As soon as the spectroscope was used to analyze the stars, it became evident that the word "nebula" was being used for two classes of objects entirely different in structure. If with a pair of fieldglasses you look at the sword of Orion, you will see a misty patch surrounding a star in the middle of the sword. This is the great nebula of Orion, a mass of gas of enormous extent. If, on the other hand, you turn your fieldglasses on the constellation of Andromeda, you will find another misty patch, but this is not a mass of gas like the nebula of Orion; it is a vast agglomeration of stars at a distance so great that in an ordinary telescope the individual stars cannot be seen. The distinction becomes clear when we look at the spectra. The Orion nebula gives us a spectrum consisting of bright lines, as would be expected from a mass of gas, whereas the spectrum of the Andromeda nebula is essentially that of a star though it is really a composite of all the stars of the nebula—a sort of average spectrum.

The gaseous nebulae that we can investigate are situated in our own galaxy, and in some cases they are probably connected with the explosion of stars in the form of novae and supernovae. When a star explodes in a nova, it produces an expanding shell of gas and can be photographed for many years. By the use of suitable plates and filters, photographs can be taken by monochromatic light, showing differences in the structure of the envelope as a result of the distribution of different gases. Thus in photographs which have been taken of the expanding gas shell produced by Nova Herculis, which exploded in 1934, the emission of ionized oxygen at $\lambda 3727$ A. causes a nearly homogeneous cloud around the star, whereas emission of the same element (in the same state of ionization) at $\lambda 4986$ A. and $\lambda 5006$ A. causes a more clearly defined ring. Emission of H-alpha and nitrogen in the red causes a ring with a strongly accentuated crossbar. When the gas shells produced by the explosion of supernovae expand sufficiently, we get a permanent nebula, usually referred to by astronomers as a planetary nebula, such as the Crab Nebula.

A recent photograph of the Crab Nebula is shown in plate 3, figure 2. The different photographs were taken by blue light, yellow light,

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red light, and infrared light, and they show differences in the structure of the nebula. As is well known, this object is all that remains of a supernova which flared up in A. D. 1054. It is recorded in Chinese history as having been seen in full daylight.

Turning to the other type of nebulae—those that are like the Andromeda Nebula, those that are agglomerations of stars—in the last 30 years the nature of these great spiral nebulae, as they are called, has been elucidated. It has been found that they are no less than stellar universes and that if we could observe the Milky Way, in which our sun is situated, from the Andromeda Nebula, our galaxy would appear very much as the Andromeda Nebula does to us, the two galaxies being of approximately the same size, having in each of them about a hundred million stars, and according to some very recent work, being about 1,500,000 light-years apart.

Long ago E. E. Barnard called attention to the existence in our galaxy of great clouds of obscuring matter as well as of widely distributed nebulosities. The whole galaxy, in fact, when viewed with telescopes of low magnification, shows streaks, which may be either bright or dark against the backgrounds of suns. It is, indeed, probable that a very substantial proportion of the matter of the universe is not agglomerated into stars, but is dispersed through intergalactic space in particles and in the molecular form. This dispersed matter is, of course, greatly concentrated in the galaxies so that perhaps only half the mass of a galaxy is in the form of stars. The effect on the calculated dynamics of the galaxies is, of course, enormous, and it gives a very much simpler pattern of the disklike structure of a rotating galaxy than if it is assumed that the mass of such a galaxy consists entirely of discrete stars. One of the most remarkable of these masses of gas appearing dark against the skies is shown in plate 4. It was obtained with a 2-hour exposure on a red-sensitive plate with a red filter and was taken with the Hale telescope. The formation occurs along the edge of a large cloud of opaque dust and gas in the constellation of Orion. The edge of the cloud is illuminated by nearby bright stars. The cause of the streamers running outward nearly perpendicular to the cloud front has never been explained nor has the cause of the large extension of the cloud front known as the Horsehead Nebula, so-called because of its shape.

The proper combination of emulsion sensitivities and filters permits a detailed study of the structure of many astronomical objects such as the extragalactic stellar system shown in plate 5. Only a portion of the whole system is shown in order to concentrate attention on the nebulous objects indicated by arrows. The first picture, taken on a 103a–D plate through a GG–11 filter, isolates the light emitted by doubly ionized oxygen, which occurs in the so-called nebulium lines

N_1 and N_2. It has been shown that no such element as nebulium exists and that these lines are the result of a very unusual state of emission by oxygen, known as a forbidden state. In a wavelength region isolated in the second picture, recorded on a 103a–D plate through a GG–14 filter, no emission from the gases in the nebulosity is recorded. Only stars are shown. In the third picture, taken on a 103a–E plate through an RG–2 filter, only the emission of the H-alpha line is recorded in the nebulosity together with the red light of the stars. This series shows the powerful tool afforded by plates of different color sensitivities combined with suitable filters in the study of the structure of extragalactic objects.

During the last few years, a number of new telescopes have come into use, and their effective use presents some new problems in regard to the photographic materials, though their application is already giving results of great interest and value. By far the greatest of these telescopes is, of course, the 200-inch Hale telescope at Mount Palomar, of which you have already heard so much. Besides this instrument, however, Mount Palomar has the largest Schmidt telescope, the 48-inch, with which an excellent survey of the sky can be made, covering a much greater field than was available for previous telescopes. The great 48-inch Schmidt is being used in a survey of the whole sky accessible to it, using plates 14 inches square sensitive to blue light and to red light. Sufficient plates for a year's use are made to ensure uniformity of material, and they are stored at a low temperature so that they can be expected to remain unchanged until they are used. Plate 6 is one of the latest pictures of the great Andromeda Nebula made with an exposure of 35 minutes on the Schmidt telescope. The excellent definition of this instrument resolves many stars in the spiral; the two small nebulae are the well-known satellites of the Great Nebula.

Employing 103a–E plates with a red filter on the Hale telescope, Baade was able to resolve one of the companions to the Andromeda Nebula into its individual stars. With other combinations of plates and filters, the stars of different colors were separated and their distribution centered. This led to the startling discovery that there are two types of stars in the nebulae. These are called by Baade *Population I* and *Population II*, and they exist in different proportions in different galaxies. Type I population is composed of stars that are intrinsically very bright and generally blue in color. A blue-sensitive plate primarily records these stars. Population II stars are intrinsically fainter and redder. These are recorded on red-sensitive plates.

The most sensational discovery of the astronomers in this century has undoubtedly been the announcement by E. P. Hubble of Mount

Wilson that the spectral absorption lines of distant nebulae show a shift toward the red. The most obvious explanation of this shift is that it is caused by a recession of the nebulae in the line of sight, and Hubble found that the calculated velocities of recession were proportional to the distance of the nebulae. By 1948 the velocities of more than 500 nebulae were known, and even at distances of 200 million light-years, which is the limit of the 100-inch telescope for spectra, the velocity computed from the red shift was found to be proportional to the distance. One of the points of chief interest in the application of the 200-inch Hale telescope was to see whether the relation between the velocity and the distance would hold for even more distant nebulae than those of which the spectra could be photographed with the 100-inch.

Using the Hale telescope with a short-focus spectrograph at the principal focus, M. Humason has photographed the spectra of a cluster of nebulae in Hydra. The shift of the H and K lines of calcium indicates a recession of 37,500 miles a second, and the displacement is so great that the lines fall in the blue-green near the long wavelength limit of sensitivity of the undyed IIa–O emulsion used. Recently Baade published evidence for a revision of the distance scale of the distant stellar systems, as a result of which the nebulae may have to be assigned distances twice as great as those which have heretofore been used and the time scale will be doubled. This change in the scale and the application of the Hale telescope with its powerful auxiliary equipment may make possible some clearer picture of the nature of the red shift.

Advance in the study of the universe is dependent on the collaboration of three different branches of science, all of them employed finally by the skilled astronomer, whose results must be analyzed by the mathematician. The optician is making great strides in the development of new telescopes and new spectroscopes; the chemist is making the new sensitizing compounds derived from ever more complex organic bases; and the photographer must make improved emulsions and apply to them the sensitizing dyes, so that he can place in the hands of the astronomer photographic materials worthy of the instruments and the skill that the astronomer employs. Fortunately, we all are working in harmony and, as the results that I have put before you in this paper show, we are making progress.

Radioisotopes—New Keys to Knowledge[1]

By Paul C. Aebersold

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Oak Ridge, Tenn.

[With 4 plates]

CHRONOLOGY

Twenty-five years ago the field of atomic energy as we know it today had not even been conceived; nuclear science was just getting under way. Of course, Roentgen had discovered X-rays; Becquerel had discovered radioactivity; the Curies had discovered radium and polonium; Rutherford had originated his concept of the atom with a tiny, heavy nucleus surrounded by planetary electrons; and Soddy had proved the existence of isotopes—different forms of atoms of the same element—and some 30 different naturally occurring radioactive isotopes had been identified. The fact that atoms of an ordinary stable element may differ in weight, that elements may have stable isotopes, had been determined from positive ray studies by J. J. Thompson and Aston. Also, Rutherford, working with alpha particles from radioactive sources, had observed the transmutation of nitrogen atoms to oxygen atoms.

In spite of the seemingly large volume of information that had been accumulated by 1928 on the atom and its nucleus, the real attack on the nucleus itself and an understanding of what it is made of was yet to come. Chadwick had not discovered the neutron; Anderson had not discovered the positron; Urey had not discovered deuterium; I. Joliot-Curie and her husband, F. Joliot, had not discovered that radioactivity could be induced in ordinary stable elements; E. O. Lawrence, of the University of California, had not invented the cyclotron; and nuclear fission and the uranium chain reactor were entirely beyond the realm of imagination of our most learned physicists.

Roentgen's discovery of X-rays and Becquerel's discovery of radioactivity just before the turn of the century had begun the era of modern physics. It was generally agreed by such learned nineteenth-century

[1] Twenty-Sixth Annual Faraday Lecture, Pasadena City College, Pasadena, Calif., February 19, 1953.

scholars as Kelvin, Helmholtz, Boltzman, Michelson, and Lorentz that all the great discoveries in physics had already been made and that future progress was to be looked for, not in bringing to light qualitatively new phenomena, but rather in making more exact quantitative measurements upon old phenomena. In simpler terms this meant obtaining more significant figures beyond the decimal point. As Robert Millikan said after hearing Professor Roentgen report his discovery of X-rays to the German Physical Society, ". . . we all began to see that the nineteenth century physicists had taken themselves a little too seriously, that we had not come quite as near sounding the depths of the universe, even in the matter of fundamental physical principles, as we thought we had." But no one, even as recently as 25 years ago, dreamed of the amazing developments of nuclear physics or atomic energy that have taken place since.

Radioactivity was the key that had opened up door after door in the dramatic development of nuclear science. It was the study and use of radioactivity that led to Rutherford's concept of the atom, to Soddy's concept of isotopes, to Chadwick's discovery of the neutron, to the Joliot-Curie's man-made radioactivity, and finally to Hahn's discovery of fission from which have come both the chain reaction and the nuclear reactor.

ISOTOPES

But radioactivity proved more than an ordinary key. It has been a master key, for it has provided us with a whole chain of "new keys." We shall concern ourselves here with only one of these "keys"—the reactor-produced radioactive isotopes. We shall consider the production, distribution, and use of these radioisotopes and look at what radioisotopes have meant to science and what they may mean to the individual.

At the risk of going backward once more, let us try to imagine what scientific tool investigators of 25 years ago might have desired most. I am thinking now not only of physicists but also of chemists, biologists, physiologists, and other types of researchers. Among the things that scientists of that day could not do but no doubt sincerely wished they could do was "to trace atoms." Think of being able to trace a certain diet element or compound through the digestive and metabolic processes of an animal or even a human being. Think of being able to find out what plants do with carbon dioxide or with fertilizer, or following the diffusion of atoms in solid metal. Scientists of 25 years ago could only dream of doing these things. Man-made radioisotopes have now made these dreams possible! Today, even undreamed of things have become routine. But the story taken from this page of science is much more dramatic than "first you can't, then you can."

DEFINITIONS

Webster reminds us that the word "isotope" comes from two Greek words, "iso" and "topos," meaning "same" and "place." The word "isotope" was chosen to describe certain atoms which, although different in weight, still occupy the same place in the periodic table of elements. Since they are atoms of the same element, they will behave alike chemically, their differences being only in physical properties. Isotopes, therefore, are like twins that look and act alike but that are different in weight. Radioactive isotopes, or radioisotopes for short, are atoms that give off radiation and disintegrate to become other kinds of atoms.

Actually, isotopes are very intimately associated with our everyday lives. They are not only to be found in the laboratory but everywhere. Isotopes are common in the elements around us here—including those in our bodies. For example, hydrogen, the simplest and one of the most abundant elements, exists naturally in two forms (fig. 1). One is

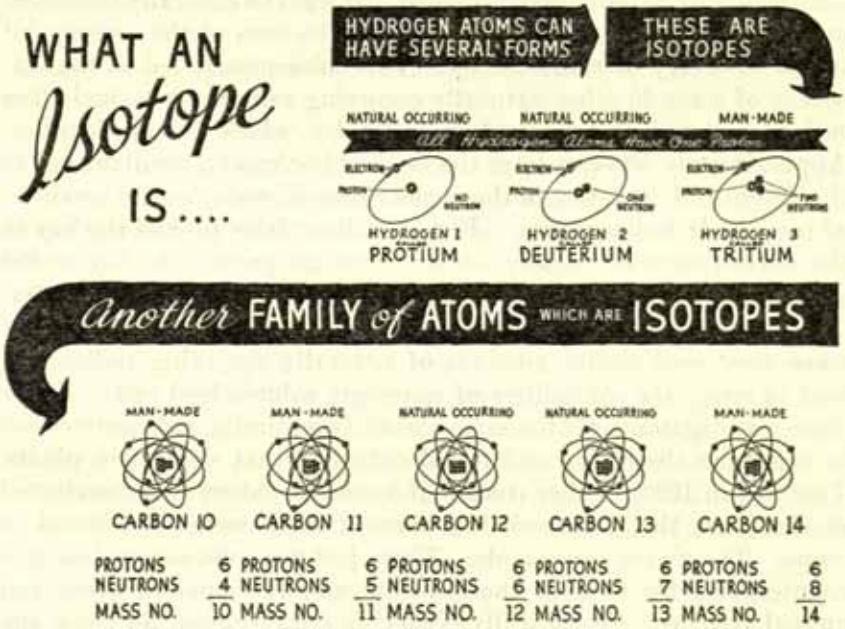


FIGURE 1.—The word "isotope" is used to distinguish different-weight atoms of the same element. The simplest of the elements, hydrogen, has three isotopes. Two of them—hydrogen having a unit weight of 1, called protium, and hydrogen having a unit weight of 2, called deuterium—exist in all naturally occurring hydrogen in the respective concentrations of 99.985 percent and 0.015 percent. Hydrogen 3 can be made by man in the nuclear reactor although it does not occur in nature. All other elements have at least three isotopes and some have considerably more. The element xenon, for example, has 24 known isotopes. A total of more than 1,000 isotopes have been identified to date. Pictured with the isotopes of hydrogen are the isotopes of carbon.

ordinary hydrogen, which has a weight of approximately one unit of atomic mass, called hydrogen 1. The other is approximately twice as heavy and is called heavy hydrogen, or hydrogen 2. We can also make a still heavier hydrogen 3.

Both hydrogen 1 and hydrogen 2 are stable; that is, they do not change with time, or disintegrate, or give off radiation. Hydrogen 3, on the other hand, is radioactive and disintegrates or decays to a stable isotope of helium. In disintegrating, hydrogen 3 gives off radiation.

Five isotopes are known for the element carbon, only two of which are stable and naturally occurring. The other three are radioactive and have to be made. Generally speaking, most naturally occurring isotopes are stable, whereas most radioactive isotopes have to be made. There are, however, exceptions particularly in the case of the heavy elements.

NATURALLY OCCURRING RADIOISOTOPES

The historical sequence of events leading to today's widespread availability of radioisotopes is unique. It was the naturally occurring radioelement uranium which even before the turn of the century led to the discovery of radioactivity. This subsequently led to the discovery of some 45 other naturally occurring radioisotopes, including such important isotopes as radium and radon, whose uses are familiar. Approximately 50 years later the same radioelement, uranium, led to the design and operation of the nuclear reactor, today's mass producer of man-made radioisotopes. Just as radioactivity proved the key to the development of nuclear science, uranium proved the key to the availability of radiomaterials. But we are getting ahead of our story.

In 1913 Hevesy and Paneth conducted the first tracer experiment when they used minute amounts of naturally occurring radioactive lead to study the solubilities of sparingly soluble lead salts. Later these investigators used the same naturally occurring radioactive lead to study the absorption and translocation of that element in plants. This was in 1923. Other studies of a similar nature were conducted in the years that followed, but none of them were very broad in scope. The reason was simple. There just were not any radioactive counterparts for most of the elements usually found in plant and animal systems. No naturally occurring radioisotopes for those elements existed, and no one knew how to make them. Here then was a technique that admittedly had unlimited possibilities but that could not be used because the materials to do the job were not available.

MAN-MADE RADIOISOTOPES

Then came the key to a whole new era for radioactivity. In 1934 I. Joliot-Curie and her husband, F. Joliot, while bombarding light

elements with alpha particles from polonium, discovered quite by accident that ordinary elements can be made to become radioactive.

The first man-made radioactive isotope produced was phosphorus 30. It was immediately shown that the path of this new isotope in chemical reactions could be followed by its radioactivity. In less than a year Hevesy was using another form of radioactive phosphorus, phosphorus 32, to study the uptake of that element in plants, but only infinitesimally small amounts of radioactive isotopes could be produced in this way.

CYCLOTRON-PRODUCED RADIOISOTOPES

Shortly thereafter a new way was found for making larger quantities of man-made radioisotopes. E. O. Lawrence and M. S. Livingston had built their first cyclotron at Berkeley in 1931. It was not long after the discovery of man-made radioactivity that the cyclotron was put to work making radioactive forms of most of the elements.

Physicists all over the world immediately became engrossed in the possibilities offered by these two developments, the invention of the cyclotron and the discovery of man-made radioactivity. By the start of World War II, 10 years later, radioactive isotopes were being made in perhaps as many as 50 cyclotrons throughout this country as well as in a number of foreign laboratories. By this time the usefulness of radioisotopes for tracing atoms was well established. At least two isotopes, radioactive iodine 131 and radioactive phosphorus 32, had also been used in medicine for the radiation treatment of certain diseases.

But there was still one catch. Cyclotron production of most radioisotopes was and still is very slow and very expensive. But most serious of all, the cyclotron can produce only limited quantities of radioisotopes. Therefore, with the exception of those laboratories which were fortunate enough to have cyclotrons, there just were not enough man-made radiomaterials to go around. And even when a cyclotron was available, tracer studies were generally limited to those experiments that would require only a very small amount of the precious radiomaterial.

REACTOR-PRODUCED RADIOISOTOPES

The nuclear reactor developed during World War II makes an excellent radioisotope production unit. Although not so wide a variety of radioisotopes can be produced in the reactor as in the cyclotron, what is much more important, the radioisotopes can be produced in large quantity. Also, with the reactor it is possible to produce many different radioisotopes at the same time. This, of course, is not possible with the cyclotron or with other particle accelerators.

Uranium, which heralded the discovery and use of naturally occurring radioactivity, reentered the scene to make an even greater contribution in the production of man-made radioactivity or radioisotopes.

NUCLEAR REACTOR

A few facts concerning the Oak Ridge reactor, the production unit for most of the radioisotopes made in the United States today, may be of interest.

As one first sees the Oak Ridge reactor (fig. 2; pl. 1) it appears to be a concrete structure 47 feet long, 38 feet high, and 32 feet deep. The concrete, however, is a 7-foot thick shield built around the reactor to protect operating personnel. The reactive portion of the reactor is a 24-foot cube built of stacks of graphite blocks through which pass some 1,200 channels containing uranium metal as fuel.

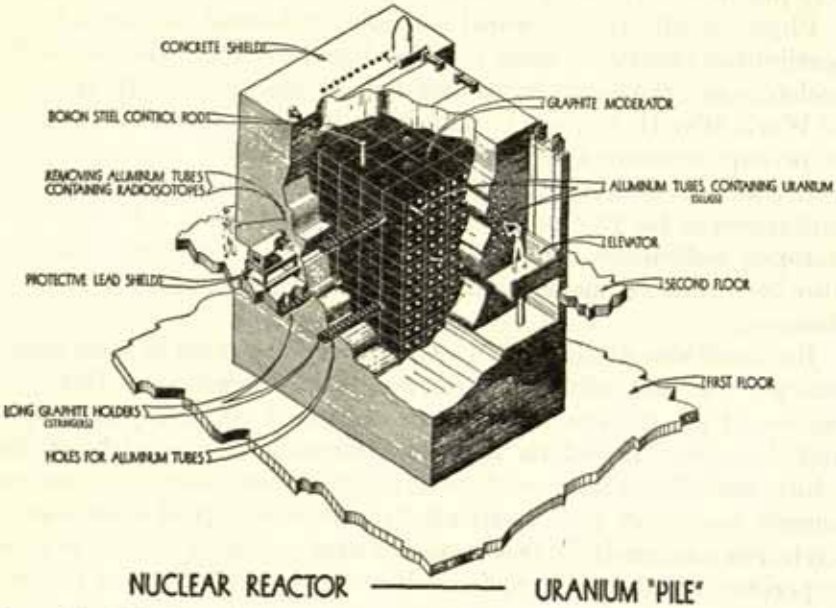


FIGURE 2.—This schematic sketch of the reactor is designed to show the two principal ways in which radioisotopes are produced. The three most important functional parts of the reactor are the uranium slugs, the graphite moderator, and the boron steel control rods. When a fissionable uranium 235 atom in one of the slugs is hit by a neutron, it fissions or splits. In the fission process, 1 to 3 more neutrons are produced which, when slowed down by the graphite moderator, are available for splitting more uranium 235 atoms. The multiplication of this process many many times leads to the chain reaction. Boron has a greater affinity for neutrons than does uranium, and therefore when the boron steel control rods are inserted into the reactor, they "soak up" a sufficient number of neutrons to slow down the chain reaction or stop it, depending on how far they are inserted into the reactor.

Reactor operation is based on the fissioning or splitting of uranium 235 atoms in the uranium fuel. Perhaps the only other characteristic necessary for a simple understanding of the reactor as a radioisotope production unit is the neutron flux or density. The flux of the Oak Ridge reactor is of the order of a million million neutrons passing through each square-centimeter area (about the size of a fingernail) per second.

Radioisotopes are produced in a nuclear reactor either by fissioning—that is, by splitting of uranium (figs. 3 and 4)—or by bombarding ordinary stable elements with neutrons, the subatomic particles that keep the chain reaction going. Although from the standpoint of the physics involved as well as from the standpoint of a manufacturing process, radioisotope production is a complex operation, in principle it is as simple as putting biscuits in an oven to cook (pl. 2). Almost any element, or for that matter almost any object such as a penny or dime or a bobby pin or the phosphorus from the head of a match, can be placed in a small aluminum tube and introduced into the

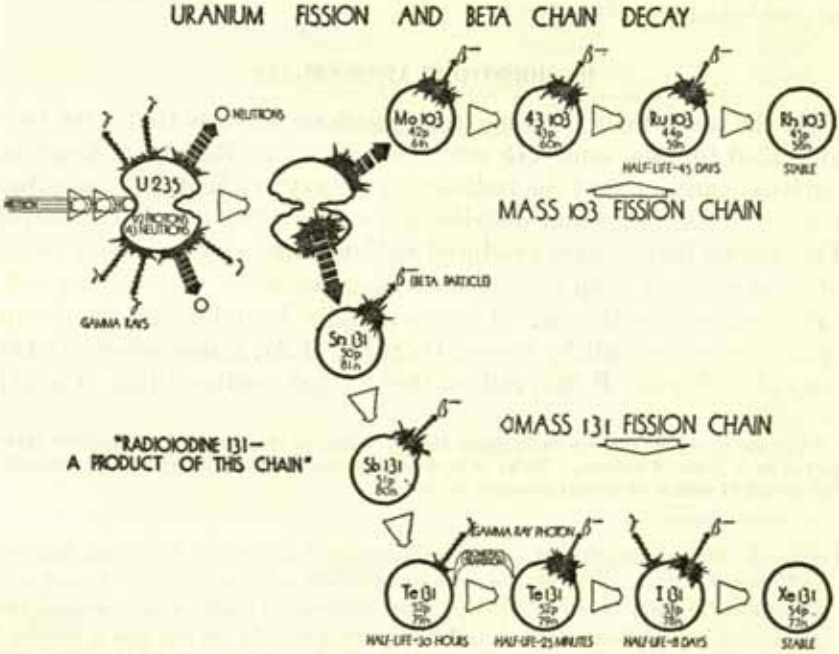


FIGURE 3.—When a fissionable uranium 235 atom is hit by a neutron, it fissions or splits the uranium atom into two different atoms. These atomic fragments are called fission products and make up a wide variety of radioisotopes of elements from zinc, with an atomic number of 30, to gadolinium, with an atomic number of 64. After the uranium slug is removed from the reactor, the fission products are chemically separated from the uranium and plutonium and from each other. One of the most useful radioisotopes produced by this method is radioactive iodine.

reactor. After neutron irradiation or bombardment for a week, a month, or perhaps longer, depending on the radioisotope being produced, the aluminum tube is taken out and the radioactive material removed. Depending on the radioisotope produced, it may or may not be chemically processed before shipping it to the user. In some instances the aluminum tube and all are shipped directly to the user after having been placed in the proper shipping container.

The production output of the reactor is phenomenal. For example, over 14,000 curies[2] of radioactive cobalt 60 have been shipped from Oak Ridge in the 6 years since the distribution program began. This is comparable to nearly 50 pounds of radium. Although it is difficult to estimate the current world inventory of refined radium, in the 6 years preceding the availability of reactor-produced cobalt 60, less than 1 pound of radium was imported by the United States.

Another example is the case of radioactive carbon 14, one of the most useful radioisotopes for biological tracer studies. It has been estimated that 1 millicurie of carbon 14 produced in the cyclotron would cost $1,000,000. The same quantity of reactor-produced carbon 14 can be purchased today for $36.

RADIOISOTOPE AVAILABILITY

Of the more than 1,000 nuclear species or isotopes that have been identified to date, some 275 are stable and over 750 are radioactive. Approximately 100 of the radioactive variety are routinely manufactured at Oak Ridge and distributed to scientists all over the world. This means that reactor-produced radioisotopes or radioactive forms of most of the known elements are now available in quantities sufficient for wide-scale use. Those available include such important radioisotopes as radiohydrogen (tritium, H 3), radiocarbon (C 14), radiophosphorus (P 32), radiosulfur (S 35), radiocalcium (Ca 45),

[2] The curie, which gets its name from Madam Curie, is the unit of radioactivity represented by 1 gram of radium. Today it is defined as the quantity of any radioactive material giving 37 billion disintegrations per second.

FIGURE 4.—One of the principal ways of producing radioisotopes in the nuclear reactor is to bombard ordinary stable isotopes with neutrons, the subatomic particles formed when a uranium 235 atom fissions. The chart shows two types of nuclear reactions which take place when a stable isotope is bombarded with neutrons. In the first case a neutron is absorbed and a gamma ray given off. This has the effect of increasing the atomic weight of the target nucleus by 1, as shown in the production of carbon 14 from carbon 13 and in the production of phosphorus 32 from phosphorus 31. In neither instance is this a particularly good way of producing the radioisotope since there is no way of chemically separating the radioactive isotope from the original stable isotope. The transmutation reaction, on the other hand, results in the production a of radioisotope of a different element than is used in the original target. Here a chemical separation can be effected and the resultant radioisotope made available in pure form.

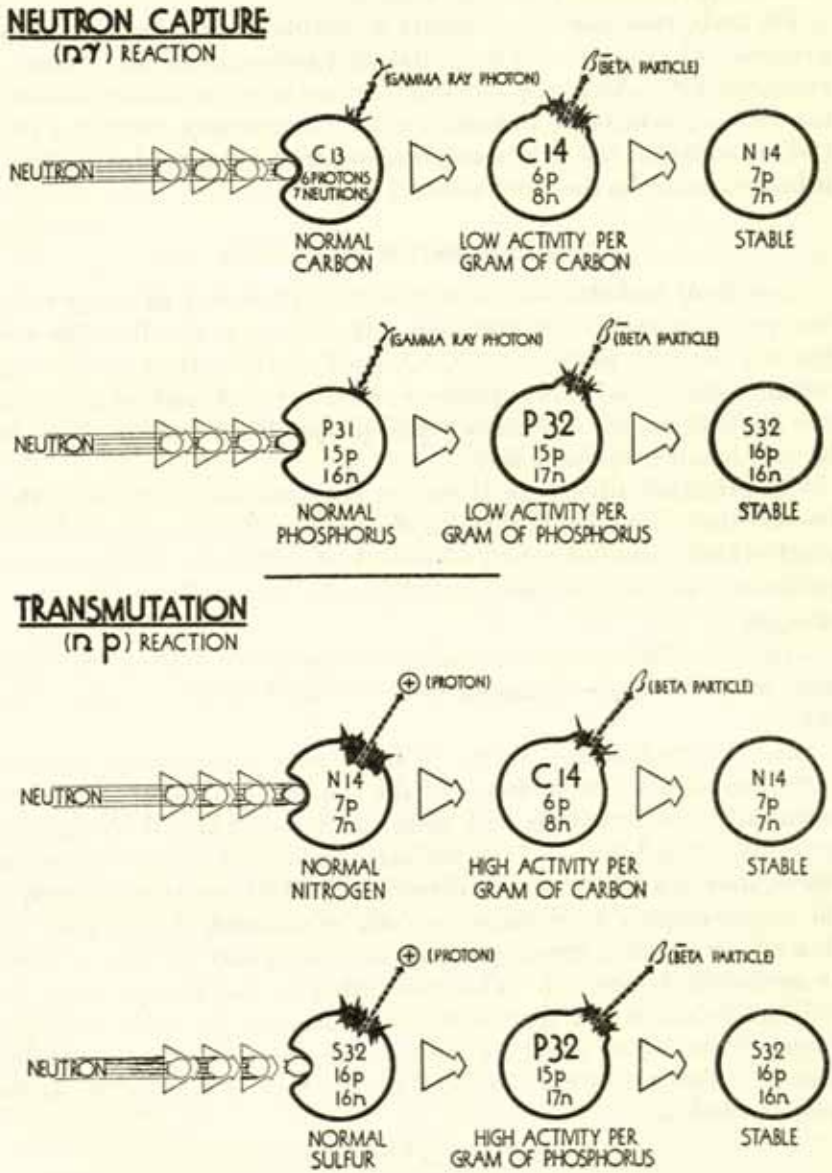


FIGURE 4.—See legend on opposite page.

and radioiron (Fe 55, 59). Most of these radioisotopes emit either beta radiation (high-speed electrons) or a mixture of beta and gamma (electromagnetic radiation like X-rays). However, the energies of radiation and the half-lives, that is, the rates with which the various radioisotopes disintegrate, vary widely.

The only radioisotope currently available under the distribution program which emits alpha radiation (nuclei of helium atoms) is polonium 210. Although this radioisotope exists in nature as one of the decay products of radium and is commercially extracted from radium wastes, it can now be obtained easier and cheaper by producing it in the reactor by the irradiation of bismuth.

HOW RADIOISOTOPES ARE USED

Sources of radiation.—The first and simplest way of using radioisotopes is as sources of radiation. Most persons are familiar with the way in which radium and X-ray machines have been used to treat certain diseases and to take pictures of heavy metal castings in looking for possible cracks and flaws. Reactor-produced radioisotopes can be used in much the same way.

The principal advantage of reactor-produced radioisotopes is that, because there are a lot of them to choose from, the investigator has a much wider choice of type and energy of radiation. Also, reactor-produced radioisotopes are generally easier to handle and are much cheaper.

Tracers.—Radioisotopes or radioactive atoms are much more widely used as tracer atoms—atoms that can be traced by the radiations they emit.

Since the radioactive atoms of an element are like the ordinary nonradioactive or stable atoms of the element and behave like them chemically, they go along with them in all chemical and biochemical processes. But because of the radiations given off by the radioactive atoms, they can act as "atomic detectives." With instruments such as the geiger counter these radiations can be detected, that is, they can be made to produce impulses or signals which may be seen or heard or mechanically counted. This means that we can always locate the radioactive atoms and hence distinguish between the atoms added to a system and other atoms of the same element which were already present. The use of radioisotopes in this way is referred to as the tracer technique.

POWER OF TRACER TECHNIQUE

The tracer technique derives part of its power from its versatility. We can label and trace almost any compound or material that we care to. Sometimes radiomaterials can be used in the simple chemical form as shipped from Oak Ridge. This means as the element, as a simple

salt such as the carbonate or nitrate, or as the oxide. For most biological tracer experiments, however, it is necessary to incorporate the radioisotope in some complex compound. If an investigator wants to use a radioisotope, say carbon 14, in trying to find out what happens to a sugar or an amino acid or a vitamin in a plant or animal process, he must first incorporate the radioisotope into the compound being studied. Sometimes these labeled or tagged compounds can be made by the chemist in the laboratory. Frequently, however, it is necessary to make them by biological means, that is, the radioisotope in some simple form is injected into an animal and subsequently extracted from the blood, urine, or tissues of the animal as the desired complex compound.

The tracer technique to a greater extent, however, derives its power from a combination of extreme sensitivity and unique specificity. So sensitive are the methods for measuring the radiations from radioisotopes that it is possible to detect the presence of atoms with millions to hundreds of millions times the sensitivity possible with other ordinary physical and chemical means now known. It is not difficult to detect radioisotopes that have been diluted as much as a billion or 10 billion times, while dilutions of more than a trillion are attainable (pl. 4, fig. 1). This means that in a tracer experiment in biology it would be possible to detect one-hundred-millionth of an ounce of radioactive material after it had become distributed in an animal as large as a 1,000-pound cow. Or to put it another way, it would be possible to detect 1 ounce of radioactive material, say radioactive sugar, mixed uniformly in 100 million tons or in 2 billion 100-pound sacks of nonradioactive or ordinary sugar.

When we say that the tracer method has a unique specificity, we mean simply that radioisotopes provide scientists with the ability to follow a specific batch of atoms through a complicated system irrespective of all the chemical processes that may be going on. For example, it would be possible to trace an isotope in a soil nutrient through a plant grown on the soil, through a cow fed on the plant, and finally through a rabbit fed on milk obtained from the cow. Even though the isotope would pass through a number of complex processes, its telltale radiation would permit its positive identification throughout.

Radioactive tracer atoms have allowed us to increase our power of perception. They have permitted measurements and analyses at concentrations far below those hitherto permissible. Equally important, they have permitted us positive identification of products and processes. Their value as research tools can perhaps be best described by noting what they have meant to the field of biology.

In the seventeenth century the invention of the microscope marked the beginning of our understanding of the importance of individual cells and their relations to the whole organism. The discovery of

isotopes and their applications as tracer atoms in the twentieth century has given us a tool whereby we can explore the physiology and biochemistry of organisms in the dynamic state with even greater detail. The microscope permits examination of the structural details of individual cells. Isotopes permit examination of the chemical activities of individual batches of molecules, atoms, and ions within cells.

The isotope, particularly the reactor-produced radioactive isotope, has truly been a new key to knowledge. It is a key that has already opened up many doors. Many many more, however, remain to be opened and can be opened by this new key.

EXAMPLES OF APPLICATIONS

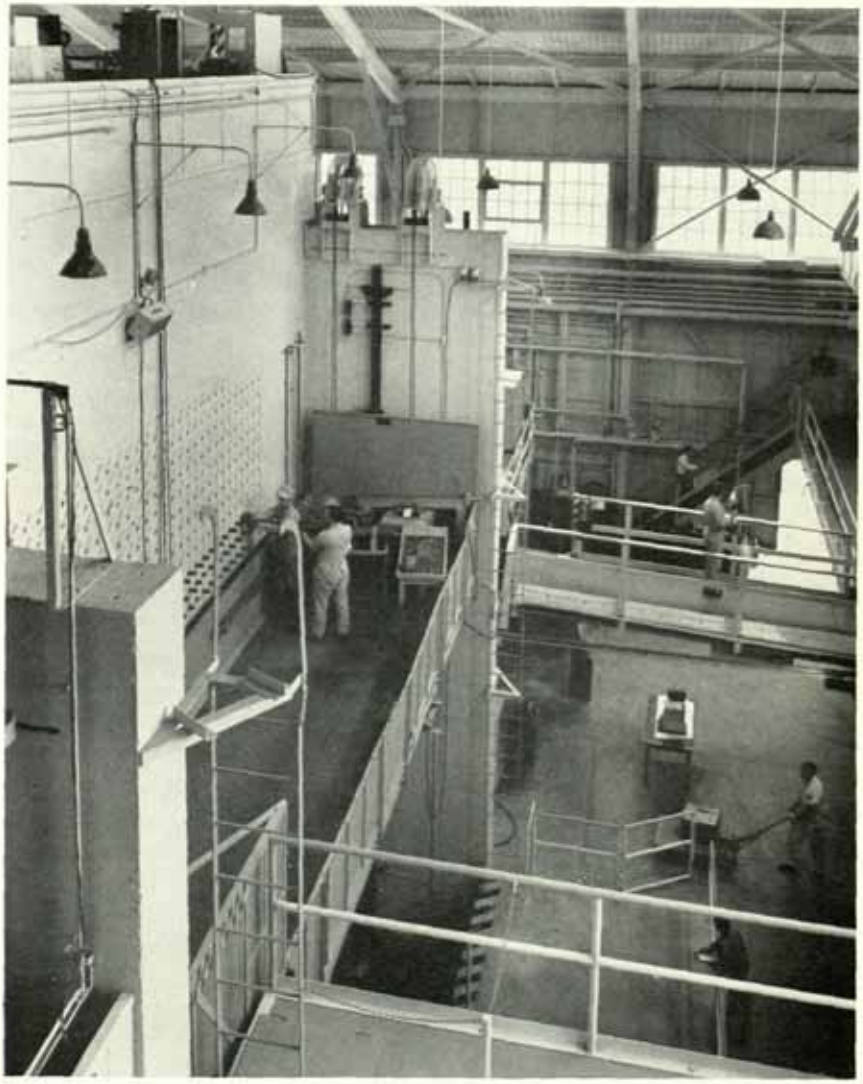
Reactor-produced radioisotopes have been used, particularly as tracer atoms, in nearly every phase of the physical, chemical, and biological sciences. They have also been used extensively in many of the applied problems of medicine, agriculture, and industry. Since the distribution program began in the summer of 1946, more than 32,000 radioisotope shipments have been made from the principal production facilities in Oak Ridge, Tenn., to some 2,000 departments of over 1,200 institutions throughout the United States. In addition, more than 1,600 shipments have gone to approximately 360 institutions located in some 33 foreign countries. Also, several thousand shipments have been made from secondary commercial suppliers in the form of specially processed radiomaterials, radioactive drugs, radiation sources, etc.

In the past 6 years somewhere between 4,000 and 5,000 papers and reports dealing with isotope investigations have been published in some 200 different scientific and technical journals. These only include papers on work done with Commission-supplied isotopes. Also, a number of books have been written on the subject.

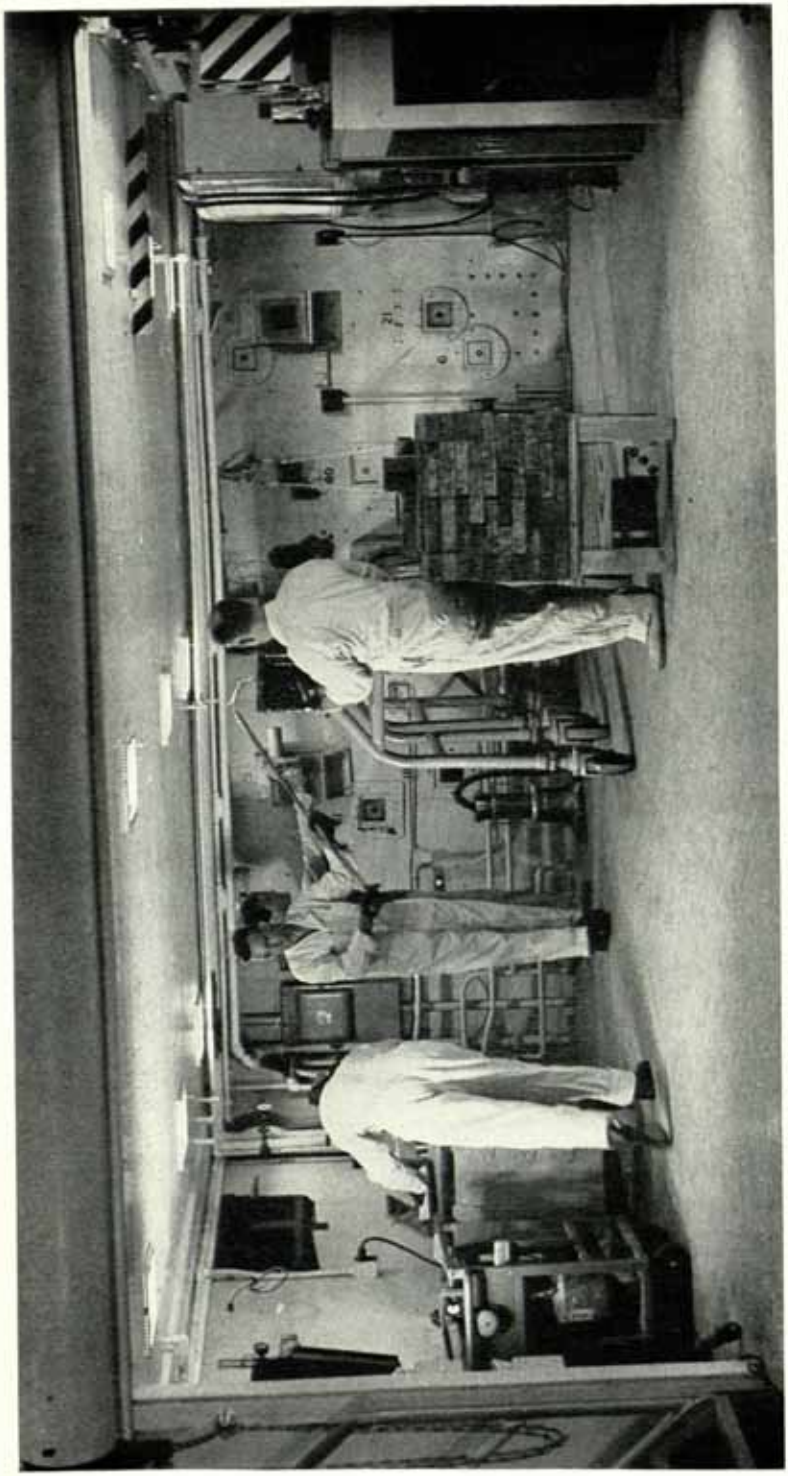
Since the number of different kinds of applications could run into the thousands, we shall try to select examples representative of a large number of applications. Also, to keep the story short, we shall stick to applications in medicine, agriculture, or industry.

MEDICINE

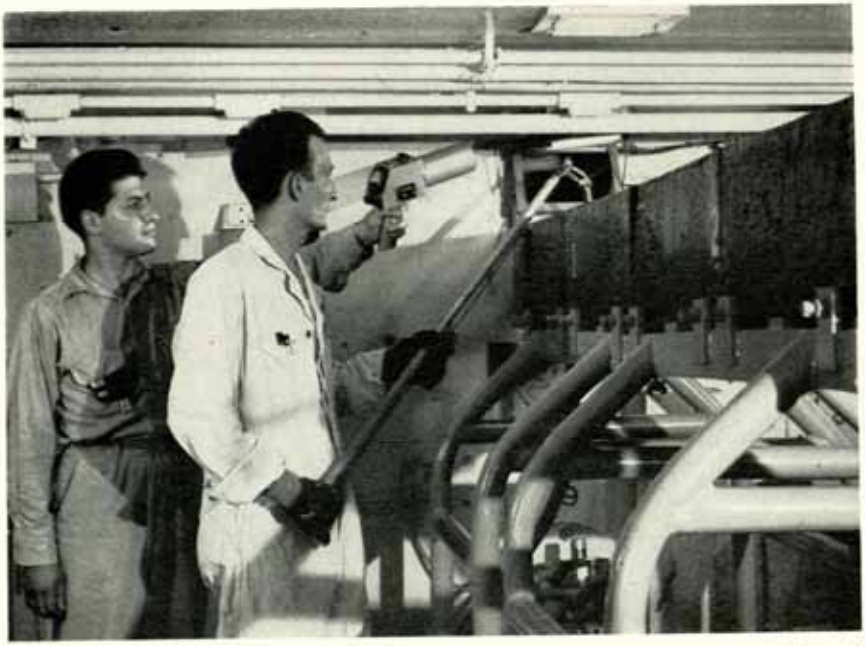
The largest percentage of radioisotope shipments go for use in the field of medicine. This is not only because radioisotopes are used extensively in medicine but because most medical applications use short-lived radioisotopes and therefore require repeated shipments. Radioistopes have found valuable uses in medical research, diagnosis, and treatment.



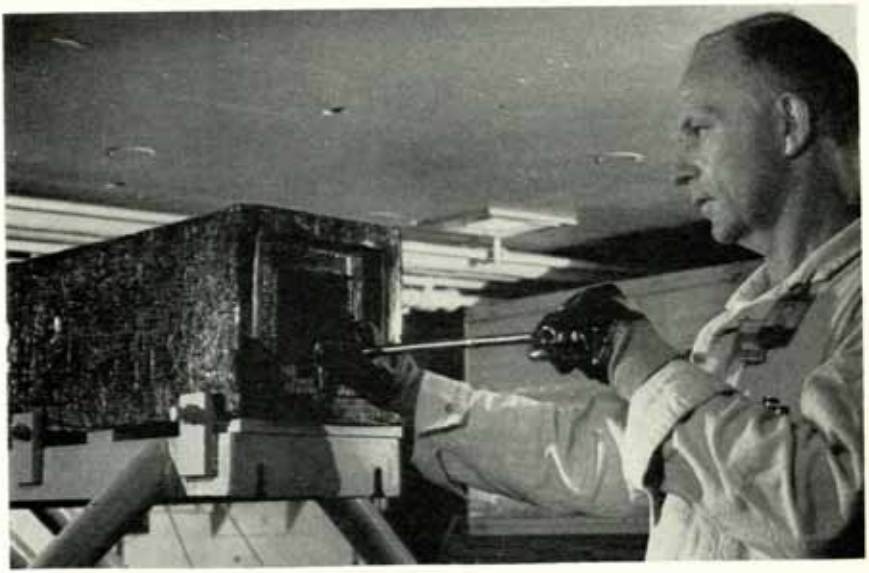
Preparing to remove plugs from some of the 1,248 fuel-channel openings in the shield of the Oak Ridge graphite reactor, personnel stand on an elevating platform. In brackets on the wall of the elevator, in front of the two men, can be seen a horizontal bundle of 10-foot lengths of light steel poles used as "push rods." As a rod is inserted into a channel, another rod is threaded to it, increasing its length to permit traversing the length of the fuel channel.



Here we see operating personnel at the Oak Ridge National Laboratory removing some material which has been irradiated in the graphite reactor. The material is in the small aluminum tube held by the extension tongs which permit the operator to maintain a "safe" distance from the radioactive material. The operator in the foreground is opening a lead-vault storage container in which the radioactive material will be kept until it is transferred to the processing and shipping facility in another building.



1. This is a close-up view of the operation shown in plate 2. The graphite "stringer" containing the holes in which the aluminum tube has been inserted for irradiation can be seen in the mirror above the lead "coffin" through which the stringer is being pulled out of the reactor. The operator at the left is surveying the level of radiation with a "cutie pie" radiation-detection instrument.



2. This shows a close-up of the lead "coffin" through which the stringer shown in the photograph above will be pulled out of the reactor. Note that the operator wears rubber gloves to prevent the possibility of his hands becoming contaminated. Also note that he wears a film badge clipped to his collar and two pocket meters in the pocket of his coveralls to measure the amount of radiation to which he is exposed during the operation.

1. Pictured here is a typical counting setup for assaying radioactive samples in the laboratory. The cylindrical unit on the work bench at the right is a shielded container, often called a "pig," housing a geiger counter. The sample to be counted has been placed on one of the shelves in the "pig." The rectangular unit in the center is the scaler, which picks up the impulse from the counter, amplifies it, and records it on a mechanical counter. The plastic box on the left is a container to hold various absorbers which will be used in counting certain samples. The absorbers, usually aluminum sheets, are placed in the "pig" on a shelf above the sample.

2. Here we see the application of radioactive phosphate fertilizer. The fertilizer is prepared in the laboratory and then applied to the soil from a hopper attached to the tractor shown in the photograph. The operator in the foreground is surveying the row with a radiation-survey meter to determine the distribution of the radioactive fertilizer. Note that both of the men in the foreground are wearing dust masks to prevent possible inhalation of the radioactive fertilizer.

MEDICAL RESEARCH

Radioisotopes have been used as tracer atoms in medical research to study the movement of elements and compounds in the body. For example, they have permitted investigators for the first time to measure the absorption of a specific batch of atoms of an element by a particular tissue or organ. They have shown how elements are transported within the body, how they are absorbed from the intestinal tract, and how they move across blood-vessel walls. They have even been used to measure the uptake and turnover of biochemicals within cells.

But what can isotopes tell us that cannot be determined by other methods? Let us assume that we want to find out how rapidly sodium travels through the body and at what rate it is taken into various body fluids and tissues. All we have to do is to take some table salt and irradiate it in the reactor at Oak Ridge. This gives us radioactive sodium. We can then give some of this radiosodium to a person by mouth or by vein and then follow its path through the body with a geiger counter or some other radiation instrument.

The gamma rays from radiosodium are so penetrating that we can detect them just by holding a counter over various areas of the body. This simple procedure allows us to see when blood carrying the radioactive sodium reaches a certain part of the body. In fact, this technique is used for determining the adequacy of blood circulation to the extremities such as the arms and legs. If we want more detailed information on the movement of sodium within the body, we cannot just hold a counter outside but we have to measure the radioactivity of samples of blood, urine, sweat, and other body fluids taken at various intervals after the radiosodium is injected.

Such an experiment shows that sodium goes across the blood-vessel walls at an extremely rapid rate—back and forth at the rate of 50 pounds of salt a day. Movement of this type could not be found by other methods because we could not tell the ordinary sodium atoms on one side of the blood-vessel wall from those on the other side. However, by putting labeled sodium atoms on one side we can observe the rate at which the labeled sodium atoms appear on the other, and thus find the rate of transfer of sodium.

Similar experiments using isotopes of hydrogen to label water molecules show that water passes back and forth across the blood-vessel walls at the rate of about 20 barrels a day.

The most rapid transfer of sodium in the body is by circulation of the blood. Only about 15 seconds are required for the sodium to go from one arm through the heart, through the lungs, and into the other arm. It was found that in 60 additional seconds the sodium had

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diffused out into the tissues and had been excreted from the sweat glands on the opposite arm.

But radioisotope studies have called our attention to much more amazing facts on the day-to-day operation of our bodies. Medical men used to think of the human body as an engine that takes in food, air, and water mainly as fuel to keep running on. Only a small part of the intake was thought to go for replacement of engine wear. Investigations with isotopes have demonstrated that the body instead is much more like a very fluid military regiment which may retain its size, form, and composition even though the individuals in it are continually changing: joining up, being transferred from post to post, promoted, or demoted; acting as reserves; and finally departing after varying lengths of service.

Tracer studies show that the atomic turnover in our bodies is quite rapid and quite complete. For example, in a week or two half of the sodium atoms that are now in our bodies will be replaced by other sodium atoms. The case is similar for hydrogen and phosphorus. Even half of the carbon atoms will be replaced in a month or two. And so the story goes for nearly all the elements. Indeed, it has been shown that in a year approximately 98 percent of the atoms in us now will be replaced by other atoms that we take in in our air, food, and drink.

Instead of just tracing atoms of an element in the body, radioisotopes are used for the much more complicated job of tracing complex compounds and molecules and even parts of molecules. Such studies have permitted investigators in physiology to develop an entirely new technique for studying body metabolism, that is, the details of biochemical reactions by which foods and other materials are taken into the body, used, and finally broken down and eliminated. In such studies they have been used to label and trace through complex body processes a wide variety of important materials such as amino acids, proteins, vitamins, hormones, antibodies, viruses, and cancer-producing agents.

A typical case would be that of studying the biological fate of a labeled amino acid. The compound is synthesized using a radioisotope such as radioactive carbon or radioactive sulfur. It can then be fed to rats or other animals. After the labeled compound has entered into the body's reactions, the animal is sacrificed. Analysis of radioactivity in various tissues such as the spleen, liver, and kidney indicates where the radioactive atoms have become located. In addition, biochemical analysis indicates the chemical form in which the radioisotope now exists. Some of the radioisotope will be found in protein material, some in uncombined amino acids, and some in breakdown products of the amino acids. In this way the investigator determines what happened to the originally ingested amino acid and what its role is in the body.

Such experiments clearly prove that our body processes are continually breaking down and building up organic molecules. The breaking-down process or degradation of complex molecules releases the energy which is necessary for proper functioning of our bodies. It also furnishes some of the less complex components of our tissue. A fine balance is maintained between the degradation to obtain energy and the synthesis to make new organic molecules for our body's needs.

Radioisotopes are thus providing us with information not only on how we "tick" when healthy but on what goes wrong in disease. By comparing the behavior of isotope-labeled compounds in normal animals with their behavior in animals having diseases such as cirrhosis of the liver or cancer, investigators are able to look for differences which may give valuable leads as to the cause and cure of the disease.

Another goal of this type of investigation would be to use the behavior of the labeled compound for diagnosing such diseases.

MEDICAL DIAGNOSIS

In medical diagnosis radioisotopes have been used to determine blood volumes; blood circulation to the extremities; pumping efficiency of the heart; thyroid-gland activity; and the location of brain tumors.

Radioisotopes have been used by many large hospitals and medical centers for measuring the volume of blood in patients, especially those scheduled for surgery. In this particular diagnostic test a portion of the blood, the serum albumin, is labeled with a known concentration of radioiodine and then injected into the patient. After the blood has had a chance to circulate throughout the body, another blood sample is taken and the concentration redetermined. The amount of dilution that has taken place is a measure of the total volume of blood in the patient. Even wounded United Nations troops in Korea have been tested for loss of blood by radioisotope blood-volume determinations. These same troops have also benefited from better methods of using blood preservatives and plasma substitutes developed through tracer studies.

The most widely used diagnostic test, however, is the radioiodine test for thyroid activity. The test is also simple. Radioactive iodine in the simple compound, sodium iodide, is given to the patient by mouth. It appears that the patient is simply drinking a glass of water.

Practically all iodine, which is absorbed in the body, is taken up by the thyroid gland. This is because of the gland's production of an iodine containing hormone called thyroxine. If the gland is overactive (hyperthyroidism), its production of thyroxine is large and accordingly its ability to take up iodine is large. Underactivity of the gland (hypothyroidism) produces the opposite effect.

The radioactive iodine will also go to the thyroid, but since it gives off penetrating gamma rays, its rate of uptake in the gland may be

determined by using a geiger counter or other radiation detector placed over the neck outside the gland. Comparison with a normal uptake rate indicates whether the gland is overactive or underactive. This particular test is now being used routinely by hundreds of hospitals and physicians all over the world.

One thing that makes radioisotopes such a useful diagnostic aid is that only extremely small harmless amounts of the radiomaterial are required. This means that we should see a much wider diagnostic use of radioisotopes in the future.

MEDICAL THERAPY

Radioisotopes have also been used in medical therapy for treating such things as hyperthyroidism (overactive thyroid), cancer, polycythemia vera (overproduction of red cells), leukemia (overproduction of white cells), and lesions of the eye and skin.

Some applications are like those of radium and X-rays; a diseased tissue or organ is exposed to radiation from a source placed either inside or outside the body. Some of you no doubt have read in the papers about the teletherapy cobalt unit at the Los Angeles Tumor Institute. This device contains a large amount of radioactive cobalt—about 1,000 curies—and it gives out a penetrating beam of gamma rays which can be used in treating deep-seated lesions, like cancer of the lung. The beam is as penetrating as that from a 2- to 3-million volt X-ray machine. The radiocobalt unit, besides being cheaper to buy and operate, offers a number of medical advantages. As soon as a sufficient quantity of highly radioactive cobalt has been produced, similar units will be put into operation in a number of other hospitals and clinics throughout the country.

The same radioactive cobalt in much smaller quantities has been used, again like radium, for treating cancer of easily accessible areas of the body like the cheek and lip. Radium is usually used as "seeds" or "needles," and although it is widely employed it is expensive and cannot be easily adapted to a wide variety of uses. The use of cobalt, on the other hand, can be made very flexible. For example, radioactive-cobalt wire can be inserted into small-diameter nylon tubing and sewed into the tissue to be treated.

The more unique type of treatment possible with radioisotopes is based on giving the radiomaterial to the patient by vein or mouth and depending on body processes to locate the radioactivity in the desired tissue or organ. For example, radioactive iodine is used in treating hyperthyroidism in the same way that it is used to diagnose hyperthyroidism, except that much larger quantities of the radiomaterial are used. Indeed, radioactive iodine is becoming the treatment of choice in an increasing number of medical centers both in the United

States and abroad for hyperthyroidism. It has been reported that in about 90 percent of the cases treated, hyperthyroidism is controlled in 2 to 4 months by one or two treatments; 10 percent of the patients may require a third treatment. Similarly, radioactive phosphorus is considered the treatment of choice of many physicians in treating polycythemia vera and has been found to offer some relief in certain cases of chronic leukemia.

Neither the physical-placement nor biochemical-placement type of radioisotope treatment, however, should be regarded as a "permanent" cure. Both are mainly measures to control the disease and prolong the comfortable and useful life of the patient.

AGRICULTURE

Many of the complex and difficult problems in agriculture, like those in medical research, have to do with the fundamental processes of growth. What minerals and organic nutrients do plants need? How do plant roots pick them up and how are they utilized? What are the innermost workings of photosynthesis, the little-understood process of nature that accounts for all the world's food and most of its fuel?

In some respects the agricultural problems confronting us today are even bigger than the medical problems and certainly more critical. Advances in medicine tend to lengthen man's life and hence we have more people to feed, clothe, and house. Also, our birth rate is on the increase.

Carroll A. Hochwalt, vice president of the Monsanto Chemical Co., sized up the situation recently in a paper before a meeting of the American Association for the Advancement of Science in St. Louis. As he pointed out, if we keep populating our Nation at the present rate, by 1975 we shall have at least 25 percent more people to feed and clothe. It will take 15 billion more eggs a year; 20 million more hogs; and another 10 billion quarts of milk just to keep our people eating as well as they are today. And this is only part of the story, for this only includes the United States. Even today many people in other areas of the world are badly undernourished.

The problem becomes even more serious when we consider the waste that is taking place. For example, it has been estimated that insects alone destroy as much as 4 billion dollars worth of crops annually. Plant diseases destroy another 4 billion dollars worth. But what is more amazing is the costly damage that we can attribute to weeds. It is almost beyond belief to realize that by choking out crops, clogging irrigation ditches, and poisoning farm animals, weeds cost the farmer 5 billion dollars each year.

Thus, we must find ways to increase the world's productivity not only because we have found ways to increase the world's health and because our world population is increasing at a rapid rate, but also because so many factors are working against us.

Radioisotopes are helping to provide some of the answers. They have, for example, become an extremely useful tool in studying the efficient use of fertilizers. Since food productivity is dependent to a large extent on soil fertility, the replenishment of depleted and overworked soils with fertilizers is a major problem.

One of the most important group of fertilizers, the phosphate fertilizers, can be readily studied with radioactive phosphorus (pl. 4, fig. 2). Here, as in so many other tracer studies, the radioisotope technique is used primarily because it provides the means for following a specific batch of atoms. The radioactive phosphorus is incorporated in the fertilizer which is added to the soil being studied. Later, radioactivity analyses of the plant show what parts of the plant have taken up the radioactive atoms and hence the fertilizer. Chemical analyses of the plant indicate the total amount of phosphorus coming from the fertilizer plus that coming from the ordinary phosphorus previously present in the soil.

From such studies investigators can determine not only how much phosphorus is taken up by a plant and where it came from but also the efficiency of the fertilizer, the best type of fertilizer to use, and the most desirable place to put the fertilizer with reference to the location of the plant. The U. S. Department of Agriculture, working with various State agricultural experiment stations, has conducted an extensive program of such tests during the past 5 years. Last year the program included 94 field experiments in 26 States, Hawaii, and Puerto Rico on 18 different crops including alfalfa, cotton, corn, rice, peanuts, sugarcane, peaches, pineapples, and cantaloupes.

The most fundamental of all tracer experiments, however, is the use of radioactive carbon and other isotopes in man's effort to learn the secret of photosynthesis. Chemical studies have shown that plants combine water and carbon dioxide in the presence of sunlight to form sugars and starches, but the details of how the synthesis takes place are still unknown. By tagging with radioactive carbon 14 the carbon dioxide fed to plants and studying intermediate products formed during this complicated synthesis, investigators are beginning to achieve a more detailed understanding of the photosynthetic process.

Radioisotopes have also been used to supply new knowledge on reactions between various soil elements, on insecticides and weed killers, and on various types of blight and other plant diseases. Sim-

ilarly, radioisotope investigations have helped scientists to understand better the problems concerned with nutrition and diseases of livestock and the production of milk and eggs.

INDUSTRY

Like the fields of medicine and agriculture, industry has used radioisotopes most frequently as tracers in its research and development laboratories. A number of ways, however, have been found for employing radioisotopes as sources of radiation, especially in the control of certain manufacturing operations.

The simplest type of application depends merely on measuring the change in intensity of radiation from a stationary radioactive source when something is placed between it and the detecting instrument. This change is usually measured by a counter, such as the radioactive thickness gage or liquid-level gage. Sometimes, however, as in radiography, a photographic film is used as the radiation detector. Instead of an instrument recording we get a photographic picture of the change in radiation intensity. Another type of industrial application depends on using the radioisotope as a movable source of radiation. A source on the end of a flexible rod in tracking an underground sewer line or as an oil marker in an overland pipeline illustrates this type of application. And finally, radioisotopes may be used as tracer atoms to measure the transfer of materials by physical and physical-chemical means and to follow the mechanism of industrial chemical processes.

Radiographic testing is probably the oldest industrial application of radioactivity and one of the simplest ways of using a radioisotope as a stationary source of radiation. The test is carried out by placing the radioactive source on one side of a weld or casting and a photographic film on the other side. A darkening of the developed film indicates the location of any flaws or cracks since more radiation penetrates through these places and causes greater exposure to the film.

Naturally occurring radium and radon used to be the only radioisotopes available for this kind of application. Today, however, more and more industries are using radioactive cobalt instead; nearly 200 firms have been authorized by the Atomic Energy Commission. Radiocobalt is more readily available and easier to handle than radium. It can also be obtained in greater radiation strength, in any desired shape and size, and is 5 to 40 times cheaper, depending on whether the radium is purchased or rented.

Another stationary-source type of application is the so-called radioactive thickness gage. In the simplest type of gage a radioactive source which emits beta rays, that is, high-speed electrons, is placed

on one side of the material whose thickness is to be measured and a radiation instrument on the other side. The amount of radiation which penetrates through the material decreases with the thickness of the material, that is, the thicker the material the less radiation gets through and vice versa. The radiation meters used in these gages are designed to read in thickness values.

Radioactive thickness gages are now being sold by three commercial manufacturers, and approximately 100 industrial firms have obtained permission from the Commission to buy and install them. They are very sensitive to small differences in thickness and give very reproducible results. Another big advantage is that the gage makes no mechanical contact with the material being measured. This means that the gage can be used without stopping or cutting the rolling sheet and without danger of tearing or marking the sheet. Still another advantage is that the gage can be made to control automatically the settings of the rollers rolling out the sheet.

Radioactive thickness gages have been used to measure the thickness of paper, rubber, plastic, glass, and steel sheets. Firms using them have been able to meet more exacting specifications and as a result have been able to cut down on the amount of reject material. This has meant a savings of thousands of dollars a year to some firms.

An example of an application that uses the radioactive material as a movable rather than stationary source of radiation is following the flow of oils through pipe lines. It is common practice to use the same pipeline to transport a wide variety of crude or refined oils. The location of the boundary between the two oils must be known in order to route different oils to different takeoff points and terminals along the line. The radioisotope method is based on injecting into the line a small amount of radioactive material just at the boundary as a product is changed. Geiger counters detect and record the passage of radioactivity in this boundary at various points along the line. Clean separation of the different oils means a large saving in money. One company is routinely using this method of boundary marking in a pipeline running from Salt Lake City, Utah, to Pasco, Wash.—a distance of more than 550 miles. The same company has said that the new method means a saving of hundreds of barrels per day of oils that would have an average retail value of about $10 a barrel.

An example of an industrial tracer application is the radioisotope method of measuring wear or friction. Several companies are using this method for studying wear in engines. A piston ring or some other motor part is sent to Oak Ridge, made radioactive in the nuclear reactor, and then returned for replacement in the engine. The motor with its radioactive piston rings is then run. As the rings wear, some

of the radioactive atoms will get into the oil. Periodic sampling and radioactivity analysis of the oil lubricant will show just how much the ring is wearing away by friction.

In summing up the industrial use of radioisotopes as stationary sources of radiation, we should mention the radioactive liquid-level gage used in measuring the level of molten metal in a cupola and the radioactive density gage used in measuring the water content of mountain snowpacks in remote areas and the silt and mud content of water in front of power dams. Additional examples of applications based on using radioisotopes as movable sources of radiation include the detection of leaks in water lines and the control of acid treatment in oil wells.

As tracers in industrial studies, radioisotopes have also been used to test the efficiency of washing machines, to follow the movement of preservatives in telephone poles, to study the action of detergents, to investigate the mechanism of such industrial processes as vulcanization and polymerization, to study the synthetic production of gasoline, to investigate the raising of bread, and to help solve a host of other industrial problems.

THE FUTURE OF RADIOISOTOPES

We can certainly expect a much wider use of radioisotopes in the future. They are being produced in sufficient quantities to make them available to everybody who has a need for them and who knows how to use them. They are becoming recognized by scientists everywhere as a valuable and necessary tool. Old uses, like the radioiodine treatment of hyperthyroidism and the radioisotope gaging of thicknesses, are becoming routine procedures in hundreds of institutions. New uses keep appearing on the scene. Manufactures are continually improving the design and performance of radiation instruments and handling devices. Better techniques are being developed for getting more out of the sensitivity and precise labeling of the isotope method.

There is little doubt that radioisotopes are one of the most valuable analytical tools now known. Yet not nearly as many chemists or biologists or engineers use isotopes as could profitably do so. We need more people trained in the use of isotopes—people who can apply this new tool to tomorrow's problems in medicine, science, and technology—more "isotopologists." But the need goes further than this. A rapidly expanding atomic-energy program, for instance, needs many more young scientists and engineers who know and want to work with radioactivity. Our whole national security and national welfare today are more dependent than ever on advancements in science. The

need for technically trained people has never been greater. The opportunities have never been greater.

We have hardly scratched the possibilities of scientific achievement. I have no doubt that someone 25 years hence in presenting the Fiftieth Faraday Lecture will tell us of things which even now are beyond our remotest dreams. I hope, however, that I may be able to point to some of these developments of the future and say that they were made possible in part by isotopes—by what we now call new keys to knowledge.

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 Push-button Factory[1]

By Frank K. Shallenberger

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Six years ago, two Canadian physicists, Eric W. Leaver and Dr. J. J. Brown, wrote an article for Fortune magazine showing how electronic controls developed for military use might be used to control factory machines and processes and thus make possible the push-button factory of the future—the automatic factory, where all work would be done by machines without operators, where the only attendants would be observer-technicians.

They devised an automaton, or hand-arm device, directed and controlled by a punched-paper tape, which would automatically load, operate, and unload the machines. They proposed devices to inspect, move, and assemble parts. They suggested that with a new set of tapes and a little rearrangement, the plant might shift from one product to another—for example, from vacuum cleaners to electric motors.

The automatic factory has become one of the most challenging subjects of discussion in engineering and management circles today. The April 1952 issue of Factory magazine was devoted to it. Even the Russians have climbed on the bandwagon. In February 1952, the U. S. S. R. Information Bulletin printed a somewhat vague article which purported to describe "The World's First Automatic Piston Factory." This was proclaimed another Russian "first." The fact that a group of "capitalist" Harvard students had demonstrated in some detail 8 months previously how such a factory might be built was not mentioned.

Actually, the idea of automation is nothing new. It is the logical and ultimate result of imaginative methods study and uninhibited machine design. Anything which substitutes mechanical, electrical, or other devices for human guidance and control is a form of automation. The automatic feed or cam which advances the tool and the template which guides it, the pneumatic cylinder which clamps, in-

[1] Reprinted by permission from the Engineering Journal, vol. 35, No. 11, November 1952.

dexes, or positions the work, the hopper which feeds the machine, the conveyor which takes the finished work away, the elaborate electronic device which directs, coordinates, and controls a series of complex operations—all these are examples of automation and as such are steps toward the push-button factory.

The term "automation" is of postwar vintage, but to discover its beginnings we must go back even before there was any real American industry, to 1784, when Oliver Evans built the first mechanized factory just outside Philadelphia, a continuous flour mill. This mill incorporated all three basic types of powered conveyors in a continuous production line, unloading grain from boat or wagon and processing it to finished flour without human aid. In 1833 biscuit manufacturing was mechanized in the "victualling office" of the British Navy, and in 1869 endless monorails were introduced into the meat-packing industry. These were designed for disassembly of hogs, but they were the forerunner of the modern mechanized assembly line.

Henry Ford first used progressive assembly on a powered conveyor in 1914, the same year in which he offered $5 for an 8-hour day in an industry where $2.40 for a 9-hour day was standard. That he was successful in doing both is indicated by the fact that his original investment of $28,000 grew to three-quarters of a billion dollars by 1927.

Many process and chemical companies achieved a high degree of automation in the twenties. So did manufacturers of such products as electric light bulbs, cigarettes, bottles, and tin cans. The A. O. Smith Company in 1920 built an automatic factory to make automobile chassis—a plant in which strip steel was blanked, formed, assembled, riveted, and painted, producing a complete chassis every 10 seconds, ultimately 10,000 a day. The few workers present served not as producers but as observers and troubleshooters. A more recent milestone was the construction in England in 1948 of two machines to produce radio sets automatically.

These are the dramatic examples, but we must recognize that automation is not limited to completely automatic plants. The automation of segments of industry and of individual machines is much more widespread and much the same in its economic and social effects. The lathe was little more than a woodworking novelty until it was given a mechanical hand to hold the tool. Henry Maudslay in 1797 gave it a lead screw, in effect a cam to control the movement of the cutting tool along the work. Today we have the automatic screw machine on which cams automatically advance the stock, change spindle speeds, index and feed the tools to the work.

The same story may be repeated for automatic drilling and milling machines, for punch presses which feed automatically through

progressive dies, and for grinders which feed and eject stock and adjust themselves automatically for wheel wear. We have machines guided automatically by templates and even some guided by a line on a blueprint. During the war we witnessed the development of the transfer-type machine, which combined both machining and materials handling. Raw forgings or castings enter at one end and emerge as finished products at the other. These are actually a number of machine units automatically coupled together and centrally controlled.

As machines become more automatic, emphasis shifts to *materials handling*. The word "automation" as originally coined at Ford, means automatic transfer of parts between machines. Ford has had an automation department since 1947, and one has only to look at the "iron hands" which load and unload mammoth presses, conveyors which carry cylinder blocks through complete processing without human direction, hoppers and chutes which load grinders or other machines, and transfer devices which carry forgings through successive press operations, to realize the effectiveness of this department's efforts. Machine time seems destined to be greatly shortened by current developments in metal-cutting techniques and in many instances has been eliminated altogether by die casting, investment casting, shell molding, and powdered metallurgy. The result will be an even greater relative emphasis on the automatic handling of materials.

Inspection has also been automatized extensively. Automatic devices count, inspect, and sort by weight, color, or dimension much more rapidly and reliably than any human could do. They check performance, seek foreign metals or internal defects, detect overfilling or underfilling of cans and bottles. Both Ford and De Soto have crankshaft-balancing machines which measure out-of-balance condition, then automatically drill out enough material from the right spot to remedy it. This will be characteristic of the automatic plant—inspection devices will not only detect defects but will remedy them or pass the information back to previous machines to avoid repeating the error.

Assembly operations have not been so extensively mechanized, although we have continuous brazing, welding, automatic riveting, nailing, cementing, filling containers, packaging, painting, plating, and the like. Leaver and Brown described in general terms a machine to assemble a telephone receiver automatically.

The great dream of the future is *electronic control*. Why, we are asked, cannot the electronic devices developed by the military to control the flight of aircraft, to guide unpiloted missiles, to direct the firing of guns, be used to control industrial processes? We have devices which can see better, hear better, measure better than humans.

They are more reliable, more powerful, more precise, think and move faster than human operators. They never tire, will willingly work around the clock, do not make mistakes, do not talk back, are obedient and fully predictable, have few personal problems, and they will not go on strike.

Actually, many electronic devices are already in industrial use. There are simple circuits which, through a sensor unit, such as a photoelectric cell, pick up an impulse, amplify it, and pass it on to an effector unit, such as a valve or motor, for appropriate action. There are the complex computers and servomechanisms which can solve involved equations and translate the solution into automatic control of complex processes. There are others which can translate and use information fed in on a tape or cord. It is the ability of such devices to think, choose, and remember, to move accurately and with great speed that makes them the key to the factory of the future. One of the most important characteristics of electronic controls is their ability to utilize the principle of "feedback," a sort of built-in supervision, which insures that the unit has carried out the orders exactly as they were given it. Thus tolerances become a problem of little consequence. The versatility of electronic controls is almost without limit—there are few if any production jobs which they could not perform.

To me the striking thing about automation is not what *can* be done in the future, but rather how little *has* been done in the past. There are thousands and thousands of jobs now performed by human workers that could be performed more accurately, more efficiently, and much more cheaply by automatic means, using devices which are already available.

Why have not industrial engineers taken greater advantage of these opportunities? The answer seems to lie in limited capital, lack of knowledge, lack of imagination, inertia, and misguided economic thinking. In many small plants, funds are lacking even for the simplest automatic devices. Whatever the potential payoff, there always seems to be some other need more acute. In other situations plant management simply does not know what is available and what can be done, or has not had the time to sit back and evaluate the developments that have taken place.

Many offer the alibi of low volumes, changing markets, nonrepetitive operations. Certainly transfer machines, custom-built conveyors, automatic loading and unloading devices are too specialized and too expensive for the needs of many plants. But this must be examined further. In the first place, you can buy whatever fits your pocketbook and your problem. If the stakes are high, you "pull out all the stops" and make the job fully automatic. However, there is nothing sacred or

necessarily desirable in 100 percent automation. Circumstances may warrant making the job only 50 percent or maybe 10 percent automatic. The cost may not be as great as first assumed. Ford reports that automatic handling equipment frequently costs less than standard equipment. Moreover, one need not always sacrifice flexibility for automation. The new Magnadrill, for example, has drill heads which can be quickly and easily positioned at any angle for cycled multiple drilling. Keller Airfeedrills, which fasten directly to the drill jig, can be readily converted to other jobs. Pneumatic pistons can be switched from one job to another.

General Electric has developed an automatic lathe equipped with "playback" control. As the machinist makes the first piece, his operations are recorded on a magnetic tape. The tape can then automatically direct the movements of that lathe or any number of others so equipped. The Arma Corporation has developed an automatic lathe directed by a punched-paper tape similar to a player-piano roll. On demonstration, this lathe turned out in 4 minutes a piece which would require a skilled machinist 30 minutes, referring to blueprints, to produce. It took only 15 minutes to punch the tape, and tolerances were held to 0.0003 inch! Neither of these machines is yet available, and at this stage they are probably limited to fairly simple parts. But the same control principles may some day substitute for cams on automatic machines of all types to make highly versatile yet highly productive equipment. The next step will be to connect these, or automatic machines already available, with automatic handling devices, electronically tie in inspection and assembly, and the automatic factory will be a reality.

Some of the hesitancy in automatizing processes and operations comes from a feeling that electronic controls are unreliable and expensive. Past experience has justified that belief. They have been fragile and temperamental. In most cases they must be engineered specifically for the job, and that costs money. But it must be recognized that electronic control is not always required. Mechanical means (cams, templates, pneumatic or hydraulic pistons) or electrical devices (thermocouples, limit switches, relays, solenoids, and the like) can often do the job. Our students are developing an almost completely automatic shell-molding machine without using any electronic controls whatsoever. The cost of the control mechanism will be less than $500. And this machine will be highly flexible—it is, in fact, being developed for the job-shop foundry.

Military demands are leading to electronic controls which are much more reliable and less expensive. With new developments in miniaturization, in printed circuits (which in themselves offer tremendously fascinating possibilities for automation), in circuits imbedded

in plastic, in transistors which will substitute for vacuum tubes, traditionally the least reliable electronic component, and in unitized circuits in which whole plug-in segments can be readily replaced, electronic controls can be as reliable and as easily maintained as the machine itself.

Inertia is another deterrent to automation, especially in a period of easy profits. Still another is business uncertainty. Another is the type of management thinking which keeps equipment operating long after it is technologically obsolete. It is usually easier to obtain funds to keep an old machine running than to purchase a new unit, especially if the old machine still operates well and shows a substantial undepreciated value on the books. At the same time it must be evident, to anyone who will exercise the most elemental logic, that book value is in no way relevant to the question of whether or not a machine should be replaced. Obsolescence is the result of technological change and is not affected by accounting procedures. Whether the machine is 1 year or 20 years old, the question of whether or not it should be replaced with a better machine depends entirely upon comparative performance in the future, not upon bookkeeping entries of the past. As a rule of thumb, Ford assumes that automation tooling is justified if it will increase production and if its probable cost will not exceed $3,000 per man transferred. The figure is very low to insure a writeoff within the model year. Most plants are satisfied with a payoff within 3 to 5 years. The intangibles and unpredictables usually result in a much faster writeoff.

Labor groups have in many plants retarded technological progress by insistence on former piece rates, prohibitions on the assignment of workers to more than one machine, and outright obstructionism. At the same time, the increased cost of labor is without question one of the greatest incentives to increased automation, and the higher labor wages go the more the likelihood of replacement.

High income taxes and unrealistically low depreciation rates have also retarded plant improvement. Management often asks "Why invite labor trouble and tie up more capital when the Government takes away in taxes most of the benefits from improved efficiency?" It should be noted, however, that with taxes currently at an all-time high, plant investment is also at an all-time high.

What is the future of the automatic plant? One tries to be logical and realistic in appraising the prospects and to avoid the temptation to overrate the possibilities. And like being a poor lawyer, it is far easier to be a poor engineer, easier to find reasons why it cannot be done, than develop ways in which it can be done. But there is danger in being too logical. The famous individual who resigned his position in the U. S. Patent Office because there was nothing left to invent was attempting to be logical.

When I look around at western plants I see many where the volume, the type of product, or the lack of finances make automation of any magnitude completely impracticable. On the other hand, when, as a consumer, I look at the articles I buy, many of them (such as pens, pins, pencils, lamp bulbs, cigarettes, bottles, nails, paints) already produced by virtually automatic processes, and others (hardware, clothing, toys, plumbing fixtures, plastic products, radios and television) which could be automatized, I lose any fears of overstating the possibilities. Certainly there will be many plants which will never enjoy extensive automation. There will be many products which will, for purely economic reasons or by customer demand, continue to be made by nonautomatic methods. Yet every plant will have some degree of automation, and I cannot doubt that the vast majority of the things we eat and use and wear will be made in plants where the only workers will be technicians, not producers. These will not always be products as we know them today, for automation very often involves new materials and complete product redesign.

In assessing the prospects for automation, we must stretch our thinking far beyond manufacturing alone. The punched card, which may some day run our machine tools, had its beginning and greatest development in the clerical field. It has recently been predicted that electronic brains will "keep business accounts, run continuous sales records, compute and send out bills, handle entire payrolls, keep running inventories, fix production schedules, serve as vast filing systems, and chart corporate expansion," all without human aid. In retailing there is no reason why electronic circuits could not automatically record each sale, check credit, bill the customer, post the new stock balance, reorder if necessary, and at the same time give management a continuous and up-to-the-second accounting of all operations. For a long time we have had "Automat" restaurants in New York. Automatic vending of candies, beverages, fruits, and other products has grown rapidly in recent years.

With increased air-traffic congestion and travel at supersonic speeds, the shortcomings of human control of aircraft become critical. Automatic electronic controls are not subject to such shortcomings, and it is reasonable to believe that they may some day take over full control of aircraft in flight. The same may be true of rail, ocean, and other transportation. Computers are already used to handle plane reservations in large centers. And the possibilities in accounting, statistical, securities, research and engineering organizations, and in the making of management decisions are tremendous. With the aid of computers, decisions can truly be based on *calculated* risks, not on hunches.

The possibilities in agriculture are likewise great. Early in 1952 a Senate subcommittee estimated "conservatively" that chemicals

alone would displace more than 1.5 million farm workers in the next 10 years, and almost 3.5 million (or a third of our farm jobs) over the next 20 years. Chemical weed killers can do in 12 minutes what it would require 20 hours to do with a hoe. Chemicals can prevent premature shedding in fruit trees and increase yield. Others can induce shedding and replace hand thinning. Chemicals can destroy the foliage to hasten ripening or facilitate picking. Fungicides, growth hormones, and soil conditioners will help increase crops. Most cotton is already picked by machine. One of our western electronic companies is currently field testing an electronic crop thinner, which automatically detects and removes unwanted plants four rows at a time. The experiments conducted by the Bureau of Mines in burning unmined coal underground in its natural seams may lead to another form of automation.

What will be the impact of automation on our society, our economy, our way of life? In the first place, automation should be recognized as a gradual and progressive development, an extension of changes which have been underway for over 150 years. Furthermore, there are whole segments of commerce and industry which will see only a limited application. This is not to minimize its importance. Historians may well point to automation as the heart of the second industrial revolution. In the first, machines replaced man's muscle in plant operations. In the second, controls will replace his brain. But although there will be an accelerated use in the near future, there is no reason to think that widespread automation will come overnight.

Commonly associated with technological development is the fear of unemployment. But Factory magazine points out that if we are to continue to increase our standard of living and to support the current defense program, we will have to increase output per man-hour 43 percent by 1960, or over twice the increase which took place between 1940 and 1950. This hardly bespeaks widespread unemployment! If medical science continues to make advances in combatting the diseases of old age comparable to those made against infection, communicable diseases and the like, the support of the non-working elderly population will in itself demand a large portion of our increased productivity. Add to this the defense program, the increased proportion of children bursting the seams of our school system today, and the demands of other nations whose aid we have undertaken, and there seems more reason to fear a shortage than a surplus of workers. Barring a serious depression, there should be adequate opportunity for reabsorption of displaced workers. Technology has always created more job opportunities than it has destroyed. A much higher standard of living and a shorter workweek are both likely when and if automation reaches its full potential.

One of the most challenging aspects of automation is its effect on job skills and job satisfactions. In the past, technology has tended to degrade skills. The turret lathe and the automatic screw machine, for example, replaced skilled journeymen lathe operators with relatively unskilled machine tenders. The war brought about an even greater simplification of jobs and decrease in job skills. Norbert Wiener has written pointedly, "It is a degradation to a human being to chain him to an oar and use him as a source of power; but it is an almost equal degradation to assign him purely repetitive tasks in a factory which demand less than a millionth of his brain power."

Further automation may reverse this trend. Gwilym Price is reported to have said at the Corning Seminar on "Living in Industrial Civilization," "Unskilled work is a mistake in engineering." Automation could remedy that mistake, could replace large numbers of unskilled and semiskilled workers with a relatively few highly trained technicians, whose function it would be to keep these fabulous and expensive machines operating. But what happens to those who are displaced, those who have neither the aptitudes nor training to be technicians? In past years the expanding economy which technology created has always absorbed those who were displaced. But this took place during periods of decreasing skill requirements. Can the worker displaced by automation fill the highly skilled jobs which automation creates? Henry Ford is reputed to have said that a whole stratum of humanity was unfit for anything but repetitive assembly-line work. Modern psychology disputes this. Such workers may well be the product of the mechanized factory, not a justification for monotonous, repetitive assignments.

Perhaps the answer lies in the fact that we will always have many semiautomatic and nonautomatic plants which will employ large numbers of unskilled and semiskilled workers on routine jobs. Automation will result in increased leisure and an increased proportion of the national income available for luxury spending, and thus create new job opportunities in these nonautomatic industries. This in turn raises the most challenging question of all—have we the intelligence, the character, the maturity to use our added leisure constructively?

Perhaps the other side of the problem is more serious. Will we be able to find and train the skilled technicians to supervise, service, tool, and maintain this highly complex equipment? We already have a severe shortage of technical skills. But is this not the result of our failure to utilize the aptitudes already available to us? Industry has much to learn from recent experience of the military in both aptitude testing and mass training to high technical skills. We have much to learn also on creating the incentives which will induce the worker to develop these higher skills, incentives which have largely

disappeared with the reduction of wage differentials and current high earnings of unskilled workers.

Techniques of personnel administration must necessarily change with the changing character of the employees. These technicians will be freed from the anonymity and monotony of the production line. They will see clearly their part in the operation of the plant, they will be intelligent, competent, and will insist on being treated as such. Indication of the nature of the new personnel problems to be met can be found in the problems faced in the administration of technical and research staffs in the armed services and large corporations.

The demand for engineers to design these complex plants, to keep them operating smoothly, to supervise and control the technicians, to direct shifts to other products, will be great. Operating and design problems will cut across several professional fields—industrial, electronic, instrumentation, mechanical—so a "team" approach will be needed. These engineers must be trained to exercise a high degree of competent and intuitive judgment. The stakes will be high and they will often be forced to make crucial decisions without delay or assistance from higher levels. There will be little time for the orderly, studied, analytical, leisurely approach of the laboratory. A new emphasis in engineering education seems called for. The selection, organization, and coordination of these specialist engineers and plant technicians may well be one of management's most important functions.

Preventive maintenance will be a must. The automatic factory will be a closely integrated unit from incoming raw material to a finished product, and vulnerable at any point. Emphasis will be on high utilization, with little down time available for maintenance activities. Administrative breakdowns, such as materials shortages or faulty planning, will be as serious as mechanical breakdowns, and an added premium will be placed on management competence, precise planning, scheduling, and followup. Relations with suppliers will take on added importance.

Plant location will no longer be dependent upon availability of labor. A guaranteed and stable market for the product will be essential. In most cases, the break-even point will be high, and cutbacks will be costly. Workers can be laid off, control mechanism and overhead cannot. At the same time, production increases will be difficult. Since fixed costs will be high, the automatic factory will operate 24 hours a day. Expansion of production will be impossible for a plant which is already working around the clock.

This lack of flexibility and emphasis on full utilization indicates a need for better than usual sales effort, directed first of all to an accurate determination of the market potential before the plant is

built and secondly to a steady sale of the product. Consumers must be educated to accept more standardized and in most cases completely redesigned products. How well these requirements can be met will determine the future of the automatic factory in many industries. In this area may also lie the answer to whether or not automatic factories will aggravate the fluctuations of our economy. Cutbacks will be much more costly to the company, but will at the same time be less likely to start a chain reaction of reduced purchasing power, for there will be fewer workers to be laid off. At any rate, the automatic factory offers as great a challenge to sales management as it does to the engineers and to production managers. It is, in fact, one of the great challenges to management of our time.

Let me suggest that we in the West—and I believe the same may be true throughout most of Canada—have the greatest challenge and the greatest opportunity. For although we have less mass production than the industrialized East, we are growing, and we are less inhibited by sunk costs, by existing equipment, by existing plant processes, and by vested management or labor interests.

The automatic factory has a tremendous potential for increasing our own standard of living and that of much of the world. It can also shorten our workweek and increase our leisure. It can release us from dreary, monotonous, unsatisfying repetitive jobs. It can help protect us against those abroad who would undermine our economy. It is not the biggest thing in our lives but it is certainly one of the most important phenomena of our generation. Let us hope that we are big enough to take advantage of the opportunities it offers. Every one of us—engineers, management, sociologists, economists—must read and think and discuss the subject at every opportunity so that we can foresee and avoid the pitfalls, minimize the mistakes and dislocations, and make an economic and social asset, not a Frankenstein, of the push-button factory.

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The Science of Musical Instruments[1]

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[With 3 plates]

The past 20 years have seen the development of the electrophonic organ, in which oscillations of electronic origin are transformed into audible sounds having their pitch, loudness, and timbre controlled at the whim of the player. It is not of these that I wish particularly to speak today; in fact, reading a lecture I gave on the subject in 1940,[2] I cannot say that there would now be much new to report on these instruments except in connection with the perfection of the technical details of the tone production. Rather do we now wait upon improvements in loudspeakers, especially those which will handle large power without distortion, before the electrophonic organ can replace the pipe organ or the orchestra.

The apparatus which had to be constructed to synthesize tone electronically for these new musical instruments did, however, serve equally well for the analysis of tone in the old, and even those who do not like electrophonic organs owe a debt to their constructors. The development of electronic analysis in turn directed attention to defects in the conventional instruments and suggested the means of their improvement.

The basis of such analysis is that a record of the steady wave form of the sounds produced on the musical instrument note by note is made on a disk, magnetic tape, or talkie film, and this record is then played back to a set of electric filters which respond, each to its own proper frequency when this particular frequency is present in the note to be analyzed. The response of each filter may also be made proportional to the loudness of the component in the note to which it responds. In some cases the instrument may be played directly to a microphone connected to a "sound-level recorder" with the aid of which one may

[1] Reprinted by permission from the Journal of the Royal Society of Arts, vol. 101, No. 4888, December 12, 1952.

[2] Published in the Proceedings of the Musical Association, vol. 66, p. 63.

sweep through the whole gamut of frequencies to obtain an acoustic spectrum whereon we have the loudness of the component frequencies of the individual tones which make up a certain note exhibited by the heights of the peaks standing over those frequencies.

For unsteady notes such as the transients that accompany the starting of a note, we commonly exhibit the wave form on a cathode-ray oscillograph. Here the electron beam is made to inscribe the wave form on the screen in the same way that the gramophone needle does on the plastic disk, or the light spot on the sensitive film when activated by the sound. A short portion of the oscillograph record (of which I will give examples later) is then turned into one of the "hill-and-dale" type, and fastened round the rim of a heavy wheel (pl. 1, fig. 1) so that when the latter is rotated the film passes between a pea lamp and a photoelectric cell, the current of which is passed to a vibration galvanometer of 50 c/s natural frequency. (This is a development of an apparatus which I also described in the 1940 lecture.) The wheel, having been spun by an electric motor up to a considerable speed, is allowed to come to rest slowly so that the galvanometer responds each time the rate of rotation momentarily causes the light beam to be interrupted by the film at the rate—i. e., 50 times a second—to which the galvanometer is tuned. In this way the component frequencies at various instants during the commencement or dying away of a note, e. g., of a bell, may be established.

But enough of technical details, let us turn to results. I will first discuss what has come to light about the acoustics of the orchestra in a general way and then pass in rapid survey over information peculiar to the chief types of instruments.

THE ORCHESTRA AS A WHOLE

The complex subjective processes which we call listening to music involves the three P's of science: physics, physiology, and psychology. Although the aspects of musical acoustics with which we are concerned in the laboratory or instrument factory are mainly physical, they do not comprise by any means the whole process of musical appreciation, and he who supposes that physics is the only "science of music" would err in the same fashion as he who reduces the art of Bach to a set of rules regarding the resolution of discords, related keys of subject and answer in fugues, etc., and the like.

One question may properly be answered in physical terms merely: that is, how the sounds of one instrument, played solo, may be distinguished from those of another. Every musician knows that this is mainly a question of timbre, which means the number and magnitude of the overtones (harmonic or inharmonic) which accompany the fundamental or nominal note which the player intends to produce. The

oboe and the clarinet each sounding A have then different spectra and organ pipes have different wave form (pl. 1, fig. 2) and can thus be distinguished. But this distinction is often uncertain between two instruments at certain parts of the scale, so that, for example, the violin steady tone is very like that of the oboe. Yet many people can distinguish a violin solo from an oboe solo.

How then does this happen? One factor is that the timbre of an instrument is not constant over the whole of its range, so that the quality just cited is unlikely to persist when the soloist passes from a note of medium pitch to one higher or lower. Another is the difference between different instruments in the starting and in the buildup of steady notes, in the scrape of the bow, and in the tonguing of the reed, etc. The first of these characteristics is called formant, the second transient, though sometimes the first word is used to cover both. The removal of the transients can make a great difference to the ease of distinguishing between the instruments of different, or even the same types.

The formant, in the narrower sense of the word which I prefer, is that feature in the sound of an instrument (or of a voice) which distinguishes it from another of the same breed and is largely a question of the existence of resonances which may be excited in the soundboard or box to which the primary tone producer, vibrating string, reed, etc., is coupled. In speaking of "soundboard" one must use the word in the wide sense to include all neighboring bodies which can be set in forced vibration. For instance it ought to include the cavity resonator formed by the player's lungs, whether he is playing oboe or violin!

Another factor which must be considered is the directional characteristic. An instrument with a definite soundboard like the violin probably radiates best in the direction perpendicular of the board, a wind instrument in the direction of the bell, though this direction may be changed by local reflecting surfaces.

The soundboard should vibrate as a whole up to as high a pitch as possible. If it tends to subdivide into segments—some moving out while others move in—their mutual effects at a distance will cancel each other and the sound will not radiate well.

This directivity is only, however, valid for high pitch. At low frequencies it fails and the sound spreads equally in front of the player. (Physically this is the same factor that intervenes when sound passes through a doorway; high-pitched sounds pass mainly straight ahead in a beam, but low-pitched sounds spread round a corner.) This is a matter of some importance when one wishes to localize the sound from a particular instrument in the orchestra—for instance, a good violin, in the sense of one which, if used for the solo part in a concerto, will stand out from the mass of other strings.

It is believed that low-frequency transients help also in this respect.

A factor of similar origin which will make localization of the music of the wind in an orchestra more certain than that of the strings is that the former are mostly playing parts which are not doubled, whereas the latter show a chorus effect. The fact that two or more strings playing the same part can never exactly reproduce each other's effect as to loudness, pitch and timbre, and time of initiation and duration of transients (even if they were to be played by a machine) masks any directivity, introduces slight but rapid vibrato, and smudges individual characteristics. The same is true of an organ solo stop played over chorus foundation stops on another manual. This chorus effect is, in fact, of sufficient importance to be imitated—than which nothing is easier!—by the makers of electrophonic instruments.

Recording for scientific purposes is properly done in a heavily lagged room in order that the sounds of the instruments shall not be overlaid with extraneous echoes, but since one usually listens to music, whether directly or over the radio, under circumstances in which some reverberation is superposed on the original sounds, it is proper to consider the modifications introduced by the acoustics of the buildings in which the music is produced or reproduced. The general effect of excessive reverberation is a smudged rendering. The desirable amount of reverberation depends on the individual's taste and experience. Some reverberation is desirable if only for the sake of the players who would find an anechoic chamber very unsympathetic to their efforts. What one is willing to tolerate in this respect is largely a matter of what one is accustomed to. Since we most often hear a large organ under a high vault and a piano in our own drawing room we incline to favor long and short reverberation times respectively for these two instruments.

Another concomitant of reverberation is loss of directivity. In a hall of hard wall surfaces sounds will bombard the listener's ears from several directions at once, thus masking the direct sound by which he estimates the true direction of the source. Furthermore, there will be marked foci and deaf spots at certain frequencies in such a chamber, a condition which is not only unfair to the audience but makes it impossible for the radio engineers to locate their microphones to give faithful reproduction.

From the point of view of the latter persons, indeed, the ideal would be to diffuse the sound equally in all parts of the auditorium, a condition obtained in broadcasting studios by lining the walls with half cylinders or other protuberances of varying size. This would, however, further spoil the directivity by which, as I have already pointed out, the audience is able to judge which instruments are playing at a given instant and to pick out the soloist in a concerto.

Fortunately a way out of this dilemma is suggested by a recent discovery in the use of the public address system. The disadvantage of the common use of loudspeakers to amplify sound—for example, the voice of the preacher in a large church—is that the output of the nearest loudspeaker to an auditor, since it seems usually louder than and slightly in advance of phase over the human speaker, gives the impression that it—the mechanical source—is the true source. But if the reproduction over the amplifying system is delayed so that it arrives some millionths of a second *later* than the direct sound—which can easily be done by making a record of the sermon on magnetic tape and picking it up to feed the amplifiers at a point a little farther along the tape, so as to produce the required delay—the sound is estimated to come from the *original* source and yet is amplified. Londoners may hear such a device in action in St. Paul's Cathedral and although, to my knowledge, it has not been applied to music, it seems to have possibilities in instances such as those I have cited where loss of directivity would be a disadvantage.

INDIVIDUAL INSTRUMENTS

Strings.—The problem that will most interest string players is: What, scientifically speaking, differentiates a good violin from a bad one? Though put in this bald way the problem seems puerile, it is by no means easy with scientific apparatus to tell a good modern violin from a classical one. Professor Saunders, at the University of Harvard, has spent about 20 years trying to discover what he calls "the secret of Stradivarius" and although some facts have emerged, a good deal on the psychological side remains to be explained. In one set of experiments, in which Jascha Heifetz assisted, three violins, A, B, C—one a good old one and two modern types—were played behind a screen, while a critical audience was asked to "find the Strad." This they were unable to do—that is to say, one-third named A, one-third B, and the remainder C as the veritable old master. Heifetz himself, however, claimed that he could tell a difference in ease of tone production or "singability" while playing them. Perhaps the older violin from constanly being played had acquired with age greater "efficiency" as a music maker.

Not much can be learned by comparing acoustic outputs of violins over their range except that the really bad ones will have in their formants a few pronounced and strongly separated resonances in each of which a "wolf" lurks, whereas these resonances ought to be reasonably and closely distributed over a range of four octaves. Much can, of course, be done to improve a poor violin, by altering the coupling between the strings and resonators by shifting bridge, bass bar, and sound post.

Professor Skudryzk of Vienna emphasizes the importance of the radiation by a good violin of transients and of low frequencies in order to make it stand out in solo work (*vide supra*). From this point of view tests behind a screen are inadequate to represent the effects of playing the instrument on the concert platform, particularly in concerti. Both he and other physicists have tried to pinpoint the effects of material and varnish. The general conclusions are what one would expect: the wood should possess good elasticity and small internal friction. The purpose of the varnish is to reduce the latter but since a varnish suffers a chemical change with age we cannot be sure that the old violins are, in respect of internal friction, in the same condition as when contemporary players used them. In any case, varnishes have been so much developed by the chemists in recent years that the modern violinmaker ought to be able to do better than the old masters in this respect.

In the acoustics of the pianoforte and other instruments having struck strings, recent scientific interest, particularly in the hands of Dr. George in England and Dr. Young in the United States, has been directed to the coupling between the two or three strings of the same pitch which constitute a note.

A limited amount of mistuning among the members of this trichord is not undesirable for it adds brightness. The maker aims, as with the violin, to reduce the attenuation which inevitably occurs after the string is struck. The timbre varies during the decay of the sound, the components of low pitch lasting longest. The timbre varies also with the speed of impact, that is with touch, and it is not possible to change one without the other.

Wind.—Whether the wind instrument is one of a distinct class, like the orchestral wind, or occurs in ranks all of the same pattern as in the organ, basically its sound is that of a column of air set in vibration by an edge tone (whistle type) or reed. In the former a jet of air debouching through a slit from a wind chest or from the human lung strikes a sharp edge and is set in pendulation at a frequency eventually governed by the column of air acting as resonator. In the brass we have virtually both types of excitation, for the lips of the player act like a double reed while an edge is furnished by the more or less sharp constriction where the cup mouthpiece adjoins the tube itself.

The column has either a fixed length so that its possible notes are limited to the fundamental—in theory, though it is often unattainable—and its harmonics, or it is variable by the use of side holes. It is now possible to calculate the pitch of such a system if one knows the position and acoustic "admittance"—to borrow a term from the electrician—of the side holes and of the termination or bell mouth. The principal drawback to the practical use of such theoretical predictions

of the hole size and position on the woodwind, in place of the old hit-or-miss method, is our uncertainty in ascribing precise values to these admittances, or end corrections. Work is, however, proceeding on this problem.

The material of the tube seems not to have such a marked effect on the output as some organ builders suppose. Provided the tube is not made of very lissom material it will sound—even shellacked paper will serve—though there may be differences in harmonic development. In plate 1, figure 2, are shown tracings of the wave form of four metal diapasons (C 520) of different material but identical shape. It will be noticed that there is some change in the strength of the second and third harmonics.

The nature of the coupling between exciter and resonator is a matter that has interested workers in musical acoustics of late. In a flue pipe the edge tone, which, unmodulated, would normally have a pitch proportional to the wind velocity, is brought into consonance with one of the natural modes of vibration of the column—the fundamental at moderate pressure, the overtones at higher (overblown) pressures. Exceptionally, if the pipe is underblown, a reshuffling of the pendulations in the jet takes place whereby either the fundamental or its octave again appear. Although these underblown tones are undesirable they often appear transiently as the blowing starts. Thus in the oscillograph record of the commencement of sounding of the diapason pipe, reproduced in plate 2, figure 2, *a*, the octave is apparent in the transient for about one-tenth of a second though not in the final wave form. The buildup of pressure in this pipe lasted about one-fifth of a second. Transients also occur on wind instruments when the player passes portamento from one note to another (pl. 2, fig. 2, *c*). The process of "voicing" by which an organ builder gets the pipe to speak as he wants it, cutting the mouth and making notches in the lower lip, is a mysterious art which I hope will be clarified in a scientific study of the process being made by Mr. Mercer at the University of Southampton.

In a reed pipe the coupling between reed and column may be either tight or loose. If the reed is slim and rather inelastic because of its moist condition—like many orchestral reeds, including the brass-player's lips—it accommodates itself to whatever note the player and/or the wind pressure imposes on the column. In the organ reed pipe, however, the reed is strong and elastic, and if reed and column are tightly coupled the two can only sound sympathetically when the length of the pipe is adjusted to synchronism with the reed; otherwise the system remains silent.

With the partners loosely coupled, the main function of the resonator is to purify the rather raucous sound of the reed by smothering

its overtones. This has been well shown by a former student of mine, Professor Mokhtar, who recorded the sound pressure in the neighborhood of a beating reed. The oscillograms on the left of plate 2, figure 1, show the sound of the reed in its "boot" without the pipe, and the ones on the right those when the reed was loosely coupled to the pipe—a cylindrical tube 45 cm. long and 3.6 cm. diameter—at the same pressures. Without detailed analysis it is easy by visual inspection of the records to see how the overtones of the uncoupled reed intrude as the wind pressure is raised. With the pipe added, however, these raucous overtones are smoothed off.

The transient sounds of a reed pipe, like those of the violin, are usually smaller copies of the final steady state (pl. 2, fig. 2, *b*) and do not comprise extraneous harmonics.

Bells.—The scientific interest in the sound of bells is centered on the remarkable fact that while, from theoretical considerations, it ought to be one of the most complex of musical instruments, yet through the ages the craft of the bell founder has made the sound of the church bell pleasantly simple in the sense that most of the overtones produced by striking it at the right place are harmonic or quasiharmonic. This he does mainly by varying the thickness and moving the sound bow (the place at which the surface changes from convex to concave).

The first six partial tones of bells in a carillon are usually adjusted to lie as follows:

1. Hum note; the lowest.
2. Fundamental; one octave above hum note.
3. Minor third; above fundamental.
4. Fifth; above fundamental.
5. Nominal; one octave above fundamental.
6. Harmonic decime; a major third above normal.

(It will be noted that this use of the term "fundamental" is unorthodox.) Roughly speaking the pitch of the hum note is inversely proportional to the circumference at the sound bow.

A peculiar feature of bell timbre is the "strike note," the tone most prominent to the ear and the one which is intended when the pitch of the bell is named. It seems that this is a beat note formed between two of the higher partials, falling about one octave below the fifth partial or, as some maintain, the fifth partial itself wrongly judged by the ear to be an octave lower than it really is.

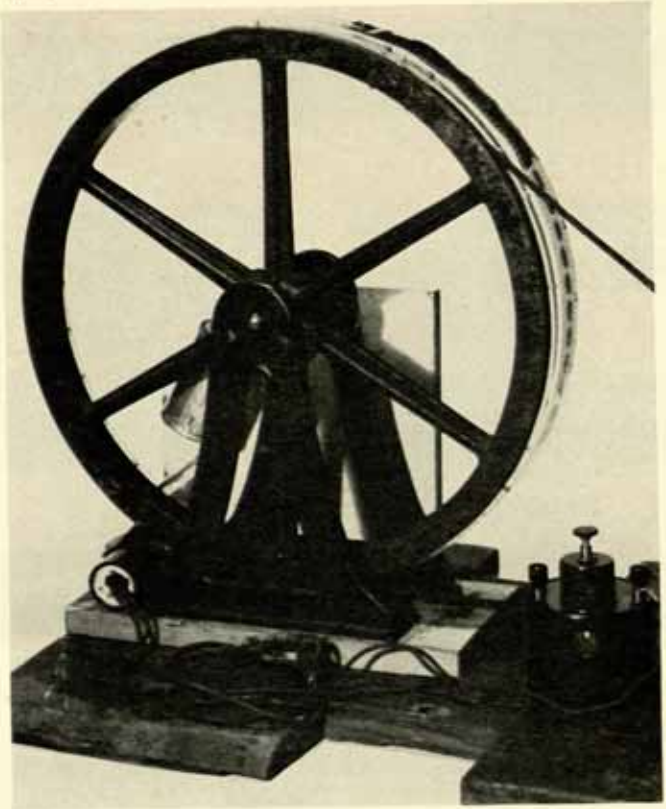
Whereas the nominal is most apparent immediately after striking, it disappears quickly leaving components 1 and 3 as the strongest. After some 10 seconds, only the hum note remains. I have a record, too long to reproduce in full, given to me by the late Prof. Taber Jones, of the sound of a bell at various instants after it was struck.

Snippets from this are given in plate 3 to show the simplification of timbre as the sound decays.

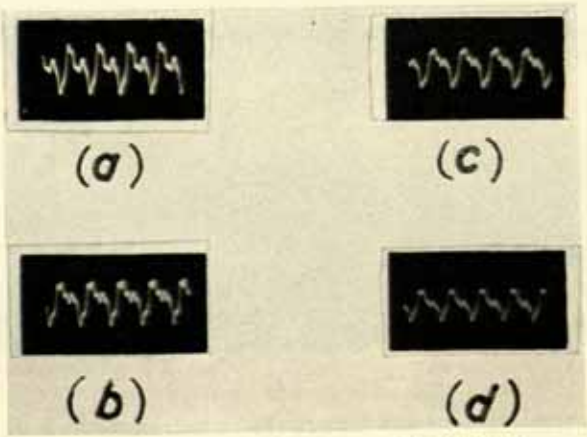
CONCLUSION

I am aware that this survey by no means exhausts all recent work on musical instruments, but there is a limit to what can be covered in a single lecture. The instruments and topics to which I have referred do in fact comprise those which physicists working in musical acoustics—all too few, unfortunately—have been interested in during the past decade.

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.

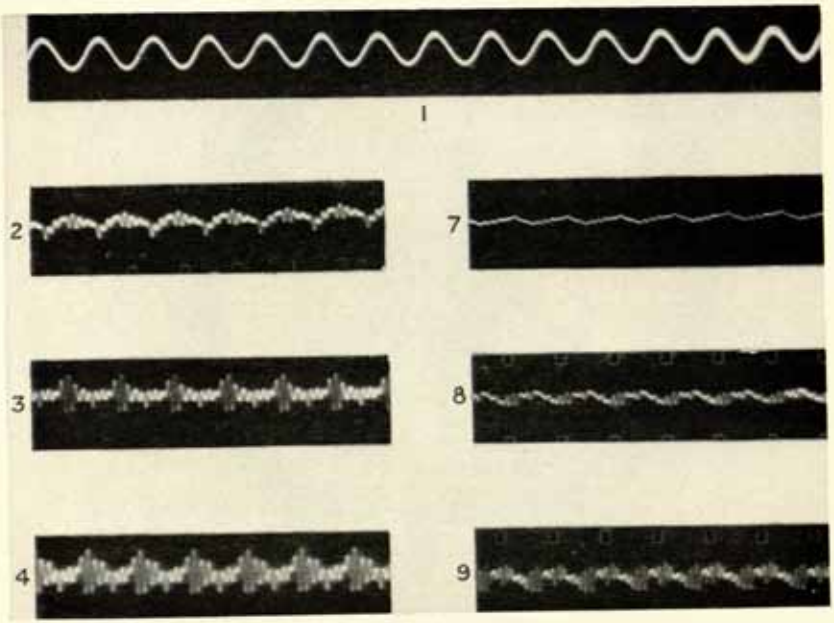


1. PHOTOELECTRIC APPARATUS FOR ANALYSIS OF TRANSIENT SOUNDS.



2. WAVE FORMS OF FLUE ORGAN PIPES (C520).

a, 60 percent lead, 40 percent tin; *b*, 15 percent tin; *c*, 50 percent tin; *d*, all tin. (The pipes used for the records were made and lent by Harrison's Organ Works, Durham, England.)



1. WAVE FORM OF REED ORGAN PIPE.

1, Reed alone; 2, 3, 4, mouthpiece alone at increasing blowing pressure; 7, 8, 9, mouthpiece coupled to pipe at same pressures.

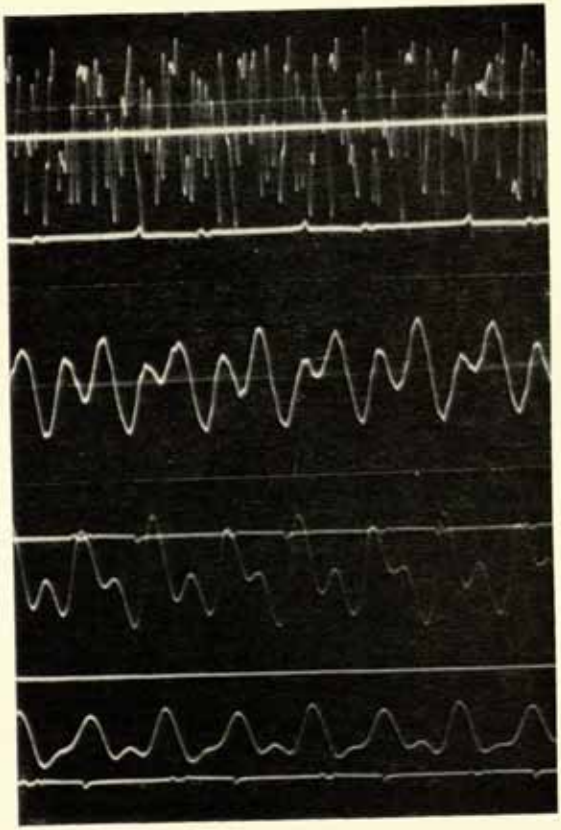
a *Courtesy of Dr. E. O. Cook*

b *Courtesy of Prof. F. A. Saunders*

c *Courtesy of Dr. J. M. A. Lenihan*

2. WAVE FORMS OF TRANSIENTS.

a, Flue organ pipe. (The uppermost trace is of a 25 c/s marker). *b*, Violin string. *c*, Bagpipe, passing from B513 to C570.



WAVE FORMS OF CHURCH BELLS, 0.1 SECOND, 7 SECONDS, AND 12 SECONDS, RESPECTIVELY, AFTER STRIKING.

Genetics and the World Today[1]

By Curt Stern
Department of Zoology, University of California

The scientists look at our world! Which world? The world of ideas? The world of human needs? The world of an authoritarian organization? Of a democracy?

Science appears different from different viewpoints, but none encompasses all its aspects. "The world" has always meant a multitude of phenomena, some apparently additive, others complementary, still others seemingly incompatible with one another. In the middle of the twentieth century we have become more conscious of this multiplicity of the world than perhaps ever before. If we look at science today we cannot afford to select some one of its aspects, but must view it from high ground and low. Genetics, the branch of science to which this discourse is devoted, may well serve as an illustration for several of the problems of science and the world today.

Let us begin with the adventures and delights of the spirit: Genetics as a *pure* science. Within the confines of the first half of our century, a body of knowledge in the field of heredity has been assembled, and a tool chest of concepts devised, which will always stand as a great accomplishment of human endeavor.

We all know the story of Mendel's successful thrust. He crossed a round-seeded to a wrinkle-seeded pea plant. All their offspring were round. He crossed the offspring among one another. Their progeny was part round, part wrinkled. He counted their numbers and found three round to one wrinkled. What of it?—one might be inclined to ask—and his contemporaries' reaction, or lack of reaction, is testimony to this shrugging of the shoulders. Yet out of this childishly simple couple of facts, the deep truth was lifted that the contributions of two parents to their offspring do not blend or merge into a unique hereditary newness but remain separable, to be recoverable unchanged in a later generation: clear-cut roundness and clear-cut wrinkledness.

[1] Reprinted by permission from "The Scientists Look at Our World," the Benjamin Franklin Lectures of the University of Pennsylvania, Fourth Series, University of Pennsylvania Press, 1952.

Mendel noticed another fact. The round-seeded parent had yellow seed color, while the wrinkled parent plant had green seeds. Among the grandchildren four types appeared, with seeds round yellow and round green, wrinkled yellow and wrinkled green. Some of you will remember their proportions: 9:3:3:1. But that is a minor matter. The lever for further insight is the childishly simple fact that the parental traits round and yellow which came from one parent, and wrinkled and green which came from the other, had not always reappeared together in the combination in which they had been introduced into the cross, but had also appeared in the new combinations round green and wrinkled yellow. This fact reveals that each parent does not transmit a unified lump of hereditary matter, one whose joint consequences are in one case roundness and yellowness and in the other wrinkledness and greenness. Rather it shows that the hereditary matter of an individual is broken up not only into the two contributions of his parents, but that each contribution itself consists of separate and separable units. Thus the concept of the hereditary makeup as an assembly of many independent units was born. Just as the atomic theory had reduced the ephemeral multitude of chemical phenomena to the eternal properties of a limited number of atoms, so the theory of hereditary elements had reduced the multitude of specific individual appearances and disappearances of traits to the existence of a limited number of combining and disjoining elementary biological constituents.

This knowledge, not appreciated during Mendel's life, became our property at the beginning of the present century. What grew out of it are adventures of our time. Mendel knew that the separable hereditary contributions were contained in the plant's egg and pollen, or in the animal's egg and sperm, but he did not speculate about their nature or their specific location. A few further facts than those he knew have permitted us to place the hereditary elements into the small but microscopically clearly visible bodies of the cell's nucleus, the chromosomes. Still more facts, demonstrated first in sweetpeas and fruitflies, have been the clues to the hereditary architecture of the chromosomes. While the chromosomes are contained in the nucleus in a haphazard fashion, like string beans in a bag, each chromosome itself is a well-arranged construction in which specific hereditary units occupy specific places. Thus we have accurate maps of the chromosomes of some organisms in which many of their thousands of different hereditary elements are assigned their locations: showing which one of the various chromosomes is the carrier of each specific element; picturing the linear order in which the elements are arranged within each chromosome; and giving the seriation of the elements and their relative distances within the chromosomal lineup.

What are these elements? Mendel himself gave them symbolic letters, A and B and C, representing the characteristic traits which he was studying. There is no doubt that he did not think of A as being redness of flowers but rather as an agent transmitted through the parental germ cells, whose action, after growth and development of the fertilized egg cell into a mature plant, resulted in the presence of red pigment in its flowers. His early followers expressed this concept in the word "factor" (i. e., maker), the factor A leading to the production of redness. The famous term "gene" at first had no other connotation. It was to express the fact that the traits of the organism are *generated* by "separable, and thus so-to-say independent 'states,' 'factors,' 'units,' or 'elements' in the make-up of the germ cells. . . ."

The term "gene," however, did not permit itself to be confined in the lofty heights of hypothesis-free abstraction. When the gene was recognized as being associated with the chromosomes, an interpretation of its nature in terms of matter became an obvious need. We are still in the middle of this process of interpretation which takes place at the molecular level. Where the speculations of former times thought of elementary submicroscopic living units, themselves endowed with the mysterious properties which constitute life, we now regard the life of cells and of whole organisms as the resultant of chemical and physical processes which involve properties and reactions of molecular matter of the same kind which the chemist and physicist study in test tubes and with the spectroscope. It is a truism that this is not all. The mystery of life remains, but it is now seen in the integrated coupling of the molecular phenomena and the consequences of this over-all molecular organization, not in the elementary processes themselves.

Thus our problem has doubled. While we want to know, justifiably, the gene's molecular structure, our task would not be completed with the attainment of this knowledge. If we could write down today an accurate structural formula of a gene molecule, the problems of genetics would not yet be solved. Indeed, we could imagine that the cellular chemist might have provided us with this structural knowledge before the science of genetics had been born. The molecular recognition would not have given us the gene, the generator of the organism's traits, but a molecule. The biological problems of genetics depend on molecular processes, but are larger than they.

As it is, the physicochemical analysis of the chromosomes has not yet led to the gene. Beautifully refined micromethods made us recognize various proteins and nucleic acids, and even gave us specific arrangements of regions relatively rich or poor in these substances. It will be a long road, however, toward the recognition of the specificity

of the thousands of linearly arranged entities which form the chromosomal gene string. We do not know whether the molecular analysis of the chromosomes will lead to the discovery of clearly separate specific entities, linearly arranged, and insulated from each other by less specific material. An alternative has been suggested, according to which a whole chromosome may be a unified kind of super-macromolecule, and the genes only regions of specific chemical activity of parts of the whole. In this extreme form the alternative is not likely to be correct, since it is possible in the living cell to break a chromosome at many places and still retain the functioning of its parts. Interestingly enough, though, this functioning often is slightly altered from its normal action in the unbroken chromosome. There is some interrelation of neighboring genes, be it interpreted as interaction of separate molecular units or as interdependence of subunits of a larger molecular aggregation.

What started as a problem of passive transmission has become a problem of active functioning. Cell growth and development are now known to be founded on genic action. A simple experiment made 75 years ago, of cutting an ameba into two parts, one with the nucleus and the other without it, had shown the necessity of the nucleus for continued life and growth. Now the geneticist can show that the loss of a single gene may lead to damage and death. This new fact has provided a new tool to the experimenter. While it seemed hopeless to replace from the outside the activities of a whole nucleus, it became possible to discover the specific cause of trouble due to lack of a single gene, and to supplement the cell or the many-celled organism with a compound which it had lost the power to manufacture itself. Not that one can give such a cell a new gene, but at least we can supply a necessary product that is otherwise gene-dependent. And what is possible for one lost gene is possible for two and more. We do not yet know how much of the intrinsic groundwork of an organism we can do without as long as we take over its jobs. That one can go very far in this substitution is not a discovery of man's intellect. All through the evolution of life many forms have degenerated, losing their relative autonomy and becoming dependent parasites upon other creatures.

The role of the genes as key reagents in the biochemistry of the cell is being elucidated by the brilliant work of our contemporary biochemical geneticists. They have clarified many of the steps in which the genes take part in the synthesis of amino acids, vitamins, and other essential compounds. Different genes control or participate in successive steps in the so-called biosynthetic pathways. These studies have made genetics a central aspect of the science of cellular physiology which comprises nutrition and growth, energy transfer in

respiration and fermentation, in synthesis and decomposition. And emerging from these phenomena, we are approaching from the aspect of genic action differentiation and development, maturing, aging, and death.

As unbelievably remarkable as the functioning of an organism is under the guidance of its genes, we have not yet spoken of the still more remarkable fact that an organism can produce another organism, that it can reproduce. Once, in the century of rationalism and deism, some men believed that they could dispense with the solution of this biological enigma by laying it directly in the hands of the Creator. They thought that a man's reproductive cells, his sperm, were fully preformed little men, in turn containing inside their tiny bodies still smaller fully preformed human beings to constitute the grandchildren and so on in ever smaller proportion the encapsuled miniatures of all future generations. In terms of molecular biology this picture dissolves if it ever did have justification.

Reproduction of an organism, basically, has become reproduction of genes. Reproduction of a gene is an elementary process, the copying of an original molecular configuration within a cell. However dependent this copying process is on the preexistence of the larger, living assembly of parts which constitutes a cell, genic reproduction becomes accessible to study by the physicist and chemist.

It is at the genic level, once more, that the problems of the evolution of living forms at present find their most fundamental treatment. If the genes of an animal or plant are responsible for its given nature, how is it possible that this nature changes in the course of biological history? If evolution implies deviation from conservative, accurate reproduction of an organism, the genetic interpretation demands deviation from conservative, accurate copying of the generators of living form. Genetics indeed has demonstrated that the so perfect copying process of the genic matter leaves room for some imperfections; that the stabilizing transmission of exact replicas of parental genes is accompanied by occasional upsetting lapses in which a new kind of gene originates and causes the appearance of hereditary newness. Some of these lapses are known to us in detail: rare cases where the copy of a gene remains with the original gene assembly instead of becoming part of the general duplicate; or rare cases where genic material gets lost from the genic assembly. Other lapses in exact copying may consist in a permanent change within the molecular makeup of a gene itself, a change which may have occurred before the gene began its reproduction, or may have been an error in copying itself.

The occurrence of such changes has been known for some time. They initiate *permanent* newness, and their discovery is possible

primarily on account of the remarkable property that, once changed, further copies are reproductions of the new kind of gene, and do not return to the old pattern. We now do not need to wait for these mutations to occur spontaneously; we have learned to produce them artificially. The same century which brought us the artificial transmutation of the chemical elements has given us the artificial transmutation of the hereditary elements. X-rays and gamma rays from radium were the pioneer tools, and still are indispensable. Most recently, chemical agents such as mustard gas, formaldehyde, and urathene have been found which accomplish permanent genic alterations. The mechanism of induction of mutations is on the way to being clarified. Undoubtedly the solution of these problems will bring with it insight into the origin of the natural mutations which, uncontrollable at present, occur all the time in all organisms. It is clear already that these spontaneous mutations are elementary events dependent on accidental phenomena of nature: intrinsic instability of genic molecular compounds; unusual exposure of genes to reactive chemicals formed in the cell; and unavoidable events like natural radioactivity or cosmic irradiation.

These sources of mutagenic action are part of the forces of the universe. Life pays tribute to them, and harnesses them. The tribute consists in the sacrifice of many changed genes. Since the change is accidental in origin, much more often than not its result is detrimental. The mutated gene will not be suitable to take part in the established paths of gene action, and early death or weakness of the organism will result. This tribute is a tragic reality. While any one gene will mutate only in one out of many thousands of cells, the fact that each cell embodies many thousands of genes means that in each generation very many germ cells have acquired at least one mutated gene not present in their ancestry. In each generation millions of mutations are dumped into a species. Why then its apparent stability? The answer to this question has already been given. The early death or weakness of the individuals who carry the mutations removes the unstabilizers at the same rate as they are produced.

But not quite at the same rate. A few are harnessed to the yoke of survival. Are those a few good genes in contrast to the great bulk of bad genes? Molecules and genes are not good or bad by themselves. However, a few changes in the living assemblage of cellular molecules will happen to be compatible with continued good function, although the majority will not. The internally compatible new assemblages then will have a chance to be perpetuated. Whether they will coexist with the original ones, or whether they will replace them, will vary from case to case. Sometimes the new assemblage may thrive in a niche of the environment which had not been occupied before. The existence of thousands of different species in the same

environment of a forest or a meadow is evidence of the existence of thousands of occupied ecological niches, and surely of many more yet unexplored. Sometimes the new assemblage will happen to survive in a changing environment where the original assemblage was doomed to extinction. The "deterioration of the environment," so-called by unadjustable men, is a continuous process; for the flexible, environmental change is a challenge to inventiveness.

Let us, however, not be deceived by this anthropomorphic phraseology. It fits our discussion in a figurative manner, but only in a most indirect way does the genetic model of evolution provide an organism with attributes of unadjustability or inventiveness. Changes at the molecular level all too often happen not to be adjusted to the demands of a higher level. Occasionally they do. The wonder is that for two billion years the genes have succeeded in escaping extinction. They survived, that is, left duplicates when they happened to clothe themselves in lambs and lions, amebae and bacteria, algae and oak trees, tapeworms and men. They perished when they were trapped within trilobites and dinosaurs, or within the tree ferns and giant horsetails of the carbon ages. The genetic view of evolution may be expressed in a variation of a well-known sentence: All living forms are only the genes' ways of making other genes.

Not that the genes could escape the process of evolution themselves. In order to create the superstructures of animals and plants within which to survive, the genes had to change themselves. Single, separately existing genes at the dawn of life had to become associated into harmoniously fitting groups; mutations of the genes had to make possible the development of the manifoldness of organisms. The one prerequisite invariant in the evolution of the gene had to be its property of reproducibility. What else remained constant we can only guess—perhaps protein or nucleic acid structure, taken in a general sense; perhaps enzymatic property. The evolution of the gene, as gene, is a field of inquiry barely touched.

This then is genetics as a way of interpreting living nature. This is Mendelism—Weismannism—Morganism—Mullerism—Goldschmidtism—Beadleism—Haldaneism—Fisherism—Wrightism. This is the framework which our times have built. It has been called "idealistic" by those to whom this term is one of condemnation, and with equal reproach has been termed "materialistic" by their opponents.

The new view of biology which genetics has provided may seem to many a denaturation of nature. Instead of birds with beautiful feathers and sweet songs, with artful nests and loving care of the young, we speak of the gene molecules which control pigmentation reactions and the deposition of cartilages in the singing box, determine the architecture and physiology of the brain, and the hormonal secretion of the pituitary gland. But the molecular interpretation

of the individual development and functioning of an organism and of its historical evolution does not negate the existence of all the marvels of what we called the superstructure. The emergence of the latter is a miracle itself, and the exploration of life as it exists truly only above the molecular level remains as valid and tempting a task as ever before.

Our discussion of genetics up to this point has been subsumed under the heading "The adventures and delights of the spirit." The pursuit of such adventures and the tasting of their delights has had a respected place in civilization, not the least in our own Western tradition. "The world," wrote Sir Thomas Browne in the seventeenth century, "was made to be inhabited by beasts, but studied and contemplated by man: 'tis the debt of our reason we owe unto God, and the homage we pay for not being beasts. Without this, the world is still as though it had not been, or as it was before the sixth day, when as yet there was not a creature that could conceive or say there was a world. The wisdom of God receives small honour from those vulgar heads that rudely stare about and with a gross rusticity admire His works. Those truly magnify Him whose judicious enquiry into His acts and deliberate research into His creatures return the duty of a devout and learned admiration." Had genetics accomplished nothing else but its studies and contemplations, its position in the world today would be assured as one worthy of a mankind which not only wages war, invents nuclear explosives, and cannot learn fast enough to use its powers for good, but also creates and supports seats of learning and thought, preserves and defends some of the beauties of the world, and, in spite of all, succeeds with innumerable unselfish acts of duty and love.

Yet man liveth not of adventures and delights alone. Genetics has had the good fortune to fulfill not only the social function of exploring its realm of the universe, but to contribute to our material well-being and provide foundations for social measures. Let us now consider some of these material products which we may call "the produce of the mind."

The most famous of the applications of genetics to the practical world of today is the technique of raising hybrid corn. It had always been the goal of plant and animal breeders to produce strains which have two properties: one, to give high yields; and two, to be pure. This latter trait, purity, would assure the homogeneity of the strain, that is, the likeness of all individuals grown at the same time, *and* the constancy of the strain, that is, the likeness of parents and offspring. The likeness of the individuals of the same generation would assure equal potential performance or yield from all of them, the likeness of successive generations would enable the farmer to continue his stock through the years. The radical innovation of hybrid corn retained

the goal of homogeneity of one generation and increased immensely its yield. For this increase it had to pay a price, the renunciation of likeness of successive generations. The technique of raising hybrid corn arose from a theoretically and experimentally inspired contemplation of the composition of a field of corn as it used to be grown all over the world. It became apparent that the varieties of corn then on the market were far from being homogeneous. When genetic procedures were used to obtain pure lines they were successful. Many different pure lines were produced, each one homogeneous within and between generations—but none was of practical value. Always growth was stunted, and fertility low. This appeared strange enough, but stranger still, and happier, was the outcome of crosses between the poor, pure lines. The hybrids not only showed better vigor than their parents, but they surpassed the desirable qualities of the individual members of the old field of corn.

That the desirable crossbred plants were undesirable as producers of seed for future generations lay in the nature of the genetic makeup of the hybrids. The shuffling in reproduction of the parental genes would result in renewed heterogeneity of the next generation, and in loss of the specific hybrid vigor. Thus the discovery which had yielded such desirable produce requires each year anew the effort of hybridization of the, by themselves, undesirable pure strains.

The theoretical problems of hybrid vigor are not yet solved. On the contrary, the cause of this phenomenon is a matter of extensive research at present. The practical fact is that after a slow start with the first commercial seed field of hybrid corn grown in 1921, and a gradual rise to 80,000 acres in 1932, now the greater part of the nearly 90,000,000 acres of field corn and sweet corn in the United States are planted with hybrid corn. It has been estimated that perhaps a billion bushels a year are now harvested in excess of the best national yields we enjoyed before we had hybrid corn.

Genetics is credited for this practical result because of the historical fact that a pure geneticist, G. H. Shull, working at the Station for Experimental Evolution on Long Island—not at an agricultural experiment station—was the father of hybrid corn. Admittedly it was no absolute internal necessity that the introduction of hybrid corn into practice had to wait for the concepts of genetics. Indeed, the use of crossbred field corn had been proposed many years earlier, while mules, the vigorous but sterile hybrids of the horse and ass, had long had a recognized place in animal production. Yet it seems that the modern intellectual penetration into the phenomena of heredity was required to rediscover, refine, and assure the acceptance of the unconventional procedure.

The success of applied genetics with hybrid corn is followed closely by the success of the breeder of disease-resistant wheat plants. Each

year the loss of yield due to widespread infection of wheat by parasitic fungi used to be a drain on the national economy and, even worse, on the source of livelihood of many farmers. Then genetically trained plant pathologists discovered that susceptibility to infection was not a ubiquitous fate. Specific genetic constitutions were present in many plants which endowed them with resistance to the invaders. Varieties were bred which not only possessed those desirable properties for which they had been selected by plant breeders, but which combine these properties with resistance to infection. In this way for many years whole regions suffered little loss in the yield of this important crop. Genetics, furthermore, served to explain and to prepare the farmer for the breakdown in protection which again and again brought catastrophe to the wheat grower. A gene that protects a wheat variety is not all-powerful. The fungus itself is heterogeneous, and different genetic types of the parasite are repulsed by different genetic types of the potential host. Invasion by a new strain of the fungus into a territory where no resistance against this specific strain existed, seems to undo past successful efforts. Even worse, mutations in some of the myriads of spores produced by even a few fungi may lead to the origin of new virulent varieties. Thus the plant pathologist and geneticist has a never-ending task, but he can anticipate a future unavoidable genetic breakdown of any specific resistance mechanism by preparing new varieties of wheat, resistant to new laboratory-cultivated varieties of the fungus.

This recognition of parasite mutability strikes still nearer home. Bacteria have been found which are resistant to sulfa drugs or streptomycin, though their ancestors could have been combated successfully with these drugs. Even streptomycin-dependent bacteria occur which thrive only on what means death to their brethren. The origin of these new types is due to mutations in the genetic composition of the bacteria. One of the newest branches of genetics, microbial genetics, is now elucidating these phenomena and contributes to overcoming the impediments to drug therapy.

It happened that at about the time when the artificial production of mutations was first accomplished by means of radiations, the action of the penicillium mold in inhibiting bacterial growth was discovered. Years later, during the last war, when the large-scale production of penicillin became an urgent task, the geneticist's method was applied to the production of strains of the mold with greatly increased output. The strain now used most widely by commercial firms originated from irradiating spores from relatively low-yielding strains and selection of a spore in which a mutation to high yield had been induced. Similar methods of causing mutations responsible for desirable new qualities in agricultural plants have been employed, particularly in

Sweden. Success has been slow in coming, for reasons which might have been foreseen. In evolution, establishment of new genetic types results not directly from the occurrence of a new, mutated gene variety within the genic assemblage of an individual. Rather, it requires a process of selecting some of the varied genic assemblages of the species, namely, those which happen to complement in a harmonious way the newness of the mutation. Similarly, in artificial breeding the production of a useful mutant requires a selection of suitable genetic background. This adjustment between the new and the suitable elements of the old takes time. By now, improved strains with superior stiffness of the straw in barley, and an improved strain with superior seed and oil yield in white mustard, have been created on the basis of X-ray-induced mutations.

They were pure geneticists who discovered the peculiar mode of inheritance of some special traits which are called "sex-linked." In suitable crosses with such traits all daughters resemble their fathers and all sons their mothers. It was another pure geneticist who proposed to use this criss-cross inheritance for the sexing of chicks. Male and female chicks are hard to distinguish until they are several weeks old. But when you cross barred Plymouth Rock hens and not-barred Rhode Island Red roosters, the female chicks are not barred and the male chicks are barred. This trick is now being used each year for the commercial production of several million chicks in the United States alone. Obviously, only females can be used for the all-important egg production, and it is more economical to destroy most of the newly hatched now easily recognized males than to feed them until their normal development betrays their relative uselessness.

One more example from agriculture. Cattle and horse breeders as well as breeders of other animals have always been troubled by the birth of abnormal types of young, often doomed to early death. When genetics arose it showed the frequent occurrence of lethal genes in mice and in fruitflies, genes that lead to abnormal, destructive development of their bearers. Soon it was recognized that many of the stillbirths which had troubled the animal breeder were due to specific lethal genes, often brought into a herd by some famous sire who carried the lethal gene in a harmless combination with a normal one. Among his numerous descendants many would be carriers again, and breeding the carriers with one another would result in 25 percent of the pregnancies ending in disaster. This insight into the stock breeders' troubles carried with it means of avoiding them. It was easy, on the basis of Mendel's first law, to devise trial matings through which bulls or stallions could be recognized as carriers of dangerous lethal genes and, if found genetically unsound, be excluded as sires of large numbers of offspring. The savings accomplished in this

way are very considerable. Even in so inexpensive an animal as the chicken the recent discovery of a particular lethal gene has bared losses, now avoidable, which in a single hatchery amounted to more than $180,000 over the last 10 years.

The most significant applications of genetics concern ourselves. Men are born genetically unequal. This is a fact of nature, and quite independent of the conclusions which may result from its political and sociological interpretations. Man is therefore a subject of genetic investigation, and much has been learned about him in our time. The produce of this knowledge extends both to the individual and to the community. How much personal worry is relieved when the human geneticist can advise a healthy questioner that his or her chances of having normal children are as good as anyone else's in spite of the fact that perhaps the father, his mother, and several brothers and sisters have been afflicted with some serious abnormality. How much further suffering has been avoided when the genetic counselor had to predict the high probability of a sad affliction reappearing in a family, should a new pregnancy be attempted. Human heredity clinics fulfill a great need, and are still all too few.

Yet more important than such advice from case to case are the applications to policy. The urgent warnings of geneticists against careless use of X-rays and other ionizing radiations may well have prevented the production of thousands of human mutations bad in effect, as most of them are. In today's world of atomic-energy use, the need of shielding workers from radiation has taken on greater significance than ever.

The case against careless irradiation transcends the interest in the immediate offspring of exposed persons. Many induced mutant genes will not show their effect in the first generation but at any time, far into the future. This aspect widens the responsibility of a world today beyond its usual care. The well- or ill-being of our distant descendants is, to some extent, in our power. This power is not restricted to the yet minor aspect of radiation genetics. If men are unequal genetically, then our actions and inactions are bound to influence the genetic composition of the future human populations.

The applications of genetic knowledge to this great problem are largely negative at present in that they serve to expose misconceptions. It is important, for instance, to debunk authoritatively distributed pamphlets which endeavor to encourage large families by the misstatement: "Heredity favors the third, fourth, fifth and subsequent children rather than the first two, who are apt to inherit some of the commonest physical and mental defects!" It is important to rectify the opinion that political and moral equalitarianism has any bearing on the biological facts of man's genetic diversity. It is

equally important to stress the great adaptability and plasticity of man particularly in mental attributes. Much of the genetic diversity may play an insignificant role in the actually observed range of normal and even abnormal human behavior and accomplishments. The results of genetics are fully compatible with the recognition that many men with equal accomplishments may greatly differ genetically, and many other men with different accomplishments be much alike. Genetics gives little basis for belief in basic distinctions among classes and races.

Those who in their hearts applaud the last statement in general often are loath to accept the relative term "little" which was used. "No basis," they feel, would be a more fortunate expression. The observing scientist, however, has no power over what is fortunate or unfortunate. If he comes to the conclusion that there is no difference he will say so, but if his finding is "some difference, even if slight" he cannot falsify the record as he reads it.

One of the most comforting results of the geneticist's thoughts has been the recognition that the problems of the genetic future of mankind are not as urgent as they seemed a generation ago. Mankind will not degenerate overnight if nothing is done to change its reproductive patterns, nor would it have blossomed out suddenly if the old-time eugenicists had had their will. We now know that the immense genetic pool of mankind can be changed only very slowly, for better or worse. Here then is one problem at least about which mankind can take its time.

A problem it is, nevertheless, and eugenics, in a sobered mood, is still a demanding goal. While it is true that the methods of the animal husbandman should not be applied to human beings, the discovery of man's genetic diversity cannot escape the treatment which men have successfully applied to so many other facts, namely, use in intelligent planning. It is strange that resistance to this proposition seems strongest among some of the most audacious social designers.

Genetics in the world today can point to spiritual flowers as well as to material fruits. It can justify its existence on either ground. Nor does it need to be ashamed of either. The student of universal phenomena may well rejoice when his search leads to practical benefits, and the biological engineer may well appreciate the more detached task of his theoretical colleague. We cannot afford to measure all human endeavor by its practical benefits. Where would painting and poetry be, where astronomy and archeology, where games and hiking and sports? If we do not permit these activities for pure joy's sake alone, we shall end up with the slogan *Kraft durch Freude* (strength through joy) which historically turned strength into disaster. If you might call my point of view "romanticism" then

I would reply that it is one aspect of reality, and would paraphrase a poet's lines regarding a too narrow view of reality:

> Never mind reality . . .
> Holy hold life's ecstasy.

The enjoyment of the arts and the sciences, of nature and life, is the individual's privilege, but it can be thwarted or encouraged by a social control. The munificence of princes made possible the painting and sculpture of the Renaissance, that of the wealthy men in our country the foundation of research institutes and of well-endowed centers of learning. Now that learned activities depend more and more on society at large, on its delegates to the Congress and the State legislatures, an enlightened understanding of the spiritual significance of thought and search must be kept awake and strengthened over the widest possible ranges of our citizenship. Should that not be possible in a country in which almost one-fifth of the young people between 18 and 24 years of age are enrolled in school or college?

Genetics has a particular reason to sound a warning. Its recent fate in Russia was intimately bound up with a disdain for the humanistic aspects of science. It is unavoidable, in any society, that the support of humanistic activities is subject to general conditions. The demands of economics, of a mobilization, of changing social needs, will create forces which divert at one time more, at another time less manpower and funds to a given function. There would not have been necessarily dangerous implications had the Soviet Government decided to curtail to some extent the expenditure of its intellectual and financial resources which had been devoted to genetics. It would probably have meant bad judgment about the long-term advantages to be gained from asking experts in basic research to turn to more immediate tasks. What is so distressing was the contempt for scholarship and abstract—yet real—thought which motivated, not the curtailment, but the suppression of genetics. In his "victory" address of 1948, Lysenko made this clear once more when he emphasized ". . . what led me to study profoundly theoretical problems . . . was never mere curiosity and a fondness for abstract theorizing," and when he held up to the ridicule of his audience a basic work of one of the most brilliant of his countrymen.

We ourselves are by no means immune to influences which regard the activities of the spirit as dispensable luxuries. Let us remember the sober words which Washington wrote in the war-torn America of 1780: "The Arts and Sciences essential to the prosperity of the State, and to the ornament and happiness of human life, have a primary claim to the encouragement of every lover of his country and of mankind."

Climate and Race[1]

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Three-quarters of a century ago, in 1877, J. A. Allen, a zoologist at the American Museum of Natural History, wrote, in an article reprinted, like this one, in a Smithsonian Annual Report: "The study of man from a geographical standpoint, or with special reference to conditions of environment, offers a most important and fruitful field of research, which, it is to be hoped, will soon receive a more careful attention than has as yet been given it" (Allen, 1877, p. 399). Allen's paper dealt with geographically correlated variations in North American animals and birds, on three axes: color, general size, and the relative size of the peripheral parts; or more simply, color, size, and form. The first of these had already been studied in 1833 by Gloger, the second by Bergmann in 1847. Only the third was new with Allen. Wholly apart from the study of man, few scientists in the zoological field have concerned themselves, since Allen's day, with the subject of geographical variations within species. An outstanding exception is Rensch (1936–37) who, during the late twenties and thirties tested these rules and added several observations of his own; but even with this work available, Ernst Mayr (1942, p. 93) was moved to state: "The study of these ecological correlations and the establishment of definite rules is such a new field that we may consider ourselves at the beginning of the work."

If, 64 years after Allen's statement, an authority of Mayr's stature could say that we were at the beginning of the work, it is clear that up to 11 years ago this aspect of biology had been greatly neglected, and such is still the case. During those 64 years the study of biology passed through several phases of emphasis. First was the Darwinian epoch, in which Allen's work could clearly be rejected as Lamarckianism, and then came the era of genetic orthodoxy, during which it could be tossed into the bin of discredited interests, for at this time it was fashionable to call people interested in taxonomy, naturalists.

Mayr himself, probably more than any other man, has brought taxonomy back into the biological social register. He has shown how essential the study of systematics is to a comprehension of the total life process. Although his interest in ecological rules does not represent a complete rediscovery, as Morgan rediscovered Mendelian genetics, yet his emphasis on this aspect of biology may turn out to be an equally important landmark in biological history.

If the study of ecological rules has been neglected by biologists, physical anthropologists have slighted it even more. The study of race in man has been influenced not only by biological fashion but also by current political ideologies. In each country of Europe, as in America, and in some African and Asiatic nations, a small but persistent group of men has continued to pile up objective data on the metrical and morphological characters of human beings. In some European and Asiatic countries, before World War II, politicians and propagandists concocted theories of racial superiority and inferiority with which to bolster their political schemes. In other European countries corresponding politicians and propagandists interested in internationalism brewed up opposite theories: first, to the effect that all races are equal in every respect, and second, to deny the existence of races at all. In America we have followed both of these fashions in turn. Each has served the political motives of its period. The second movement, unfortunately for the progress of science, is still with us. So strong is the feeling against thinking or talking about race that the study of the facts of race itself is nearly at a standstill. But fashions come and go. What is laughed at in one decade becomes the rage in another. Perhaps our turn will come.

Just as Rensch was the only voice crying in the zoological wilderness, the combined plea of three men, Garn, Birdsell, and myself, raised, in 1949, a feeble noise in the desert of physical anthropology. In our small and conceptually indiscreet book "Races" (Coon, Garn, and Birdsell, 1950), we suggested that some of the racial variations in man may be due to adaptations, by mechanism or mechanisms unknown, to extremes of environment. At the time we wrote it I, at least, had never heard of Allen, Gloger, Bergmann, or Rensch. It was only in a review of our book by Dr. M. T. Newman (1951) that I learned of their work. Since then I have found a little time to read what these zoologists have written, and to think about how their findings may possibly apply to man. Just this small amount of contemplation has made it abundantly clear that if a person is to study the racial variations in man in terms of ecology, he must be a superscientist, thoroughly conversant not only with his own subject, including anatomy, but also with physiology, particularly heat-and-sweat physiology, nutrition and growth, radiation physics, optics, body mechanics,

genetics, and cultural anthropology in time and space. With all due respect to my colleagues I know of no one individual who can meet these qualifications. Hence it looks as though Allen's prediction would have to be still further delayed.

Still the problem can be stated. According to the modern concept of species formation expounded by Mayr and others, most animal species are polytypic—that is, they extend over a varied geographical range, and in a number of observable characteristics the local populations vary gradually from one end of the spatial range to another. A minority of species is monotypic—that is, lacking in geographical variation in any known character. Monotypic species are usually confined to small and isolated areas. Man is a polytypic species. Cases of genuine isolation, like that of the Polar Eskimo, are rare and probably of short duration. Like other polytypic species man varies from place to place, and the different forms which his variations take seem, in some, but not all, instances, to follow the same ecological rules as do those of other warm-blooded animals. Three of these rules, the longest known, concern us here.

1. *Gloger's rule.*—"In mammals and birds, races which inhabit warm and humid regions have more melanin pigmentation than races of the same species in cooler and drier regions; arid regions are characterized by accumulation of yellow and reddish-brown phaeomelanin pigmentation." (Dobzhansky, 1951.) "The phaeomelanins are subject to reduction in cold climate, and in extreme cases also the eumelanin" (polar white). (Mayr, 1942, p. 90.)

2. *Bergmann's rule.*—"The smaller-sized geographic races of a species are found in the warmer parts of the range, the larger sized races in the cooler districts." (Ibid., p. 283.)

3. *Allen's rule.*—Protruding body parts, such as tails, ears, bills, extremities, and so forth, are relatively shorter in the cooler parts of the range of the species than in the warmer parts." (Idem.)

The rest of this paper will be devoted to an inquiry into the possible application of these three rules to man. They cannot be called laws in the sense of Newton's Law or the Second Law of Thermodynamics, although these two, and other well-established physical principles, no doubt contribute to whatever validity they may be shown to possess. That no one simple law is involved in any instance is shown by Rensch's discovery (1929, 1936–37) that these three rules, along with several others of his own formulation (Rensch's clutch rule and hair rule, for example) are subject to 10 to 30 percent of exceptions. They cannot be called laws, because controls have not been sufficiently established to eliminate outside functions, and because not enough experiments have been made. However, a hibernating animal that defies Bergmann's rule is no more a valid exception to it than a helicopter is to

the law of gravity; if all exceptions were run to the ground and all leads followed, the physical basis for these observations could in each case be established, or the rule refuted.

With man we have several advantages, and one disadvantage. We are dealing with a single species, or *rassenkreis*, to use Rensch's term (1929, 1936–37), that is extremely numerous for a mammal and that covers a larger geographical area than that of almost any other mammal. More human beings have been "collected" than any other kind of fauna. Our measurements, while far from adequate, are relatively numerous. Another advantage is that we know quite a lot about the history of man. One principal disadvantage is that man possesses culture. In addition to his enormous capacity for physical adjustment to many climates, he has developed artificial adaptive aids, such as the use of fire, shelter, clothing, food preservation, and transportation, which have permitted him to occupy every single part of the land surface of the world except the Greenland and Antarctic icecaps, and by means of which he is already looking for further conquests in other planets and outer space. There neither Gloger, nor Bergmann, nor Allen can help him.

For the best part of a million years, some kind of man has existed, probably occupying not one but several environments, and during his evolutionary life span the climates of most, if not all, of the regions in which he has lived have been altered, in most cases more than once. As part of the cultural growth of man, two principal evolutionary shifts have been achieved. The brain has gone through two major changes in size, quite independently of body size,[2] by means of two consecutive doublings of the cortical area. This means that two major steps in human evolution may have taken place since the ancestors of man became erect bipedal primates feeding themselves with their hands. This further means that some, if not all, of the climatically adaptive changes which distinguish modern races from one another may have been acquired in stage 1—or stage 2 of this process, rather than in stage 3, the modern level of potential cerebration. The late Franz Weidenreich postulated (1943) that the Mongoloid face began with *Sinanthropus* in stage 2. Whether or not he was correct, that anatomist was prepared to accept the thesis of presapiens raciation, and the concomitant thesis of multiple evolution from an earlier evolutionary level. Whether or not one or several human stocks made this jump, we do not know, but for present purposes the latter possibility must be taken into consideration.

We must not, however, assume that any or all stocks which passed through the first two cerebral size stages to the third were any more

[2] Schultz, 1950, graph on p. 45. See also Bok, 1939; Bonin, 1937, 1938, 1950; Danilewsky, 1880; Dubois, 1898; Kraus, Davison, and Weil, 1928; Schepers, 1946; Stiles, 1946; Van Dilla, Day, and Siple, 1949.

apelike in many respects than the reader. Schultz has shown (1950) that some of the features which distinguish man from his fellow occupants of the great primate house are more conservative and ancient in man than in the apes. For example, the heavy hair on the human scalp is also present in the newborn chimpanzee, which has hair elsewhere only on its eyelids, eyebrows, and arms. The erect position of the head on the top of the spine, with the position of the face and orbits below the brain case, is another example of what Schultz calls ontogenic retardation, or conservatism, rather than using the less palatable and perhaps less truthful, if commoner, word, fetalization. The human position of the great toe falls also in this class of phenomena, while the smaller size of the other toes is due to shortening rather than to an increase of the length of the big toe itself. Furthermore, we cannot assume that all earlier human types had big teeth and prognathous jaws. The gibbon's face is no larger in proportion to its brain and body than that of man. The siamang, in a few examples, has a chin.

In the basic evolutionary characters all men are equally human as far as we can tell; if some races resemble one or another of the anthropoids in some particular feature, that may mean only that that particular race is more specialized, more differentiated from the common stock, than the others. No earlier evolutionary status is necessarily implied, at least until we know all the pertinent facts.

Schultz has shown that among the apes just as much variation is seen as among men, if not more. He says (1950, p. 49) that the "skin color of the chimpanzee varies from black to white . . . the writer has the body of a young chimpanzee, born of black haired parents, which had straw-colored hair at birth, and later this color changed to a reddish tint. . . . Giants and pygmies have developed among chimpanzees and orang-utans, and long-armed and short-armed varieties among gorillas. . . . Of the great apes . . . each has a very limited distribution, in contrast to man, yet each has produced several species or subspecies which are morphologically but not geographically as different from each other as the main races of man."

Schultz's statement shows that many of the differences between men which we consider racial also occur individually and racially among the apes. This means that the early human forms must have possessed the capacities for these same variations, some of which can, therefore, be very ancient and can go back to the earlier evolutionary stages. In other words, a Negro may have become black before he became a man, a Nordic's ancestor blond and blue-eyed while his brain was still half its present cortical surface size. The evidence used in this paper does not favor any such interpretation, but neither does it render it impossible.

Taking up Gloger's rule, first, we find that it was originally formulated to account for the color of feathers and fur, rather than skin. Birds and beasts of humid forested regions, in the cooler latitudes as well as in the Tropics, tend to adopt sombre colors; the association is with humidity and shade, rather than with temperature. Since individual birds and animals have been seen to grow darker or lighter when carried from one environment to another, it is clear that whatever influence produces this effect reflects a genetic capacity of considerable latitude. At any rate, it does not apply to man. His color variation is primarily concerned with the skin, which in a precultural state must have been wholly, except for the scalp, exposed to the elements, as in some racial and cultural situations it still is.

Speaking very broadly, human beings have three kinds of skin. One is the pinkish-white variety that burns badly on exposure to the sun and fails to tan. Such skin is found in a minority of individuals in the cloudy region of northwest Europe, among descendants of the inhabitants of this area who have migrated elsewhere, and among albinos anywhere. It is quite clearly defective skin, and causes its owners trouble anywhere anytime they step out of the shade. Clothing, lotions, wide-brimmed hats, and sun glasses help to mitigate its deficiency. Luckily for the rest, relatively few of mankind possess it.

At the opposite extreme is black or chocolate-brown skin, familiar as the integumental garb of the full-blooded Negro. Persons who wear skin of this type are the same color all over, except for their palms and soles. As I discovered in Ethiopia, the unexposed skin is sometimes even darker than the portions exposed to the sun such as the hands and face, perhaps owing to an increased thickening of the horny layer in contact with solar radiations. Once this layer has thickened, man with this kind of skin can travel anywhere without fear of the sun; he can roll up his sleeves, toss off his shirt, or run naked in any climate where he or any other human would not be hindered by the cold. Negroes have gone to Alaska and to the North Pole.

In between is the range of integumental color possessed by the majority of mankind, belonging to skins which, although appearing as white, olive, yellowish, reddish, or brown, have one feature in common. The skin that is covered by clothing, if any, is relatively light. Exposed areas, if the light is strong enough, tan. In some populations this tanning can approach the darkness of the black-skinned peoples. However, skin that can tan can also bleach. Peoples who live in mid-latitude regions where the air is dry and the sky cloudless in summer, while in winter dampness and clouds are the rule, can shift their skin color with the seasons. This capacity for developing pigment in re-

sponse to light and losing it when the light is gone is probably the original genetic situation with man.

The physiological advantages of the second and third types of pigment are easy enough to see. They concern entirely, as far as we know, ultraviolet radiation. The UV scale runs from about 2,400 to 3,900 Ångstrom units, where it joins the lower end of the range of visible light. Actually, although shorter waves are produced artificially by lamp makers, all solar radiation under about 2,900 units is filtered out by the earth's atmosphere and has nothing to do with the adaptive character of the human skin (Luckeish, 1946, pp. 59–72). Through the remaining thousand-unit range, UV radiation penetrates exposed skin to irradiate some of the subcutaneous fats, thus producing vitamin D, which is of benefit to the system.

However, those rays which are concentrated in an extremely narrow peak near the short end of the range, and centered at 2,967 units, can damage the unpigmented skin if the sky is clear, the sun overhead, and if the exposure is prolonged past a critical time limit. Sunburn, erythema, prickly heat, and sunstroke can follow. However, the hazard carries its own cure, for if the skin is exposed for short periods it will tan. The pigment so acquired absorbs the UV radiation concentrated at this critical peak and converts it into radiant heat, which the skin then loses through the normal processes of radiation, convection, and sweating, along with other heat produced by the metabolism of food within the body. The pigment granules do not interfere with UV penetration along the rest of the scale, and thus vitamin D production can continue. Tanned skin is thus useful in regions where the peak of UV radiation is seasonal, since in the season of reduced light the skin bleaches and permits the maximum of irradiation.

In contrast to the genetic capacity for change inherent in skin that tans, black skin is constant. In the distant and naked past, it must have had a clear advantage in the Tropics over tannable skin. That advantage remains to be discovered experimentally. Geographically speaking, peoples with black skin who are known to have lived in their present habitats since the rather mobile dawn of history live in regions close to the Equator where UV is strongest. They inhabit the forests and adjacent grasslands of central Africa. The second great center is Melanesia, including Papua and northern Australia. They also include the extinct (in the full-blooded state) Tasmanians. In between Africa and Melanesia fringes of land and islands hold connecting links; southern India, Ceylon, the Andamans, the Malay Peninsula, and the Lesser Sundas contain black-skinned peoples, as do some of the islands of the Philippines.

Except for Tasmania, whose inhabitants had obviously migrated there from a region of lower latitude, these areas are all within 20°

of the Equator, and most of them are within 10°. In all of them there is little seasonal change. Aside from these uniformities, they represent a variety of environments, including shady forests, grasslands, deserts, and coast lines. Since we have a good idea what black skin is good for, we can discover no particular reason for it in the forests. Bright equatorial sun is, however, a problem in grasslands, deserts, and on the water.

Returning to the rest of the animal kingdom, we find that grassland and desert mammals are generally light or tawny colored (Buxton, 1923). This is true of animals whose skins are protected by hair. A few animals, however, are naked like man, and these are black or dark gray. They include the elephant, rhinoceros, hippopotamus, buffalo, and certain types of pig. These animals reach their peak of numbers and development in the grasslands or desert fringe; except for the rhino they enter the forest, where they are fewer and less favored. Their color, carried in from the sunlight, is neither an advantage nor a disadvantage in the shade.

In Africa the blackest Negroes live in the grasslands. In the forest we find two kinds of people: Pygmies, who are not completely black, and Negroes. The Pygmies hunt, the Negroes farm. The two exchange products. Since the Negroes make the arrowheads and nets with which the Pygmies hunt, the latter would have a hard time living without either these implements or the plantains which the Negroes give them for food. Furthermore, the food plants which the Negroes cultivate are of southeast Asiatic origin, and they could hardly have been introduced later than the first millennium B. C. Since southern India got iron during this same millennium, and the motive which brought people across the Indian Ocean to Africa was a search for iron, it is unlikely that the Negroes entered the forest to live much before the time of Christ. If we look at Melanesia we see again that the forest is poor in game, the principal animal being the pig, escaped from domestication. The pig came in with agriculture, and neither can have been introduced much before the first millennium B. C. Therefore, the present black-skinned populations of these two tropical forest areas must be historically recent; black skins go with grasslands or deserts and have entered forests in numbers only with agriculture. In the Belgian Congo the forest Negroes are decreasing in numbers while the Pygmy population remains constant. If we look back to the Pleistocene, we see that the glacial advances and retreats in the north were accompanied by a succession of pluvial and interpluvial periods in the Tropics. At least once the Sahara was blooming with grass and flowers, and at other times the forest was reduced to a fraction of its present area.

Why, one may ask, did not black skins develop in the Americas, where land within 10° of the Equator runs along a course of 4,000

miles? The answer, which is geographical, confirms our interpretation of black skins in the Old World. The coast of Ecuador is heavily forested. Open country begins at the Peruvian border, 4° south of the Equator, whence it continues to the forest zone of Chile. The coastal desert averages only 20 miles wide. Owing to the combination of the mountains behind and the cold Humboldt Current in front, the air is cool, the humidity high, the sky usually overcast, and little solar radiation gets through. Moving up into the highlands, we should expect a double concentration of UV at 10,000 feet, where one-sixth more solar radiation penetrates the atmosphere than at sea level. However, the region of Quito, which is on the Equator, is frequently cloudy; the year has two rainy peaks. Thunder, Brooks says (1930), is heard on 99 days each year. Since the air is also cold, the Indians cover up as much of their skin as possible. At 17° farther south, on the shores of Lake Titicaca, less rain and clouds appear, but the humidity is moderately high. Americans with untannable blond skins suffer intensely. The Indians, who wear broad-brimmed hats as well as the usual heavy clothing, tan to a deep reddish brown on exposed parts.

Moving eastward we find most of the Amazonian countryside heavily forested. Indians, Negroes, Whites, and all shades between get along with equal ease as far as UV is concerned. However, between the great river system in Brazil, the Guianas, and Venezuela are patches of savannah, precisely the kind of country in which black-skinned animals and men luxuriate in Africa. However, these patches are small and not long ago may have been smaller. They support no tempting animal life as in Africa, and the few Indians who go out there are refugees from the forests that line the streams. There is no evidence of any earlier population in this region at all. From all these considerations no reason appears for a black-skinned population to have developed in the Americas. The relative antiquity of man in the two hemispheres is therefore beside the point.

While Gloger's rule appears to cover variations in the response of the human skin to UV, both Bergmann's and Allen's rules are cut to fit the other end of the scale, radiant heat. Unlike UV, radiant heat both enters and leaves the body, which is physiologically well adapted to maintain an even temperature under extreme environmental conditions. Clothing, shelter, and fire also help, but not to the exclusion of physiological adaptation.

Bergmann's rule, that warm-blooded animals of a given polytypic species will be larger in the colder and smaller in the warmer portions of its ecological range, is based on the physical fact that the larger a body, all else, including shape, being equal, the smaller the ratio of skin surface area to bulk, one being a square, and the other a cube.

Since most of the heat loss comes through the skin, the larger the animal, all else being equal, the easier the process of keeping it warm. Other factors, some of which will be dealt with presently, enter into this picture, and if they and others still to be determined did not, it would be more than a rule.

The simplest test of Bergmann's rule is to compare mean body weight[3] of different human populations with climate as expressed by latitude. In Europe a regular cline is found between the peoples of the northwest, as the Irish with 157 pounds and the Finns with 154, down to the Spaniards with 132 and the racially white Berbers of Algeria with 124 pounds. In Asia the Mongoloid peoples show the same tendency, with the North Chinese weighing 142 and the Annamites 112 pounds, respectively. In America the Eastern Aleuts average 150 pounds, a level maintained by most of the Indians of the northern United States and Canada, while the Maya of Central America tip the scales at only 119 pounds. In South America weight rises with altitude and latitude to a peak among the bulky Indians of Patagonia and the grasslands of Tierra del Fuego. The equatorial Andamanese weighed only 98 pounds, the Kalahari Bushmen 89. The Baluba, a non-Pygmy Negro tribe of the Belgian Congo, average only 118 pounds, which seems to be par for tropical rain forests. In Polynesia, where offshore breezes make heat loss no problem, weights are high, as they are in cool New Zealand. Polynesian figures range from 140 pounds upward. Indonesians, to whom Polynesians are supposed to be related, are 20 to 30 pounds lighter. Their islands are hotter.

It can be easily demonstrated that changes in body size may take place in a single generation. Whatever genetic mechanisms control weight permit a useful capacity for variation. Man's size is as plastic as his tannable skin color and as automatically regulated. Anyone who has visited the Lower Amazon country has seen that the Brazilian citizens in that tropical forest are of one size, whatever their hair form, skin color, or cast of facial features. At least three racial stocks are concerned, the Mediterranean, Negro, and American Indian. All come out the same size. Farther south representatives of these same three stocks are much larger.

One other environmental factor affects body size, causing different populations within a given climatic zone to vary within their limits of tolerance. That is nutrition. In my North Albanian series (Coon, 1950) I found that the tribesmen living on food raised on granitic soil were significantly smaller than those who walked over limestone, thus confirming the results of French investigators more than half

[3] Baker, 1953; Coon, 1939; Hiernaux, 1952; Hooton, 1928; Howells, 1937; Russell W. Newman, 1952b; Rodahl and Edwards, 1952; Weidenreich, 1943.

a century earlier. Trace elements are important, and so are feeding habits. In a Moroccan village studied by Schorger (Ph. D. thesis) the boys were given almost no meat until they reached the age of 14, at which time they were expected to work. From then on they ate with the men, whose diet included animal proteins. At that point their growth was relatively rapid. A main diet of polished rice goes with small people; we do not know how big they would have been if they had eaten other foods in a hot climate.

Most striking of all the size differences in man are those between the Pygmy peoples of Africa, the Indian Ocean countries, Indonesia and Melanesia, and normal human beings. However, the Pygmies are not much smaller than some of the people of the Amazon Valley. In all these selvas the leaching of the soil through excessive rainfall is held responsible, through the agency of washing out of trace elements. But man is not the only pygmy in the forest. In Africa the elephant, hippopotamus, buffalo, and chimpanzee all have pygmy counterparts. What affects man there cannot be cultural; it is of universal mammalian application, since the animals mentioned eat the whole range of available foodstuffs and are exposed to the same range of temperature, humidity, and solar radiation.

Along with size comes the question of basal metabolism. Although questions have arisen about coordinating techniques, still the geographical distribution of the results follows a Bergmannian pattern (Wilson, 1945). The norm is set for Europe and the northeastern United States; rates more than 10 percent above normal are found among the Eskimo, who reach 30 percent of excess, the Ojibwa Indians of the Great Lakes region, and the Araucanians of southern Chile. Rates 10 percent and more below the norm are found among Australian aborigines and inhabitants of the hotter parts of India, Australia, and Brazil. Americans in New Orleans are also below par. This needs a lot of checking and controlling, but despite two exceptions[4] the trend is clear. Furthermore, like alterations of pigment and gross size, changes in basal metabolism can in some cases be acquired.

That basal metabolism should change with climate makes sense, as does the whole mechanism of heat control in man. Here we enter a field where many physiologists have brutalized themselves and their friends for the sake of science; one investigator writes that he and his team even took the rectal temperatures of porcupines in the Talkeetna Mountains of Alaska at −22° F. (Irving, 1951, p. 543). Others thrust thermocouples into their own flesh, piercing their palms and wrists to the depth of the bone. Still others consented to be locked in sealed chambers from which heat and oxygen, alternately, were withdrawn, while a few pedaled themselves nearly to death on bicycles. As a

[4] Italians and Somalis in Italian Somaliland; see Wilson, op. cit.

result of this self-sacrifice we are in a position to evaluate Allen's rule in man.

Being a warm-blooded animal is a great advantage. It permits one to move and act at nearly all times in nearly all places, instead of scampering feverishly for shade or waiting for the chill to burn off before moving. However, the process of keeping the internal organs at a temperature of 98.6° F. has its problems too. This temperature can fall to 77° F. or rise to 110° F. before death intervenes, but variations of half these magnitudes are serious, particularly on the high side, for man can lose heat more safely that he can gain it. Even when he is trying to keep warm, man loses a certain amount of heat functionally in evaporation of moisture through the palms, soles, axillae, and pubic regions, just to keep tactile and hinge areas ready for action.

As long as the temperature of the outside environment is below 83° F., the body normally loses heat by radiation and convection. At 83° F. it begins to sweat, and the surface of the body grows increasingly moist, until at 93° F., in a saturated atmosphere, the whole body is covered, water is dripping off the surface, and the perspiration fails to do its work, which is to cool the surface of the skin by evaporation. At this point, if the temperature rises without a drop in humidity, trouble is near. However, in dry air only 40 percent of the body surface is normally wet at 93° F.; at blood temperature the ratio is 50 percent, and a complete coverage, in the American human guinea pig, is not attained until 106° F.[5]

The evaporation of sweat is the principal means by which the body loses its radiant heat. Experiments have shown that a resting man at 122° F. and a humidity of 44 percent will lose 1,798 grams of sweat per hour; a working man, in a humidity of 35.6 percent saturation, will lose 3,880 grams per half hour, or half his normal blood volume, at a cooling potential of 25 to 30 times the normal resting metabolism. Needless to say such a liquid turnover requires him to drink gallons of water and also taxes his heart. It is greatly to the advantage of human beings living under conditions of extreme heat to avoid this circumstance as much as possible.

Such heat is found largely in the deserts of the world,[6] which lie on either side of the Equator, on the Tropics of Cancer and Capricorn. Chief among them are the Sahara, the Arabian, Persian, Thar, Kalahari, Australian, Argentine, Chilean, and Colorado Deserts. Of these the Turkestan, Gobi, Argentine, and Colorado Deserts lie farthest from the Equator. Characteristic of deserts is a great diurnal variation in temperature, and often a seasonal one as well. On a hot day

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[5] Bazett, 1949; Best and Taylor, 1948; Day, 1949; Hardy, 1949; Herrington, 1949; Robinson, 1949; Spealman, 1949a.

[6] Adolph, 1947; Brooks, 1930; Buxton, 1923.

the mercury may fall to 71° F. at 5 a. m., reach the critical sweating point of 93° F. at 10:15 a. m., hit a peak of 108° F. at 2 p. m., and fall to 93° F. again at 7:45 p. m. A hunter, who has nothing to work with but his own body and a bow and arrows or a handful of spears, will be up before daylight, and he will be on his way by the time the coolest point of the daily cycle will have been reached. He will be able to go out to his hunting ground before the heat bothers him, and if he is lucky he can make his kill early and take his time on the way home before or during the heat of the day. If he is on a 2- or 3-day hunting trip, he can nap under a bush in siesta time, and return on another morning. An Arab who is herding camels or conducting a caravan will travel by the light of the moon and stars and sleep under a lightproof black tent in the middle of the afternoon. In Middle Eastern desert countries even truck drivers prefer to work at night, to save their tires as well as their own systems. If forced to do so, a desert-dwelling human being can walk in the heat of the day, but if he confines his traveling to the nighttime he can go three times as far, without water, before collapsing.

Animals that live in the desert belong to two classes, those that can do without water and those that use it to cool the body through evaporation. The first category includes especially a number of rodents, which derive water from desert vegetation and can even extract it metabolically from dry seeds. Such animals have no water to spare; they hide behind or under rocks or bushes during the heat of the day, or burrow far underground, in some cases pulling stoppers of earth in behind them. When the surface ground temperature is 122° F. it may be only 83° at a depth of 1 foot 3 inches, while at 6 feet it may fall as low as 68° F., with considerable humidity. Animals that hide during the day to save water will die when forced to spend a few hours in the bright sun in the heat of the day.

The other class of animals is composed of larger forms, such as the camel, oryx, and addax, which are able to hold up to a fifth of their body bulk in stored water and to utilize it gradually. In this sense they are no better off than a man weighing 120 pounds carrying a 5-quart canteen. In cool spring weather they are at an advantage over the man, however, for they can derive their moisture from herbage; only in the hot and barren season do they depend on their speed to carry them to water. In addition to their water-holding capacity, these animals have something else in common. They all have long legs and necks and are extremely gracile for their weight. Their bones are long, fine, and hard; their musculature light. In treeless country they can make high speeds. Even the cat family has its desert representative, the long-legged cheetah, which is said to be the fastest runner of all living things.

Man in the desert is also light and gracile. He too needs to be able to travel far on a small heat load. But his animal companions have buff-colored hairy coats, which reflect solar light; it is unlikely that they lose their heat in this fashion. Man must lose it through his skin surface, and the more surface he has per unit of weight the better. The more he can lose through radiation and convection the less he has to sweat, and the more skin surface he can use for evaporation the higher the temperature he can stand. The smaller his bulk, the less the load on his heart. The shape of his body takes on added importance as we realize that all parts of its surface do not lose heat equally. The back of his hand has about 400 sweat glands to the square centimeter, the forehead 200, and the cheek as few as 50. The hands, which comprise 5 percent of the body surface on normal Americans, lose 20 percent of the heat of the body by evaporation (Bazett, 1949, p. 131).

When a man begins to perspire, moisture appears first on his forehead, neck, some of the larger areas on the front and back of his trunk, the back of the hand, and the adjacent part of the forearm. The head and neck must lose heat rapidly for they have the brain to keep in thermal equilibrium, and if the head is globular in form, it has the worst possible shape for heat loss. Old World hot-desert peoples are narrow headed. After this the cheek, the lateral surfaces of the trunk, and the rest of the extremity surfaces begin, but these regions sweat much less. Sweating is always slight to moderate on areas rich in subcutaneous fat, such as the cheek and the gluteal and mammary regions. The inside of the thighs and armpits sweat even less, since they face in and not out and are in a poor position for heat loss. The palms and soles, which perspire at lower temperatures, lose the least of all in periods of stress.

The chief burdens then are on the neck and head, which have purely local duties, and on the hands and forearms, which act as radiators for the whole body. It has been shown that the average human body (American) loses heat after the fashion of a cylinder averaging 7 cm. in diameter (Hardy, 1949, p. 97). While the head and trunk are bulkier than this, the forearms and hands resemble even smaller cylinders, and the fingers and toes even smaller yet. Now heat loss increases as the square of the diameter of the cylinder decreases. Hence the survival value of long, tapering forearms and fingers in a dry, hot place becomes self-evident.

One of the racial pecularities of Negroes is long arms, with particular emphasis on the length of the forearm, and large hands with long fingers. Forest Negroes often have relatively short legs, but we have seen that the legs have much less to do with heat regulation

than the arms. The Nilotics and Somalis and Masai and other black-skinned peoples of the Sahara, Sudan, and the Horn of Africa have long skinny legs and long gracile necks; no case of adaptation to a given environmental situation could be clearer. The same is true of South Indians, Ceylonese Vedda, most Melanesians, and the Australian aborigines of the desert, as well as of white Australians from Queensland. The Bushman of the Kalahari is extremely slender; of the inhabitants of the American deserts information is defective. At any rate, as far as we know, the desert portion of Allen's rule holds for man, for obvious reasons. The mechanism of change is less obvious.

The other end of Allen's rule applies to adaptation to cold. Naked savages can live without much clothing in temperatures down to the freezing point. Several technical experiments have been performed on Australian aborigines sleeping naked in the desert when the night temperature fell to the frost point (Wulsin, 1948). These people keep rows of small fires burning and sleep between rows. Parts of their skin surface becomes quite cold, others hot. They seem to be able to absorb radiant heat from the fires on some parts of their skin surface in all of which the venous blood is at a minimum. Thus they survive until morning. In the daytime the air temperature rises rapidly.

The Yaghans (Hooton, 1928; Wulsin, 1948), canoe Indians of Tierra del Fuego, paddle nearly naked in their boats in foggy channels, in an environment where year-round temperatures hover above and about the freezing point. Darwin saw a naked woman nurse a naked baby while sleet melted on her body, and a group of Yaghans who drew up to the outer glow of the explorers' fire sweated profusely. The Ona, foot Indians of the plains on the northern part of the island, wore guanaco skin robes and moccasins, and slept behind skin windbreaks in the snow. The Chukchi of Siberia, who wear Eskimo-style clothing, like to remove their shirts to cool off, and Bogoras saw Chukchi women thrust lumps of snow between their breasts for the same purpose.

The mechanism of heat loss in cold conditions will explain this. When the environmental temperature falls the body stops sweating at 83° F., and heat loss is accomplished wholly by radiation and convection. Venous blood, which has been returning from the back of the hand through superficial blood vessels on the arm, is rerouted; vasoconstriction shuts off this road, and vasodilation opens alternate channels through deep-lying veins which surround the artery. The chilled venous blood returning to the heart cools the arterial blood, so that it will have less heat to lose, and the heat gained by the venous blood is carried to the heart. Thus heat loss through the hand and

arm is reduced to but 1.5 percent of the body's total at higher temperatures. The amount of blood that flows through 100 cc. of fingertip tissue falls from a maximum of 120 cc. to 0.2 cc. per minute (Day, 1949). The arm itself becomes an insulator in depth.

At an air temperature of 73° F. a naked American with a rectal temperature of 97° will show the following skin temperatures: head, 94°; trunk, 93°; hands, 86°; feet, 77°. Deep thermocouple work has shown that the hands and wrists chill to the bone literally. However, when the temperature of the extremities falls below a point between 41° and 50° F., vasoconstriction ceases, and peripheral bloodflow is accelerated, to keep the extremities from freezing (Spealman, 1949a, p. 236). What this means racially is that a person of north European ancestry can afford to have big bony hands which help keep him cool in hot weather, because at the winter temperatures at which he operates, particularly when clothed, the size of his hands makes no difference in heat economy; they are simply shut off from the heat system, like an empty room.

It is a matter of casual observance that most Mongoloids have small and delicate hands and feet, short distal segments of both upper and lower limbs, and short necks. However, recent studies of the Eskimo have shown that despite expectation these people have large hands (Rodahl and Edwards, 1952). It is believed, although the material proving this has not yet been published, that racial differences in venous patterns exist, which would account for the Eskimo hand as well as for the ability of the Australian aborigine to sleep in the cold without clothing.

Turning to the Eskimo foot, which is small as expected, it is common knowledge that his excellent boot keeps this extremity warm, as long as it is dry. Water can leak in through the stitch holes if the sinew is not preswollen (Spealman, 1949b; Wulsin, 1948), and it can also come from sweat induced through exertion. A wet boot affords little insulation, and some Eskimos freeze their toes. Similarly the hand is here a liability; as Quartermaster Corps researchers have shown, it is almost impossible to keep a hand warm in the best of mittens when the body is at rest outdoors in very low temperatures (Belding, 1949; Van Dilla, Day, and Siple, 1949, p. 384). Eskimos bring their arms and hands in next to the body skin, leaving sleeves dangling, when they can.

Ears, nose tips, and other protrusions need special protection; with the fall of the glass the amount of blood sent to the ears increases greatly, and a relatively great loss occurs at this vulnerable point. Polar and subpolar peoples are invariably described, in the prime of the individual, as being well equipped with subcutaneous fat. This fat is especially well developed on critical spots, such as the cheek,

wrist, and ankles. One centimeter of fat is given the same insulation rating as a complete suit of winter clothing (Bazett, 1949, p. 145). The healthy Negro living in a hot country carries almost no subcutaneous fat. His superior performance in the desert, compared to Whites of the same age and weight, has been demonstrated (Baker, 1953).

In summary, adjustment to the cold requires large body mass, short extremities, much fat, deep vein routing, a high basal metabolism, or some combination of these five features. Adjustment to the heat requires small body mass, attenuated extremities, little fat, extensive superficial vein routing, a low basal metabolism, and a greater number of sweat glands per unit of surface area. Possibly the role of melanin in starting the skin to sweat at a lower threshold by conversion of UV to radiant heat may be added. Any combination of these seven may be involved. The type or types of physique most suited to cold resistance are exactly those which, the doctors tell us, are most likely to suffer from heart trouble, and so it is a lucky thing that adjustment to the cold does not place an extra load on the heart. Heat-adapted physiques are those best calculated to stand the extra heart load, which they receive.

So far we have been thinking about heat loss from the skin, but calories also leave the body through the lungs. In hot weather the heat loss from the lungs through respiration is negligible and of little help to the suffering organism, but as the mercury drops this source of leakage becomes serious, reaching 50 kg. calories per 1,000 liters of expired air in extreme cold (Irving, 1951). Not only does this affect the total heat load of the body, but it subjects the nasal passages to heavy chilling. To what extent the Mongoloid face, inside and out, may compensate for this by its special architecture remains to be discovered.

One other climatic hazard which human beings have faced and overcome is that of reduced oxygen at high altitudes. Dill (1938) and his associates have found that the inhabitants of the Andes have become able to live and work at 17,500 feet and more, through the fact that their blood carries a much higher concentration of red corpuscles than of people at sea level. At the same time they need more air, which they obtain through more efficient automatic breathing control as well as the larger lungs. The requirements for physique in high altitude resemble those for cold. Perhaps it is no coincidence that the two great high-altitude plateaus of the world, the Andean and the Tibetan, are inhabited by Mongoloid peoples who greatly resemble each other.

This paper does not pretend to cover, even in outline, all the more obvious adaptive variations in man in the fields of color, size, and

form. No attempt has been made to deal with the eye or the hair. Little attention has been paid to genetics, in the belief that before we can discover the biological techniques by which a set of variations is inherited we should first describe the variations themselves. Since blood groups are believed to be nonadaptive, they have been temporarily ignored.

Since I started this racial heresy in 1946, when I wrote the first draft of what was to be expanded into the book "Races," with the help of Garn and Birdsell, many others who possess special technical skills, and whose interests are focused in other than purely racial channels, have been working on important aspects of the problem. Garn is conducting experiments with metabolism and body heat at the Fels Institute, Yellow Springs. Ancel Keys and Josef Brožek, in Minneapolis, have independently studied the basic components of the human body, with special emphasis on its fat content. Russell Newman, Phillip Wedgewood, and Paul Baker have been devising techniques for the same purpose in Lawrence, Mass., and conducting interracial studies of physiological tolerance for the Armed Forces. Various other Army and Air Force scientists, and their Canadian colleagues, have been working on basic differences in anatomy and physiology between Eskimos, Indians, Whites, and Negroes.

Our subject is acquiring dignity, and results are being produced. We are now on the road to learning the basic facts about race in man, facts of which no one should be proud or ashamed. In an atom-age world in which men of all races are coming into increasing contact with one another on a basis of equality and cooperation, a knowledge of what a wonderfully adaptive thing the human body is, is a much healthier commodity than the recently traditional hide-race point of view.

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Vegetation Management for Rights-of-Way and Roadsides

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[With 6 plates]

In the short time of less than a decade, a totally new field of vegetation management, that concerned with rights-of-way and roadsides, shows signs of being born as an integrated division of land management. It is the purpose of this paper to discuss some of the problems of managing this type of vegetation and especially to assess the value of herbicides when used as a "tool" in this management.

VEGETATION MANAGEMENT—WHAT IT IS

"Vegetation," a technical term used to refer to natural and semi-natural complexes of plant communities, is the subject of scientific investigation by numerous groups. "Management" is commonly used where manipulation for practical ends is involved. For purposes of orientation, we use the phrase "vegetation management" to refer collectively to the principles and practices of all these groups. On the practical side, this includes forestry, range and pasture management, wildlife management, soil conservation, and watershed management, each with its own body of data, and each often developed independently of the others. On the academic side, we have the various disciplines of plant ecology, phytosociology, geobotany, and many other realms.

THE ROADSIDES AND THE RIGHTS-OF-WAY

Most people are only subconsciously aware of roadsides and rights-of-way. To them the world consists of cities, with their industrial and residential areas, and of "country," with forests and grasslands and croplands. But gradually a new type of acreage is becoming

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manifest in our national economy—narrow strips that we cannot get away from. They hem us in on every automobile and train ride. They are with us even when we stay at home, for our telephone service involves the rights-of-way of toll lines as well as roadside distribution lines, and each electrical appliance we use involves mammoth transmission lines, as well as those for local distribution. Roadways, railways, and utility lines are thus lacing our country with superposed patterns of ever-increasing complexity. What does all this amount to, acreage-wise? No one knows, for no agency has ever made a reasonable survey. One utility in a New England State claims it has 600 miles of transmission lines and 6,000 miles of distribution lines. The average power company frequently has over 15,000 acres in rights-of-way. The State of Ohio has over 16,000 miles of State highways and over 70,000 miles of secondary roads, involving together 330,000 roadside acres, more than all State-owned forest land. Iowa has 427,000 acres of secondary roads alone, comprising a greater acreage than the largest county in the State. It is not unreasonable to assume that there are 20 million acres of roadsides and rights-of-way, not including those of the railroads, in the eastern forested areas of the United States. It is this land with which we are concerned in this article. Possessing high values for the public and for the Nation in addition to its immediate use, such tracts can be managed for multiple purposes or they can be subjected to practices detrimental to their owners as well as to the public. Each of these types of land has its own special problems.

ROADSIDES

A roadway may be defined as the roadbed itself, flanked by several parallel belts that have different functions, depending on what use is to be made of the highway. Adjacent to the paved or traveled part is a bare, oiled or grassed shoulder 5 to 10 feet wide. At the far side of this is generally a ditch for drainage. Beyond is a 5- to 15-foot strip, which is mowed once or twice a year. And farthest from the road is a strip 10 to 20 or more feet wide, which is not mowed and which often bears telephone and power lines. In addition, there are poles, posts, and signs, immediately adjacent to which no vegetation is wanted and treatment for which is beyond the scope of this discussion.

The mowed strip offers no serious problems. It rarely has any woody brush on it. The very process of mowing, perhaps by removing what would otherwise be a heavy mulch of dead grass, seems to favor the growth of colorful flowers. In many parts of the country these are the brightest parts of the landscape, and the succession of flowering forms is a never-ending delight through the seasons, from the first bloodroots to the last asters. Strange as it may seem, some

of these strips have been indiscriminately sprayed, with a consequent loss of almost all these wildflowers.

It is the unmowed strip that offers excellent opportunities for rational management techniques. Basically, it must satisfy the needs of the highway departments. The needs involve the elements of *traffic safety*, mainly visibility along the line of travel, especially around curves and at intersections. Locally there is the problem of *snow fences*, for which shrubs are valuable in some places but unwanted in others. Not of minor importance is the matter of *fire hazard*, especially since Americans have developed the habit of flinging lighted cigarettes from their cars. All plant life is flammable in times of extreme drought; at other times fire hazards depend

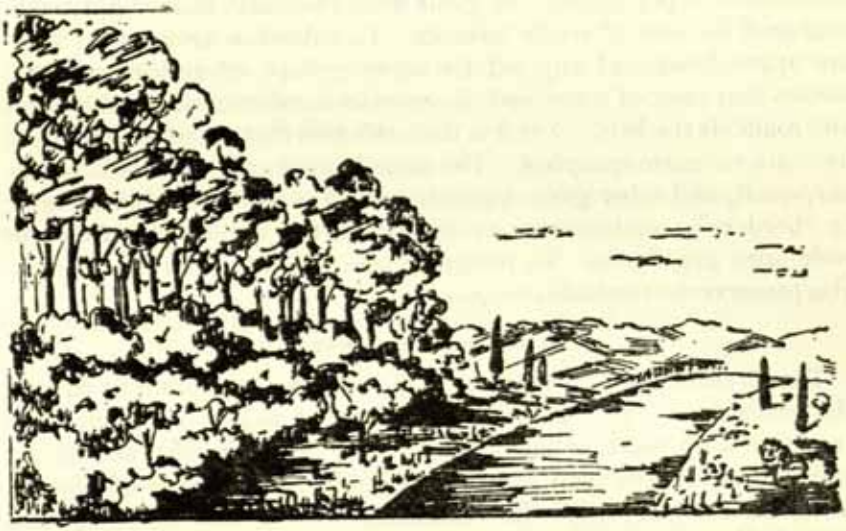


FIGURE 1.—Generalized view of roadside vegetation, showing the shrub border at the left with plants of ornamental and wildlife values. These are the plants that are needlessly destroyed by indiscriminate spraying. (Drawn by W. Thayer Chase.)

on the relative flammability of the different plant communities. In general, grasslands have a far greater flammability than other types of vegetation. Unnecessary spraying, which produces these very grasslands, should therefore not be permitted along highways where the fire hazard is great. In addition to these primary factors in roadside management, there are others which are significant in their public-relations values. Both *noxious weeds* and *insect pests* present local problems that must be solved independently, either by the adjacent landowner or the highway agency. Herbicides are of value in removing such plants as ragweed (though if the soil is left bare, ragweed will probably return, to make more business for the sprayer).

They are also of value in removing vegetation which harbors destructive insects. Nevertheless each plant, each insect, demands a separate decision. As in the field of human medicine, there is no panacea for all diseases. From another point of view, *ornamental values* rank high in roadside management, and most State departments now have their own landscape divisions, often involved in planting shrubs in strategic places along the roadways. It has sometimes seemed inconsistent therefore to find miles and miles of laurels, viburnums, azaleas, blueberries, cornels, and other brightly flowering shrubs destroyed.

Finally we have the *wildlife values*. The question of the preservation or destruction of wildlife cannot be decided arbitrarily. Each highway has its own wildlife problems. On major arteries and near the centers of population, big game quite obviously should not be encouraged because of traffic hazards. In suburban areas, song birds are appreciated and enjoyed by many groups of residents. It is known that most of these birds increase in number in the crop borders and roadside thickets. Yet it is these thickets that are often destroyed by indiscriminate spraying. The same habitats foster grouse, pheasant, quail, and other game animals. Most wildlife inhabits "edges" or "borders"—combinations of vegetation types, not solid forest or wide-open grasslands. To preserve these wildlife habitats, we must also preserve the roadside thickets.

RAILROAD RIGHTS-OF-WAY

The situation along railroads is in many ways similar to that of the roadsides. The vegetation to be treated parallels a high-speed transportation route, so that the procedure can be highly mechanized and uncostly. The land can be segregated into a series of parallel belts, for each of which the fundamental needs are different. The stone ballast surrounding the rails and ties must remain free of all vegetation, to insure quick drainage. Likewise, strips a few feet wide on each side of this should remain clear of plants. The rest of the right-of-way, often involving side strips up to 50 feet wide, can remain in plants, but of a low-growing variety. For lines using steam locomotives, the fire hazard is a factor.

POWER AND TELEPHONE RIGHTS-OF-WAY

The cross-country rights-of-way of these public utilities differ in important respects from the two preceding. Usually, the only routes they parallel are those of the crow. Sometimes, as in southern West Virginia, the lines leap from crest to crest, and progression under them is all but impossible, for either man or mule.

Telephone toll lines are generally only 40 or 50 feet wide. Power transmission lines are usually 100 feet wide but may be as much as

250 feet wide. In all these, we have a parallel series of belts, each of which has its own function for the utility. At or near the center of the right-of-way is a foot trail, for patrol and inspection. Under the wires, in a belt 25 to 40 feet wide, the vegetation should be low—about 2 feet—or with isolated higher shrubs of such a nature as not to hinder entry for emergency reconstruction and repair. The sides of the right-of-way, with a minimum width of 25 feet, serve only indirectly. They exist for controlling trees that would grow upward or sidewise into the wires, that would contact the wires when they swing outward in strong winds, or that would fall into the wires. Furthermore, in the sense that the sides are lower than the adjacent forest, they serve to demarcate and perpetuate property lines, indicating the area under the jurisdiction of the utility.

With these limitations it can be seen that the vegetation that can be tolerated on such a right-of-way would have an ultimately valley-shaped cross section. It so happens that such a cross section involves a maximum amount of the border effects and edges mentioned above as being the optimum wildlife habitat. Thus wildlife conservationists and sportsmen, were they to gain the cooperation of the utilities, could, without expending any extra money, add more game-producing acreage to the country than now exists.

GAS-PIPE LINES

The building of gas-pipe lines has been extended enormously within the last few years. These relatively narrow rights-of-way differ in several very important respects from all the preceding. In the laying of the pipe, the land is laid bare and is thus subject to initial invasion by all kinds of plants, including trees. Most of these lines have been recently laid, and invading brush has not reached sufficient proportions to become a problem to the companies owning the lines. Furthermore, patrol is often aerial, leaks in the line being indicated by discolored vegetation; and entry for repair is by heavy mechanized equipment. For all these reasons, no concern has yet been expressed for the management of vegetation on the lines. Even if the pipeline companies have not shown interest, it would be reasonable for wildlife managers to undertake the modification of these areas for their own purposes, since the major expense, that of forest removal, has already been effected.

HERBICIDES FOR BRUSH CONTROL

Let it be said first that the use of herbicides is not the cheapest means of brush control. Cropping, grazing, and burning are techniques that should take precedence whenever and wherever possible. Nevertheless such management practices are feasible only on a very minor part of the rights-of-way considered in this discussion.

I do not know who claims first honors for using herbicides for brush control. Probably even the Greeks did not overlook the possibility (as earlier races must have), for it would take no great powers of observation to note that storm floods of salt water would kill plants; and such an observation might be expected to result in the purposeful use of crystals from evaporated ocean water, either for the destruction of unwanted weeds on one's own land, or of the crops of one's enemies. Modern herbicides have been developed from research in certain hormone and growth-stimulating substances. When it was found that a few of these chemicals applied in relatively concentrated dosages would be lethal, a new industry was born. Compounds related to 2,4-dichlorophenoxy acetic acid, because of their effect on broad-leaved herbs but not on grasses, were quickly adopted for lawn management.

In the winter of 1945–46, I gave my first consideration to the use of herbicides for brush control. At that time I located but one published reference to effects on a few woody species, and these only on a small scale. At least one manufacturer had been applying herbicides the previous summer on a pilot-plant basis, but no data were available. From then on, the activity has mushroomed like an exploding atom bomb.

CHEMICALS

Chemically, the materials now mostly used are derivatives of both 2,4-dichlorophenoxy acetic acid (2,4-D) and 2,4,5-trichlorophenoxy acetic acid (2,4,5-T). The latter was found effective against certain species, especially blackberry, for which 2,4-D was useless. Now various mixtures of D and T, or T alone, are promoted. Salts, amines, and the acids themselves have yielded their place to esters. The original esters were methyl, ethyl, butyl, propyl, and other so-called "high-volatility" compounds. Because of extraordinary damage suits, following destruction of such sensitive crop species as tomatoes, cotton, and grapes, industry developed the so-called "low-volatility" esters. These have complex organic radicals, one of which is a polyethylene glycol butyl ether group.

In addition to 2,4-D and 2,4,5-T, ammonium sulfamate is widely advertised and frequently used. This chemical, corrosive to metal and thus presenting problems of its own, is dissolved in water and applied blanketwise as a foliage spray. The cost for one spray is considerably more than for a single foliage D-T spray, but the effects are said to be the equivalent of two or more such D-T sprays. This chemical is relatively unsuccessful in killing the roots of certain root-suckering woody plants, and the results of spraying the herbaceous areas, some becoming predominantly grasses and others forbs, vary erratically. Since botanical analyses have never been made of the pre-sprayed vegetation, it is difficult to estimate the amount of destruction

to desirable plants. Ammate is also applied in powder form to cups notched in the bases of trees. Although this practice has been adopted for control of weed trees in timber forests, it is relatively unusable on rights-of-way, where the individual stems are usually too small for cupping. Stump treatment on rights-of-way where the forest has been newly cut is another possibility, but here also comparative data with D-T treatments are lacking.

SPRAYING

Techniques of D-T spraying are sharply divided into opposing groups. There is dormant-season vs. growing-season spraying; pack-sack vs. power spraying; blanket spraying vs. selective spraying; and foliage vs. basal spraying. Most treatments are either (1) summer foliage blanket-power spraying, or (2) winter basal selective pack-sack spraying. Neither of these is a panacea for all ills, but both have their roles. Nevertheless, it is the former which, though giving relative relief from the high costs of hand-cutting and showing quick visual results, is unsupported by impartial vegetation-management data; whereas the latter is primarily responsible for results that point to the lowest long-term costs and the highest public benefits.

Foliage spraying involves large quantities of spray mixture (100 to 250 or more gallons per acre) at relatively low concentrations (in ratios of 1 part of commercial chemical, at 4 pounds acid equivalent per gallon, to 99 parts of solute, usually water). The actual physiological action on the plant is unknown. At one time it was widely believed that the chemical is absorbed through the leaves and then moves down through the stems and into the roots, to kill the entire plant. This theory had its origin in university studies indicating a downward movement from the cotyledons of herbaceous seedlings grown in greenhouses. Nevertheless all field evidence, except in a very few anomalous situations, indicates no downward movement in the stems of mature woody plants. The only (unpublished) study attempting to find traces of the chemical at significant distances in the roots was negative; and other studies indicate that the chemical disintegrates in the leaves and never moves out of them. The kill-to-ground effects of foliage spraying may be due in part to the chemical that accidentally gets on the stems. In any event, the effects of foliage spraying are rapid and striking. Within a week the foliage begins to turn color and soon browns to a crisp. By the next spring all woody plants and broad-leaved herbs appear dead; only the grasses survive (if there were grasses to begin with; otherwise the land is bare and may remain bare of grasses). In the second year those same root systems usually resprout, and in 2 years may be as high as 5 or 6 years of growth preceding spraying. It is true that three or four annual

sprays may possibly root-kill these plants, but such costs are prohibitive. I myself worked with foliage sprays in 1946, 1947, 1948, and 1949, and then gave them up, for though I was getting good kill-to-ground results, I was not getting root-kill on enough species. Despite these disadvantages, the very striking photogenic effects of these sprays, the over-all browning of the foliage, and the clean and neat-looking grassland the year after have all served to sell the treatment on many thousand acres.

Basal spraying involves small quantities of spray mixture (averaging between 10 and 50 gallons per acre) at relatively high concentrations (in ratios of 1 part of commercial chemical to 20, 40, or more parts of solute, usually oil). Application is generally by 5-gallon pack-sack sprayers, equipped with special nozzles. Attempts to use power equipment, either to cut costs or to avoid using human labor, have not yet been satisfactory, either in the degree of kill obtained or in the selectivity and gallonages used. Actually, the technique of application is of considerable importance, for the basal bark must not only be wetted, but soaked thoroughly for extensive rundown. This rundown (downward movement within bark or wood is apparently negligible) affects the crown collar, the source of future resprouting, although in field practice such an aim may be thwarted by deposition of soil, stones, logs, or leaves around the base of the plant.

Again, the physiological effects on the plant of this spraying are not known. Two separate phenomena seem to be involved. The first is an upward movement of chemical through the wood. This movement is evidenced in the field by a relatively early top kill, followed by kill progressively downward. The second may possibly be related to a chemical ringing, without chemical top-poisoning. In this instance, effect is deferred often for a full season. Then the entire foliage of the tree, from top to bottom, uniformly turns yellow and dries. In this deferred killing resprouting seems less likely to occur than in the more rapid top-poisoning, and there is thus an implication—though unsupported at present by any research data—that if chemical ringing does take place, it may be the roots that die first by starvation. In any event, basal spraying requires a patient and understanding client.

The spraying is usually done in winter. When spring comes the buds may burst and the plant may grow vigorously through to midsummer. Only then may the leaves begin to curl and the plant show signs of dying. By fall, kill-to-ground may or may not be complete, depending on the adequacy of the spraying and other as yet uncontrollable factors. Ultimate kill-to-ground may not occur until the end of the second growing season, and instances are known where the tree died in the fourth year, though appearing perfectly healthy in the preceding years. To make the situation more exasperating, resprouting may occur, sometimes abundantly. If the root collar was

not adequately soaked, the sprouts may survive and require respraying when they become larger. Sometimes they will die of their own accord, either in the second or third year. Very frequently such resprouts will appear after complete dormancy through one entire growing season. They have been observed to die without further spraying, either from continued effects of the chemical or secondary fungal decay. Needless to say, these delayed effects and aftereffects, both for basal spraying and foliage spraying, make any rational comparison of the two systems a matter involving several years, even though the bulk of the industry and trade literature gives glowing descriptions of situations one year after treatment.

From the standpoint of spraying, all woody species may be segregated into the *stumpsprouters* (sprouting from the base of the original stump) and the *rootsuckerers* (sprouting from the roots, at some distance from the treated stump). The stumpsprouters, including the maples, almost all the oaks, and numerous others, offer relatively few problems, if the crown collar can be soaked. The basswoods are probably the most resistant, with completely green foliage even two seasons after spraying. Nevertheless, in some of these instances the basal cambium was found to be entirely dead, and it is believed that such individuals will die from root starvation. The ashes, especially white ash, are also unusually resistant, but heavy applications seem to be effective.

The rootsuckerers give the most trouble, and this very fact indicates that the chemical or its effect does not readily pass into the roots. Kill-to-ground is easily obtained both by basal and by foliage spraying, but the resprouting may result in a greater number of stems per unit area than before the spraying. The species here involved are blackberry, sassafras, black locust, tree of heaven, and trembling aspen, as well as the sumacs. Since these are all species of abandoned agricultural lands, they can be locally predominant and demand radical alterations in any program of vegetation management. Although apparently complete root-kill of staghorn sumac has been observed at the time of this writing (October 1953) from a commercial spraying in January 1952, such a situation is anomalous. On the other hand, experiment-station tests on aspen in the Lake States, based on data taken for growing seasons after treatment, indicate that the only treatments in which basal spraying does not result in rootsuckering are those applied in late June, July, and August. These data are in accord with an as yet incompleted experiment on staghorn sumac, also dating from 1950, in Colebrook, Conn.

Of all the factors involved in successful basal spraying, the most important single variable seems to be that of qualified personnel. Several skills are involved. Not only must the bark be adequately soaked, but decisions must be made concerning snow depth and rain, which

affect adequate bark absorption. In addition, the person doing the spraying must be able to recognize plant species, for unnecessary spraying of permissible shrubs not only needlessly increases present costs but may increase future costs by allowing new trees to reinvade those spots. Knowledge of such factors as concentration of chemical used, type of oil solute, kind and combination of esters, season of treatment, soil moisture conditions, and products of different manufacturers are also important.

This discussion of herbicides for brush control has until now purposely been restricted to the effects on certain plant species, mainly trees. One must not forget, however, that the vegetation of rights-of-way is not composed only of unwanted trees and wanted grass: it is an infinitely complex assemblage of plant communities, each composed of various grasses, forbs (herbaceous plants, not grasses), ferns, shrubs, and trees. These communities vary regionally, according to floristic area, climate, soil, fauna, and human history. The problem is far more than one of "brush" and "grass." It is a problem for the plant ecologist who understands the ramifications of these plant communities, rather than for the contractor or maintenance engineer whose objective is simply to destroy the brush in order to get grass to beautify the right-of-way. The rest of this paper will deal with certain phases of vegetation science that apply to the problem at hand.

SOME PRINCIPLES OF VEGETATION DEVELOPMENT

In forested regions of the globe, all new or disturbed areas tend to progress, in a predictable or unpredictable manner and more or less quickly, to some forest type. In academic lingo, this is "plant succession"—a very unsatisfactory term, for the word "plant" gives no indication that reference is to a community, not a species or an individual, and the word "succession" implies a series of discrete steps, which usually do not occur. The theory of plant succession was developed from early studies of quiescent sand dunes and of floating bogs, types of habitat that really do show a succession of vegetative stages. Actually, the theory of plant succession has done much to retard the development of a rational vegetation management for rights-of-way, since it presupposes that every shrub stage is relatively quickly followed by a tree stage, a situation that may occur but is relatively rare, for reasons discussed below.

Rights-of-way and roadsides are nothing more than nonforested lands which are tending to develop into forests. They may start off as bare raw road cuts or fills, or abandoned agricultural lands, or lumbered areas. In each instance the normal trend is back toward forest. Forest is the one vegetation type that here is not wanted, and thus management of these lands involves (a) the destruction of the incipient forest and (b) the prevention, insofar as possible, of

reinvasion by new trees. If this reinvasion can be slowed down only by half (for example, the time for removal of new trees postponed from 5 to 10 years hence) then the yearly maintenance costs will be halved, a matter of considerable economic importance. As will be shown later, this, and much more, can be done.

PHYSIOGNOMIC DEVELOPMENT

By physiognomy is meant the gross morphologic appearance of the vegetation, as grassland, shrubland, or forest. Though there are many exceptions, the normal course of development from open land to forest is through an orderly sequence of stages, starting with (1) annual weeds, such as ragweed and pigweed, and progressing through (2) grasslands with forbs, such as goldenrods and asters, (3) shrublands, and (4) forests, often themselves composed of a sequence of stages, such as gray birch at the start, then a white-pine forest, and lastly, a hundred or more years later, a forest of oaks, maples, beeches, hemlocks, and others. For rights-of-way and roadsides, stages 1 and 4 are not wanted, and choices may be made from among those in stages 2 and 3.

There are two mechanical interpretations of this physiognomic development, "relay floristics" and "initial floristic composition."

Relay floristics is the conventional and commonly accepted viewpoint on vegetation development. The theory assumes (fig. 2) that

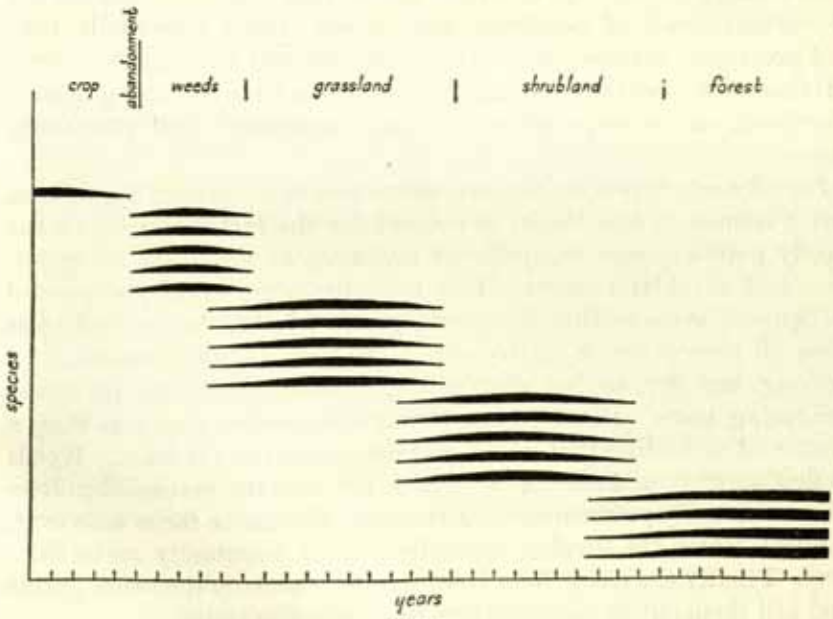


FIGURE 2.—A diagrammatic presentation of vegetation development in terms of relay floristics. According to this theory, a relay of plants invades the previous stage, and is in turn replaced by a succeeding stage.

the first community to invade the bare site changes that site, making it unfit for itself, but fit for the invasion of new species which in turn kill out the species of the previous stage. Thus, as grasses succeed annual weeds, and forbs succeed grasses, and these are ousted by shrubs, and those by trees, each group replaces, and is replaced by, the plants of the community adjacent to it in the sequence of plant succession.

The selective application of herbicides gave us the first experimental "tool" in history to test this hypothesis. Previously, we could only set back the stage of development by physically removing, e. g., the trees of the supposed last stage. Actually such removal involved the baring of the soil at that spot, which in effect was returning that spot to the very first stage of succession, not to the preceding one. Basal spraying gave us a remarkably precise tool with which to kill a species and leave it in situ. Actually, the decaying roots are an extraneous factor, and yet the resulting treeless community is a reasonable facsimile of the supposed preceding shrub stage. When and as the principle of relay floristics applies in nature, it can be seen from figure 2 that removal of the tree stage is a relatively ephemeral phenomenon and that the area will again be invaded by trees. Maintenance will thus be a repetitive process of removing these invaders.

From experimental field studies at Norfolk, Conn., came the first indication to me that many of the native woody plants had not learned their ecology lessons. Of 65 woody species that were spot-sprayed out of various kinds of nonforest associations which supposedly they had previously invaded, only half a dozen showed any urge to return. All these few were trees, not shrubs; and those were returning in such abundance as no respectable "old field succession" had previously known.

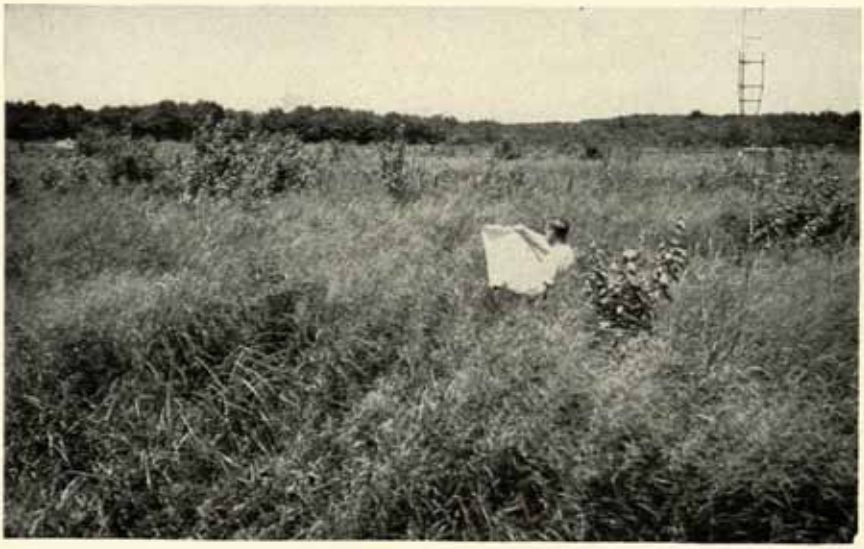
Initial floristic composition was developed as a working hypothesis, and it remains a hypothesis, to account for the fact that most of the woody plants seemed incapable of invading, as seedlings, the grassland and shrubland stages. This hypothesis, graphically expressed in figure 3, assumes that the weeds, grasses, forbs, shrubs, and trees were all present on or in the soil at the time of abandonment, last grazing, last fire, or last destruction, as seeds, seedlings, or shoot-producing roots. Development through successive stages is then a matter of unfolding that which was determined at the start. Weeds at first outgrow and overtop all others, but soon the perennial grasses become visually predominant. Eventually the coarse forbs take over, through which the shrubs, originally present, eventually make their way. Finally the trees, there from the start, overtop the other plants and kill them out or relegate them to an inferior status.

The economic importance of this hypothesis is at once apparent. If the trees had invaded at the very start of vegetation development,

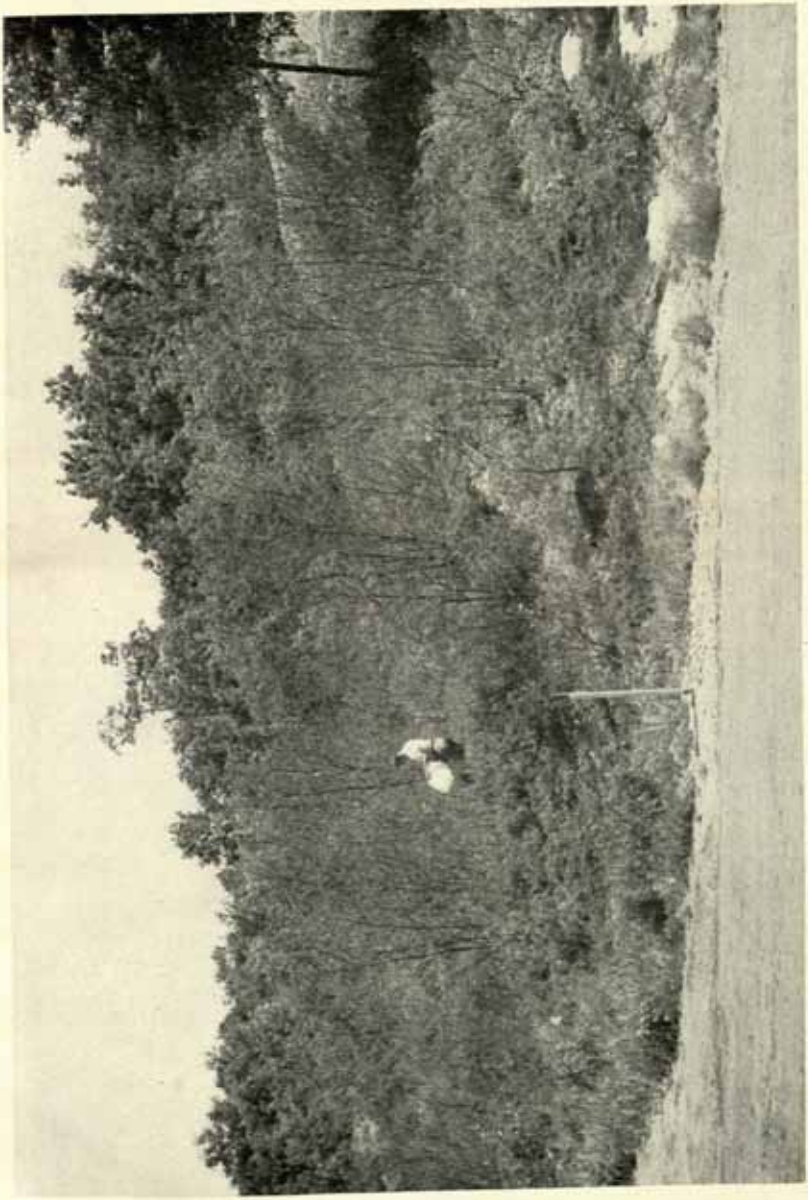
1. Control area at WHDH transmitter site, Needham, Mass., shows dense growth of tree sprouts. Figure in line with tower. (Photograph by Boston Herald Traveler Corporation.)

2. View from same point as figure 1, above, showing an herbaceous cover of low grasses and forbs 3½ years after selective spraying. The chemical treatment costs much less than the blanket spraying of the area shown on plate 2, figure 2, and no need for a future treatment is yet appearing. (Photograph by Boston Herald Traveler Corporation.)

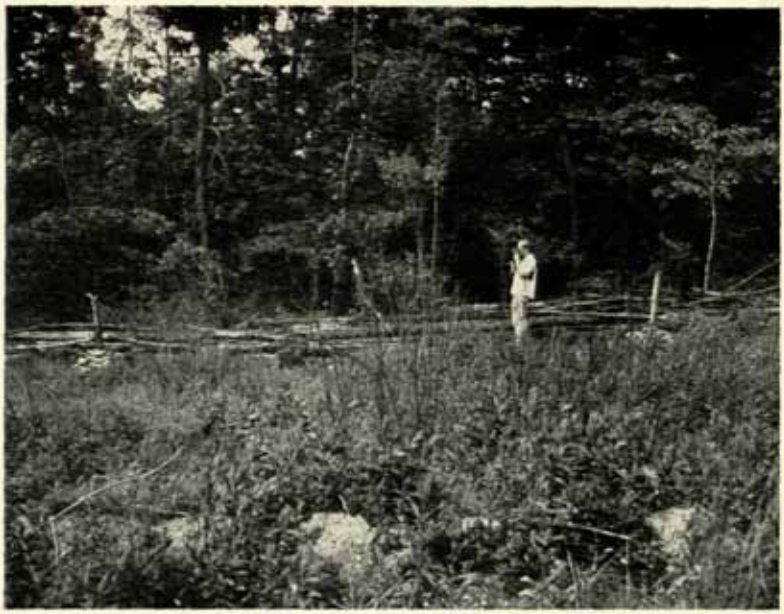
1. A low ground cover of spray-sensitive dewberry (*Rubus hispidus*) at WHDH transmitter site. Appearance 3½ years after selective spraying of brush. (Photograph by Boston Herald Traveler Corporation.)



2. A cover of swamp grass (*Calamagrostis canadensis*) on the same peat soil as that shown in figure 1, above, on an area blanket-sprayed 3 years previously. The grass is tall, dense, difficult to walk through, and a fire hazard at many seasons. (Photograph by Boston Herald Traveler Corporation.)

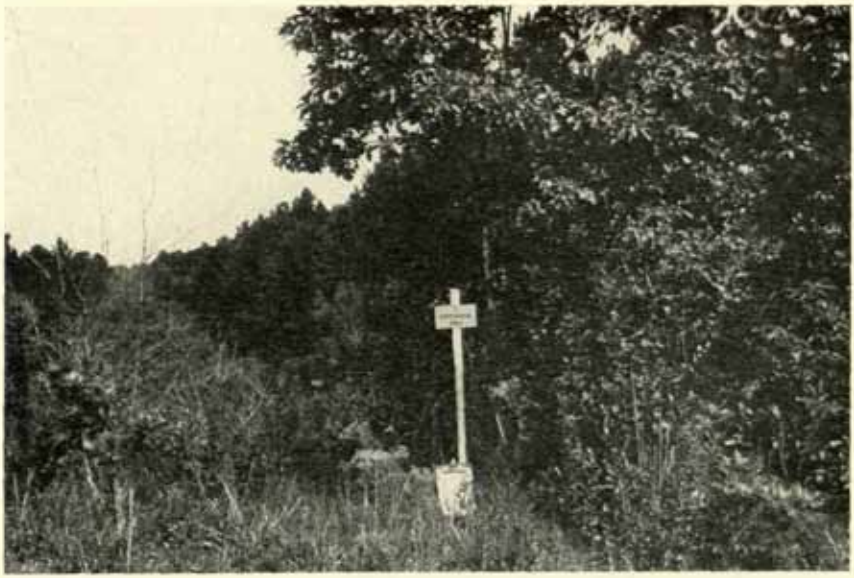


Roadside at Needham, Mass., showing selective spraying of dense oak sprouts. Low blueberries, huckleberries, and various flowering herbs remain as ground cover. Appearance one year after treatment. (Photograph by Boston Herald Traveler Corporation.)



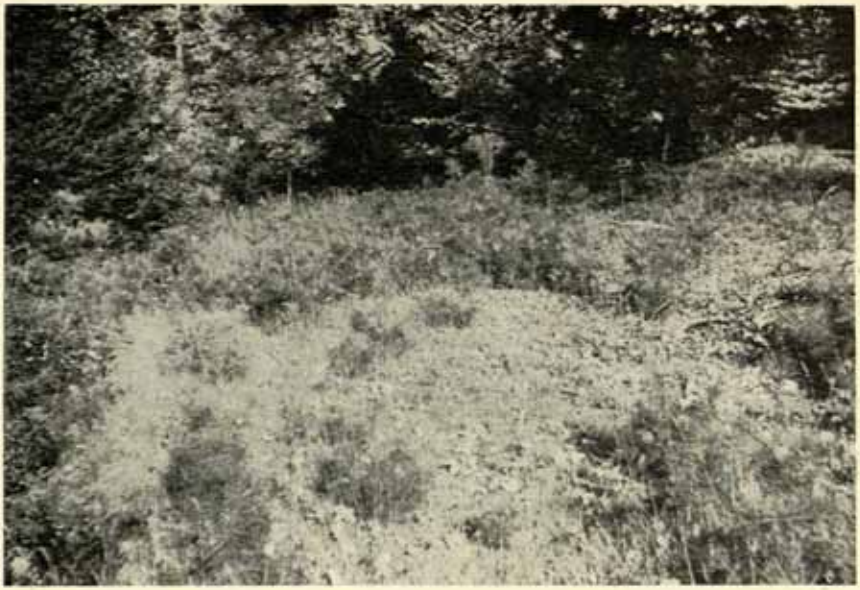
1. View of experimental plot on the Bald Eagle Area, maintained by the Pennsylvania Department of Forests and Waters. Right-of-way of the Pennsylvania Power and Light Co., in the Bald Eagle State Forest, as it appeared during the first growing season after selective basal dormant spraying, with ground cover of forbs and low shrubs.

2. View of another experimental plot on the Bald Eagle Area similarly treated for brush control. Ground cover of sweetfern, huckleberries, and blueberries, with a patch of grass in the foreground.



1. Typical untreated mixed oak brush at right. At left, low vegetation two seasons after one selective basal spray. Power transmission line, loblolly pine-hardwoods region, Federal Hitchiti Experimental Forest, central Georgia.

2. Sward of carpet grass (*Axonopus compressus*), established and maintained by physical breakage, trampling, and grazing. Gallberry (*Ilex glabra*) at the sides, a stable low cover that resists reinvasion by tree seedlings. Slash-pine region near Federal Olustee Experimental Forest, northeastern Florida.



1. Seedlings of white pine (*Pinus strobus*) invading thin grassland of poverty grass (*Danthonia spicata*) and Canada bluegrass (*Poa compressa*). Centre County, central Pennsylvania.

2. Typical untreated mixed oak brush at right. At left, low vegetation two seasons after one selective basal spray. Power distribution line, shortleaf pine-hardwoods region, Federal Lee Experimental Forest, central Virginia.

and are not part of an invading relay succeeding the shrub stages, then the dollar costs of brush (tree) control are on an entirely different plane. These trees once removed are not capable of reinvading the remaining shrublands and will not invade unless bare soil (their requisite for reinvasion) is again produced. In short, such species can be eliminated, not controlled.

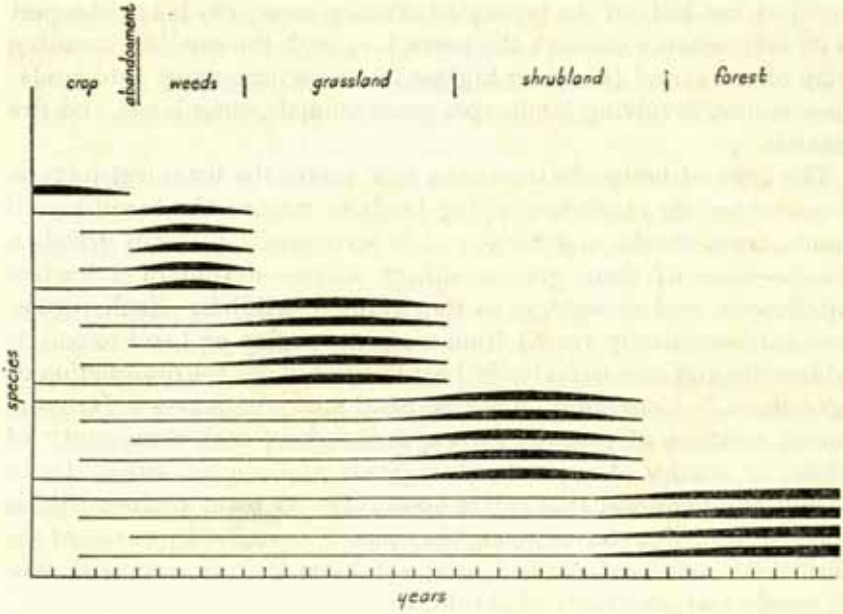


FIGURE 3.—A diagrammatic presentation of initial floristic composition. According to this theory, weeds, grasses, shrubs, and trees were all present in the soil at the time of last cropping, fire, or other catastrophe, as roots, seedlings, or dormant seeds. The successive physiognomic stages are then due to the progressive development of these plants, with the later stages taking longer to grow up and crowd out the preceding stages.

THE APPLICATION OF VEGETATION DEVELOPMENT

It is not to be assumed that one *or* the other of these hypotheses, "relay floristics" or "initial floristic composition," is exclusive in any one region. Every case of vegetation development known to me is a combination of both, with initial composition playing a larger role than had been previously anticipated. Every tree species in every type of vegetation development has a role worthy of impartial investigation if lowest-cost brush control is to be obtained for the land manager.

GRASSLAND vs. SHRUBLAND

Consideration of the above principles leads inevitably and logically to the next thought on vegetation management of these lands. Both forests (4) and annual weeds (1) are not permissible cover types.

One has to choose from among the gamut of communities lying between these, and somewhat unfortunately segregated as "grasslands" and "shrublands." Their number and variety should demand a far more complex classification. The type of community should be chosen in respect to its nature as: (1) fulfilling the physical demands of the land in respect to passability for patrol, maintenance, reconstruction, etc.; (2) being cheapest in its "construction," i. e., herbicidal root-kill (not just top-kill) of the unwanted existing trees; (3) being cheapest in its maintenance through the years, i. e., with the smallest invading relay of trees; and (4) being highest in conservation and public-relations values, involving landscape, game animals, song birds, and fire hazards.

The type of herbicide treatment now enters the botanical picture. Summer-foliage blanket spraying tends to remove the broad-leaved plants, trees, shrubs, and forbs, and to leave communities of grasslike plants—some of them grasses, others sedges—devoid of attractive wildflowers, and of legumes so important to wildlife. Such vegetation, extraordinarily varied from region to region and soil to soil, is arbitrarily and unsatisfactorily here lumped under the designation of "grassland." Conversely, selective basal spraying leaves a far more varied mixture of grasses, forbes, and shrubs, each community of which is worthy of separate observation and study. Since shrubs frequently dominate, this entire assemblage of plant communities is unceremoniously referred to as "shrubland," so called by virtue of the herbicidal treatment applied, and not because it is composed continuously and constantly of shrubs.

The economics of vegetation management of rights-of-way and roadsides has now developed into an evaluation of whether the post-blanket-sprayed "grasslands" or the post-selective-sprayed "shrublands" are: (1) cheapest for conversion to them; (2) cheapest for maintenance of them in respect to reinvading tree seedlings; and (3) highest in public relations. Brought to play upon this subject are my own investigations at Norfolk, Conn., extending through a quarter of a century. Field studies of rights-of-way have taken me in recent years through a territory stretching from the St. Lawrence River and the entire Atlantic seaboard to Illinois, Colorado, Oklahoma, and the Gulf coast. With this territory in view, and other lands in mind, no botanist would ever make dogmatic assertions concerning "brush" and "grass," any more than a forester would encompass his knowledge of American forest types and forest-management practices in a single paragraph.

A generalization is showing through the welter of botanical details. Grasslands of forested regions, 90 percent of them, are appearing as relatively "open" communities—open to invading relays of trees,

especially pines, but also white ash, maples, elms, and birches. They are not open to invasion by the shrubs of ornamental and wildlife value, and so the unnecessary destruction of these by promiscuous spraying becomes of very critical importance. The shrublands, 90 percent of them, are relatively "closed" communities, not being invaded by tree seedlings once the original component of trees has been removed. Some have lasted 25 years and are still flourishing.

Blanket-sprayed grasslands have been more difficult to investigate, for understandable reasons. Nevertheless I have inspected the rights-of-way of the three eastern organizations that have most enthusiastically embraced this type of management, and that have been most pleased with it. Let it be admitted that this type of herbicide treatment has cut brush control costs markedly below those of the original hand cutting. On the other hand, even if one were to ignore the increased fire hazards and the destroyed wildlife and landscape values, I still consider that the program is technologically short-sighted. The first project, in New Hampshire, is relatively young, but white-pine seedlings are already beginning to invade. The second, in western Pennsylvania, is difficult to evaluate, for its sponsor has usually stopped short of the goal of grassland (or rather, the herbicides have), and is allowing "brush" of increasingly greater heights to develop before respraying. After 9 years of spraying, it is not yet known what species are still being sprayed and whether these are from original root systems, or are seedling reinvaders. They are just "brush." The third, in Virginia, is "successful" in having established about 4,000 acres of a vegetation predominantly broom sedge, widely known as the Southeast's most flammable vegetation. Scrub pine is so rapidly invading this community that respraying is planned on a 5-year cycle. (This pine is peculiarly resistant to D-T sprays.)

THE EXPERIMENTAL AREAS

The committee on brush control of the American Museum of Natural History has a policy of establishing research and demonstration areas in critical regions and continuing studies of the relative stabilities of various grasslands and shrublands and thus their comparative costs of maintenance. The studies are being carried out in cooperation with other agencies, and technical reports appear at irregular intervals in various publications. The publications collectively represent the American Museum System of Rightsofways Vegetation Management. A list follows of the areas already established (fig. 4). The town in which the area is located is of the same name, unless otherwise given. All such lands have already undergone herbicidal treatments, either on a commercial or research basis.

Vermont.—*Vershire Area*, Orange County, in spruce-fir northern hardwoods. *Middlesex Area*, southern part of the town, Washington County, in white-pine northern hardwoods. Both are roadside areas, on lands of the Washington Electric Cooperative, Inc., East Montpelier.

Massachusetts.—*Shirley-Ayer Area*, northwestern Middlesex County, in white-pine transition hardwoods, on lands of the New England Power Co. *Lexington Area*, southeastern Middlesex County, in central hardwoods, on lands of the Boston Edison Company. *WHDH*, Needham, Norfolk County, a red-maple swamp in central hardwoods, in cooperation with WHDH Radio Station and the Boston Herald Traveler Corp.

Connecticut.—*Aton Forest Area*, Norfolk, Litchfield County, roadsides and old fields in white-pine northern hardwoods. *Farmington Area*, Hartford County, on future gravel pits, in pitch-pine central hardwoods, in cooperation with the Dunning Sand and Gravel Company. *Greenwich Area*, Fairfield County, a community of *Viburnum lentago* over 25 years old, in central hardwoods, in cooperation with the Audubon Nature Center. *Old Saybrook Area*, Middlesex County, in central hardwoods, on lands of the southern New England Telephone Co. *Preston Area*, New London County, in central hardwoods, on lands of the Connecticut Light & Power Co.

New York.—*Allegany Area*, Cattaraugus County, in beech-maple, on lands of the Niagara Mohawk Power Corp. *Wawarsing Area*, Ulster County, in pitch-pine central hardwoods of the Shawangunk Mountains, on lands of the Central Hudson Gas & Electric Corp. *Ten Mile River Area*, Bethel, Sullivan County, in central hardwoods, of the southern Catskills, on a line uninvaded by trees since 1936, in cooperation with the Boy Scouts of America.

Pennsylvania.—*Bald Eagle Area* on the Bald Eagle State Forest, Lewis and Hartley, Union County, and Miles, Centre County, in central hardwoods of the folded Appalachians, in cooperation with the State Department of Forests and Waters, on lands of the Pennsylvania Power & Light Co.

West Virginia.—*Clinton-Morgan Area*, Monongalia County, on abandoned agricultural sites in central hardwoods, on lands of the American Telephone & Telegraph Co., Long Lines Department, Washington Division. *Scott Area*, Boone County, in humid central hardwoods, on lands of Appalachian Electric Power Co. *Logan Area*, Logan County, in humid central hardwoods, on lands of Island Creek Coal Co.

Virginia.—*Lee Area*, Lee Experimental Forest, Buckingham, Buckingham County, in central hardwoods of the upper Piedmont, on rights-of-way, in cooperation with the U. S. Southeastern Forest Experiment Station.

North Carolina.—*Bent Creek Area*, Bent Creek Experimental Forest, Avery Creek, Buncombe County, in central hardwoods of the southern Appalachians, on rights-of-way, in cooperation with the U. S. Southeastern Forest Experiment Station. *Coweeta Area*, Coweeta Hydrologic Laboratory, Macon County, in humid transition hardwoods of the southern Appalachians, on a rain-gage site, in cooperation with the U. S. Southeastern Forest Experiment Station.

South Carolina.—*Santee Area*, Santee Experimental Forest, Berkeley County, in loblolly-longleaf hardwoods of the coastal plain, on rights-of-way, in cooperation with the U. S. Southeastern Forest Experiment Station.

Georgia.—*Hitchiti Area*, Hitchiti Experimental Forest, Jones County, in loblolly hardwoods of the lower Piedmont, on rights-of-way, in cooperation with the U. S. Southeastern Forest Experiment Station.

Florida.—*Olustee Area*, Olustee Experimental Forest, Baker County, in slash-pine flatwoods of the Coastal Plain, on rights-of-way, in cooperation with the U. S. Southeastern Forest Experiment Station.

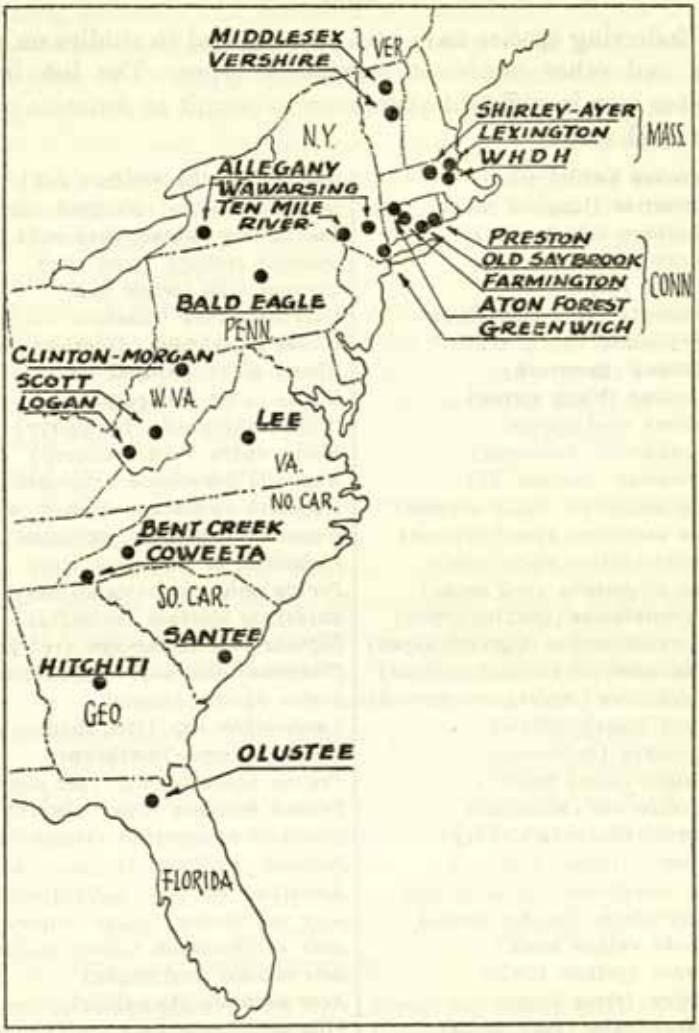


FIGURE 4.—Map of the eastern United States, showing location of the research areas of the Committee for Chemical Brush Control Recommendations, and its cooperating agencies. (Drawn by W. Thayer Chase.)

SIGNIFICANT PLANTS

In the present state of knowledge it is difficult if not impossible to summarize the data from the experimental areas and from my other studies in terms of vegetation types or vegetation regions. On the other hand, certain generalizations can be tentatively proposed for species that are known to be regionally abundant. These will be considered in the following four sections, dealing respectively with trees, shrubs (including vines), forbs and ferns, and grasses.

TREES

The following species have been investigated in studies on rights-of-way and other nonforest vegetation types. The list includes only those seen in sufficient abundance to permit an estimate of their vegetational status.

Pinus strobus (white pine)
Pinus palustris (longleaf pine)
Pinus caribaea (slash pine)
Pinus taeda (loblolly pine)
Pinus rigida (pitch pine)
Pinus echinata (shortleaf pine)
Pinus virginiana (scrub pine)
Larix laricina (tamarack)
Picea mariana (black spruce)
Picea rubens (red spruce)
Tsuga canadensis (hemlock)
Abies balsamea (balsam fir)
Taxodium distichum (bald cypress)
Taxodium ascendens (pond cypress)
Thuja occidentalis (white cedar)
Juniperus virginiana (red cedar)
Populus tremuloides (quaking aspen)
Populus grandidentata (bigtooth aspen)
Populus balsamifera (balsam popular)
Populus deltoides (eastern cottonwood)
Salix nigra (black willow)
Juglans cinerea (butternut)
Juglans nigra (black walnut)
Carya cordiformis (bitternut)
Carya ovata (shagbark hickory)
Carya glabra (pignut hickory)
Carpinus caroliniana (blue beech)
Ostrya virginiana (hop hornbeam)
Betula lenta (black birch)
Betula lutea (yellow birch)
Betula nigra (river birch)
Betula populifolia (gray birch)
Betula papyrifera (paper birch)
Fagus grandifolia (beech)
Quercus borealis (northern red oak)
Quercus coccinea (scarlet oak)
Quercus velutina (black oak)
Quercus laevis (turkey oak)
Quercus falcata (southern red oak)
Quercus marilandica (blackjack oak)
Quercus nigra (water oak)
Quercus phellos (willow oak)
Quercus cinerea (bluejack oak)
Quercus virginiana (live oak)
Quercus stellata (post oak)
Quercus alba (white oak)
Quercus prinus (chestnut oak)
Ulmus americana (American elm)
Ulmus alata (winged elm)
Ulmus rubra (slippery elm)
Celtis occidentalis (hackberry)
Morus rubra (red mulberry)
Magnolia acuminata (cucumber tree)
Magnolia virginiana (sweet bay)
Magnolia tripetala (umbrella tree)
Liriodendron tulipifera (tulip tree)
Persea palustris (swamp bay)
Sassafras albidum (sassafras)
Liquidambar styraciflua (red gum)
Platanus occidentalis (sycamore)
Malus pumila (apple)
Amelanchier spp. (tree shadbushes)
Crataegus spp. (hawthorns)
Prunus pennsylvanica (pin cherry)
Prunus serotina (black cherry)
Gleditsia triacanthos (honey locust)
Robinia pseudoacacia (black locust)
Ailanthus altissima (ailanthus)
Acer saccharum (sugar maple)
Acer saccharinum (silver maple)
Acer rubrum (red maple)
Acer negundo (box-elder)
Tilia americana (basswood)
Nyssa sylvatica (black gum)
Nyssa aquatica (tupelo gum)
Oxydendrum arboreum (sourwood)
Diospyros virginiana (persimmon)
Fraxinus americana (white ash)
Fraxinus pennsylvanica (red and green ashes)
Fraxinus nigra (black ash)

In right-of-way vegetation management, trees are of significance in two respects. First are the trees that are already there and that must sooner or later be root-killed. These include not only the large and obvious sprouts and suckers, but also a vast number of small shoots a foot high and less. Such shoots have customarily passed,

even among botanists and foresters, as "seedlings." Upon investigation, however, the great majority appear to arise from the underground parts of such root-suckering species as black locust, ailanthus, quaking aspen, and sassafras; from large massive roots, so large in the case of some oaks, that they are known as "stool sprouts" in the Ozarks, with an age of several decades at least; and from small plants 10 years of age or more, growing less than an inch a year, and being constantly nipped back by animals. These last two categories are not considered a management problem, as natural agencies have served to keep them in check and may be presumed to continue to do so.

Second are the true seedlings that are currently invading. From a management viewpoint, these include all young trees less than 10 years of age which will become a future brush problem requiring "maintenance" sprayings. Thus, "conversion" is designed to leave such plant communities as will resist invasion by these seedlings; and a study of where these seedlings occur becomes a most important field of botanical investigation.

Most tree species are not actively invading nonforest plant communities, despite the assertions of ecological theory and a wealth of ecological literature which interprets mixtures of trees and shrubs as demonstrations of such successions. Even the oaks and hickories, predominant in a majority of eastern forests, show no evidence of such active invasion. This is true for the southeastern pinelands, where the hardwood invasion is an unquestioned silvicultural fact, doubted by none but a few persons who consider the bulk of such hardwoods as coming from root systems of the same age as, or older than, the silviculturally desired pines.

The following, and only the following, tree species have been seen to invade in sufficient numbers to create a serious brush problem, involving additional costly sprayings:

Pinus strobus (white pine)	*Betula populifolia* (gray birch)
Pinus palustris (longleaf pine)	*Ulmus americana* (American elm)
Pinus caribaea (slash pine)	*Ulmus fulva* (slippery elm)
Pinus taeda (loblolly pine)	*Liriodendron tulipifera* (tulip-tree)
Pinus rigida (pitch pine)	*Acer saccharum* (sugar maple)
Pinus echinata (shortleaf pine)	*Acer rubrum* (red maple)
Pinus virginiana (scrub pine)	*Fraxinus americana* (white ash)

Of these, the one genus *Pinus* far outranks the others in acres and in numbers of individuals so invading. White ash is next in abundance. The elms, maples, birches, and tulip-trees are less important, and, in the case of gray birch, far less so than its commonly assumed status as an old-field invader would indicate.

A very sharp difference exists between the ability of these trees to invade the majority of thin grasslands (produced by indiscriminate blanket spraying) and the shrublands (produced by selective spray-

ing). All seedling invasion mentioned above is restricted exclusively to such grasslands, even though the production of such grasslands on rights-of-way is being advocated by the country's leading chemical manufacturers and spraying contractors. No tree seedling invasion in significant quantities has yet been observed in any shrubland, even though some of these shrubland types are known to be 25 years of age.

SHRUBS

The following shrubs and vines have been found to occur in sufficient abundance on rights-of-way and roadsides to form either a pure type or to give character to the vegetation. The starred names are those of importance to wildlife as food, three stars indicating those of the greatest importance. The daggered names are those of high landscape value. All these species are being destroyed in the present programs to eliminate woody growth.

- **Juniperus communis* (low juniper)†
- ****Serenoa repens* (palmetto)
- ****Smilax rotundifolia* (greenbrier)
- ****Smilax glauca* (greenbrier)
- **Salix cordata* (willow)
- **Salix discolor* (pussywillow)
- **Salix humilis* (prairie willow)
- **Salix bebbiana* (Bebb's willow)
- **Salix sericea* (silky willow)
- **Comptonia peregrina* (sweetfern)
- **Myrica cerifera* (waxmyrtle)
- **Corylus americana* (American hazel)
- **Corylus cornuta* (beaked hazel)
- **Alnus rugosa* (northern alder)
- **Alnus serrulata* (southern alder)
- **Castanea pumila* (chinquapin)
- ****Quercus ilicifolia* (scrub oak)
- **Quercus prinoides* (chinquapin oak)
- **Berberis canadensis* (American barberry)†
- **Berberis vulgaris* (common barberry)†
- *Asimina triloba* (pawpaw)
- **Lindera benzoin* (spicebush)
- *Hydrangea arborescens* (wild hydrangea)†
- ***Hamamelis virginiana* (witch hazel)
- *Spiraea latifolia* (meadowsweet)
- *Spiraea tomentosa* (steeplebush)
- *Aronia arbutifolia* (red chokeberry)†
- *Aronia melanocarpa* (black chokeberry)†
- **Amelanchier* spp. (low shadbushes)†
- ****Rubus allegheniensis* (blackberry)
- ****Rubus occidentalis* (black raspberry)
- ****Rubus idaeus* (raspberry)
- ***Rubus odoratus* (flowering raspberry)†
- ***Rosa* spp. (wild roses)†
- ***Prunus allegheniensis* (Alleghany plum)†
- **Prunus americana* (wild plum)†
- ****Prunus virginiana* (chokecherry)†
- **Crataegus* spp. (hawthorns)†
- *Cercis canadensis* (redbud)†
- ***Rhus copallina* (winged sumac)†
- ***Rhus typhina* (staghorn sumac)†
- ***Rhus glabra* (smooth sumac)†
- ***Ilex opaca* (American holly)†
- ***Ilex verticillata* (winterberry)†
- **Ilex glabra* (gallberry)
- **Euonymus americana* (strawberry-bush)†
- **Celastrus scandens* (bittersweet)†
- *Staphylea trifolia* (bladdernut)
- *Ceanothus americanus* (New Jersey tea)
- ****Vitis* spp. (grapes)
- ***Parthenocissus quinquefolia* (Virginia creeper)
- *Hypericum* spp. (shrubby hypericums)
- ***Cornus florida* (flowering dogwood)†
- ***Cornus stolonifera* (red osier)†
- ***Cornus rugosa* (round-leaved dogwood)
- ***Cornus amomum* (silky dogwood)
- ***Cornus racemosa* (panicled dogwood)†

****Cornus alternifolia** (alternate-leaved dogwood)
Clethra alnifolia (pepperbush)†
Clethra tomentosa (white alder)
Rhododendron maximum (rhododendron)†
Rhododendron nudiflorum (pink azalea)†
Rhododendron roseum (pink azalea)†
Rhododendron viscosum (white swamp azalea)†
**Kalmia latifolia* (mountain laurel)†
Kalmia angustifolia (sheep laurel)†
Lyonia ligustrina (maleberry)
****Gaylussacia baccata* (huckleberry)
***Gaylussacia frondosa* (dangleberry)
Vaccinium stamineum (deerberry)
****Vaccinium vacillans* (low blueberry)
****Vaccinium angustifolium* (low blueberry)
****Vaccinium corymbosum* (tall blueberry)
Symplocos tinctoria (sweetleaf)
Gelsemium sempervirens (yellow jessamine)†
Callicarpa americana (French mulberry)
Campsis radicans (trumpetcreeper)†
Bignonia capreolata (crossvine)
Cephalanthus occidentalis (buttonbush)
****Sambucus canadensis* (blackberried elder)†
****Sambucus pubnens* (redberried elder)†
***Viburnum alnifolium* (hobblebush)†
***Viburnum cassinoides* (wild raisin)†
***Viburnum lentago* (nannyberry)†
***Viburnum rafinesquianum* (downy arrowwood)†
***Viburnum nudum* (possum haw)†
***Viburnum dentatum* (arrowwood)†
***Lonicera japonica* (Japanese honeysuckle)†
***Symphoricarpos orbiculatus* (coralberry)†
Diervilla lonicera (bush honeysuckle)

FORBS AND FERNS

There are relatively few species of forbs (herbaceous seed plants other than grasslike plants) and ferns capable of predominating in plant communities, although the number of different species which enter all communities as minor components runs up to several hundred. Among the colonial ferns are:

Onoclea sensibilis (sensitive fern)
Dennstaedtia punctilobula (hay-scented fern)
**Pteridium aquilinum* (bracken)
Thelypteris noveboracensis.

These are all resistant to sprays and consequently tend to predominate on blanket-sprayed areas. Yet, except for the occasional use of bracken by deer, these communities are of negligible value for wildlife. They are also resistant to invasion by tree seedlings.

The only forbs observed to produce dense covers in the East are the goldenrods, and of them only the following as yet can be mentioned:

Solidago altissima
Solidago aspera
Solidago canadensis
Solidago graminifolia
Solidago juncea
Solidago rugosa

Such covers have high value as deterrents to tree-seedling invasion and for their insect populations needed as wildlife food. They are easily destroyed by indiscriminate spraying and have not been seen to return if thus eliminated.

GRASSES

Although the number of species of grasses and grasslike plants totals several hundred, those that predominate in seminatural grasslands in the East are remarkably few. Swamp grasses form a group that can be studied separately. They include not only true grasses such as *Calamagrostis canadensis* and *Arundinaria tecta*, but also many juncuses, sedges, and cyperuses. Such plant covers, not areally important, may grow 4 to 6 or more feet high, and although they can resist forest invasion they are more difficult to traverse than some shrub covers.

Among the upland grasses, *Axonopus compressus* is unique. It occurs abundantly in only a limited area of the Southeast, where it invades readily after disturbance if the land is being pastured, and produces a dense lawnlike turf as long as the pasturing is continued. In this respect, it is ideal for rights-of-way. Many of the ungrazed southeastern grasslands are mixtures of *Aristida* (three-awns), *Sporobolus* (dropseeds), *Stipa* (needle grasses) and *Andropogon* (beardgrasses). Throughout the Northeast and Central East, predominating species include the following:

Agrostis alba (redtop)
Festuca rubra (red fescue)
Anthoxanthum odoratum (June grass)
Andropogon scoparius (bunch grass)
Andropogon virginicus (broom sedge)
Panicum clandestinum and *P. latifolium* (panics)
Danthonia spicata (poverty grass)
Carex pensylvanica (sedge)

Of these, the two panics, of similar site requirements, form a dense grassland, knee-high, that should successfully keep out tree seedlings but is not too easy to walk through. All the other grassland types are low and open and successfully serve as a seedbed for the invading trees mentioned above, whenever parent trees are present. It has long been known to foresters and other field biologists that certain trees, especially pines, will invade these grasslands, and such knowledge has conditioned their silvicultural practices. Furthermore, the value of such grasslands for wildlife is extremely low. They are grazed for a very short time in spring by deer, and the insect populations are needed for the chicks of game birds, though this factor is seldom limiting because grassy patches are almost always scattered through the "shrubland" types. A few species of grasses produce important seed crops, but these have not yet been seen to predominate in right-of-way grasslands. Contemporary scientific knowledge certainly does not recommend these grasslands to the utility corporations as ideal for their brush-control problems or as satisfying the needs of wildlife.

It should perhaps be added that certain lands give no indication of having the potentiality of bearing any grassy cover. This is true for certain acid, steep, or rocky slopes. In these instances, no amount of brush spraying will create a grassland.

SUMMARY

Vegetation management, a synthetic field involving basic sciences as well as forestry, range management, wildlife management, and other branches of land management, has recently been applied to roadsides and rights-of-way. The rights-of-way include electric-power transmission and distribution lines, telephone lines, pipelines, railroad rights-of-way, and roadways, and in the aggregate represent a large acreage. These lands comprise a series of narrow belts, each with its different demands and tolerances, varying from complete bareness, as on rail ballast, to tall shrubs on the sides of power lines. In addition to the direct importance of these lands for transportation of men, materials, and power, they are of great public interest and are important in the national economy. Factors involved in maintaining such areas include potential fire hazards (such as flammable dry grasses), landscaping with ornamental shrubs, control of undesirable plants, and the preservation of wildlife habitats for game and small birds.

The control of vegetation with herbicide sprays is being studied. The chemicals now mostly used are esters of 2, 4-D and 2, 4, 5-T and, to a lesser extent, ammonium sulfamate. These are generally applied as a summer-foliage blanket spray, using knapsack sprayers. This technique has been heavily exploited by many chemical manufacturers and spraying contractors to produce grasslands. The grasslands, attractive in superficial appearance, are open to invasion by certain tree species, are frequently a fire hazard, are relative deserts for wildlife, and are devoid of ornamental shrubs and wildflowers. The technique of selective basal spraying is usually preferable, and results in a "shrubland" composed of shrubs, forbs, and grass. Such vegetation resists tree-seedling invasion, is less of a fire hazard, and has optimum value for wildlife and the ornamental plants naturally occurring.

The vegetation development refers to the orderly succession of vegetation types on land from which the original vegetation has been removed. On abandoned agricultural lands, this development comprises a succession from annual weeds, through grasslands, forblands, shrublands, and finally forests. The interpretation of this development has usually been in terms of a succession of invading "relays," each succeeding another in one community. Recent investigations show that the initial floristic composition is of major importance in that most of the trees and shrubs entered in a very early stage of development, and only assumed physiognomic importance at a later time. Such conditions are of considerable economic value, for unwanted trees of this category do not reinvade, once they are root-killed by herbicides.

Twenty-three research areas, mainly sprayed rights-of-way, have now been established in 11 States, in cooperation with research, educational, and nonprofit organizations. Over 75 species of trees are on the plots, none of which show significant evidence of invading shrub communities. Pines, birches, elms, tulip-trees, maples, and ashes can invade the grasslands however, sometimes so readily and in such numbers as to require respraying at 5-year intervals. Over 90 kinds of shrubs can be sufficiently abundant to characterize the vegetation, and the majority of these have high values as ornamentals and as a source of food for wildlife. Only four ferns and six forbs (all goldenrods) form relatively pure plant communities, and all are resistant to tree reinvasion. The number of upland grasses and grass-like plants that predominate in pure stands has been far fewer than originally anticipated. The commonest in the Northeast and Central East belong to but seven genera. All except two panics show themselves open to invasion by tree seedlings, but not by shrub seedlings. Creation of these grasslands is therefore usually detrimental to the interests of both the managers of the lands and the public through the permanent loss of attractive landscape and wildlife habitats.

In conclusion, present botanical knowledge indicates that most of the upland grasslands are easily invaded by a few species of trees, whereas the shrublands are relatively sealed against tree reinvasion.

A list of literature references concerning the American Museum System of Rightofways Vegetation Management may be had on request from the Department of Conservation and General Ecology, American Museum of Natural History, New York 24. Arrangements for the loan of a colored talking film on the subject may be made by addressing the Film Library of the Museum.

Applied Systematics: The Usefulness of Scientific Names of Animals and Plants[1]

By WALDO L. SCHMITT
Head Curator of Zoology
U. S. National Museum

It is an error to suppose as many do that classification is an outmoded phase of natural history. It affords a continuing test of evolutionary doctrine. The increasing refinement of biological study requires greater certainty than ever before of the identity of animals and plants used in experimental work. The fact that all organisms are now considered to be part of one great family tree is a challenge to the intelligence and skill of the classifier who must reconstruct that tree. Actually the business of classification has today greater vitality and significance than ever before. . . .

—PAUL B. SEARS

THE FIELD of biological systematics is a broad one, and within it are brought together at least a part of all natural-science disciplines. It represents the orderly understanding and the sum total of our knowledge of the animal and plant kingdoms. I shall confine myself chiefly to the taxonomic side of the subject, so largely devoted to knowing the scientific names of organisms. However, to name animals and plants intelligently you need to know a great deal about them, their makeup, lives, growth, behavior, and geographic distribution; in short, their biology in the broadest sense of the word.

[1] Address given at the Zoologists' Dinner, annual meeting of the American Association for the Advancement of Science, St. Louis, December 30, 1952. Grateful acknowledgment is made to Dr. Paul B. Sears, of Yale University, and Charles Scribner's Sons, Inc., for permission to use as epigraph to this article a quotation from Dr. Sears's book "Charles Darwin" (1950); to the late Raymond Pearl, of Johns Hopkins University, for a few pertinent words from his address "Trends of Modern Biology," published in Science (1922); to Charles Elton for a quotation from his "Animal Ecology" (1927; 1948); and to Dr. George Gaylord Simpson, of the American Museum of Natural History, for the quotation from his "The Principles of Classification and a Classification of Mammals" (1945).

SYSTEMATICS IN EVERYDAY LIFE

Everyone at heart is a taxonomist, either by virtue of necessity or because of mere curiosity. From childhood up we want to know the names of things. What is this, that, or the other object—how, where, why, and what? Children at an early age readily learn to distinguish a number of common things—birds, the various wildflowers, poison-ivy, bees, wasps, and yellow jackets—according to their experience.

Every good housewife can identify the tiny moth flitting through the bedroom or the parlor if it be a clothes moth. This knowledge has a dollars-and-cents value, for the name of a beast or a pest indicates the method of control to be applied. With further experience she can distinguish this kind or species from one that may more rarely flutter through the house but in more disturbing numbers—the moth that sometimes appears in your packaged grain or cereals. Or perhaps it is the winged ant coming out from under the house that catches her attention. In mere self-interest she will want to know if it is an ant or a termite, which, by the way, is not an ant but an insect of quite another order and family. There are also wood-destroying ants, the carpenter ants, infesting houses, yet these rarely if ever become serious pests. With the identification comes the scientific name, which is the key, the index entry, indeed the only device which will open up for one the world's literature containing the extant information regarding any object, animal, mineral, or plant. If a name cannot be found for it, the object is probably new and undescribed, in which case the information regarding it is yet to be developed.

Indeed, wherever man comes to grips with the problems of life and living, the importance of the names of things is most vital, whether he be concerned with disease, the production of food, or merely safe drinking water.

The physical fitness of drinking water can readily be determined by chemical analysis, but only by identifying the organisms existing in it, or rather determining the absence of certain of them, can its safety be assured. Among the biological contaminants that need to be distinguished are to be numbered first of all the enteric bacilli and amoebae, the "germs" of typhoid and cholera; copepods, which are the intermediate hosts of the broad tapeworm of Europe now established in parts of this country; and a host of other organisms that vary as to locality. Unknown waters are not safe to drink even in the high Arctic with its extremely low, often killing temperatures, for there the melting ice and snow in the spring expose and redistribute the well-preserved refuse of the long winter months from human habitations. But please do not look askance at the glass of drinking water

before you. Our modern municipal waterworks take pains to treat and filter it carefully. Yet accidents happen and plumbing installations have been found faulty, as in Chicago, where carelessness in this respect resulted in 70 deaths from amoebic dysentery a few years ago.

Whether the water be fresh or salt, pollution not only renders it unfit for use, but, if in sufficient degree, will also destroy the inhabitants useful and economically important to man.

Dr. Ruth Patrick, curator of limnology, specializing in diatoms at the Academy of Natural Sciences of Philadelphia, as the result of her investigations in certain Pennsylvania streams, was perhaps the first to stress the importance of the specific naming of the organisms present in the evaluation of stream pollution, its kind or type, and duration. She found that the heretofore frequently tried method of using indicator organisms simply did not supply the data needed to make such evaluations.

All groups of plants and animals living in a stream, particularly the sessile or attached forms, or those which moved about in only a small area, merited serious consideration definitely at the species level. This entailed extensive collecting in relatively shallow water, the area in which the majority of such forms live, and required the cooperation of a number of experienced taxonomists to identify specifically the material collected, especially the algae, rotifers, worms, mollusks, Crustacea, insects, and fishes. Sooner or later we all discover, as did Dr. Patrick, that there is no satisfactory shortcut to the solution of a biologic problem, ecologic, medical, agricultural, or otherwise, that ignores names of the species involved.

ENGINEERING

Ordinarily you would not expect an electric light company to have a biological problem, let alone one in which mollusks were involved. Six or seven years ago a heavily armored power cable lying on the bottom of the bay between Palm Beach and West Palm Beach suffered one of a series of blowouts as the result of the penetration of the outer insulation and the heavy-load casing by marine mollusks. The company's officials naturally wanted to know what manner of shellfish this was and what could be done to prevent further damage. Though the animal was found to be a new species, which was subsequently described, it was at once recognized by the expert to whom it was submitted as belonging to a genus of boring mollusks which would quickly be suffocated if the cable were buried several inches below the bottom of the bay. This would also prevent further damage

of the same sort. In the 8 years preceding, the cable had suffered 15 failures, entailing repairs costing upwards of $12,000. Here an identification solved a costly engineering problem.

THE FIELD OF ECOLOGY

Engineering problems accompanied by specimens are easier to solve than ecological ones unsupported by specimens. Recently an ecologist was discussing the behavior of a green parrotfish in the waters about a tropical island. You can imagine his consternation when he was asked to which of 10 possible species he was referring!

The importance of specific names to ecologists may be illustrated by this excerpt from a letter received by one of our Museum curators from a well-known student of jungle life: "I have all of my voluminous field notes ready and only await the names of the [specimens] which I sent you a long time ago. Have you had a chance to go over them? I have the names of most, but there are still many left and I can publish nothing until I get them."

And Charles Elton, in his book "Animal Ecology," writes: "One of the biggest tasks confronting anyone engaged upon ecological survey work is that of getting all the animals identified. Indeed, it is usually impossible to get all groups identified down to species, owing to lag in the systematic study of some of them. The material collected may either be worked out by the ecologist himself or he may get the specimens identified by experts. The latter plan is the better of the two, since it is much more sensible to get animals identified properly by a man who knows them well, than to attain a fallacious sense of independence by working them out oneself—wrong."

EVOLUTION AND GENETICS STUDIES

The abundance of the pasturage in what are known as "the meadows of the sea" is being evaluated these days by the oceanographers in terms of the chlorophyll collected by their continuous plankton recorders without having to take the pains of identifying the many species of which the plankton mass is composed. At least samplings of the organisms involved should be specifically determined, for there are bad as well as good planktoners in the sea, just as there are good and bad plants on some of our western ranges. Pasturage in meadows on land, by certain tests, may yield a very high chlorophyll rating, but a lot of it could be locoweed. If the marine chlorophyll ratings are to have real significance, the species on which they are based need to be known.

In evolutionary and genetic studies, it is especially important to know well the species dealt with and the literature about them. Years of effort can go for naught if pertinent taxonomic finds, procedures, and discoveries are disregarded.

An unfortunate instance of this sort was a rather impressive report on "An Investigation of Evolution in Chrysomelid Beetles of the Genus *Leptinotarsa*," published some years ago, a 320-page volume, illustrated with 31 text figures and 30 plates, some in color. Aside from a number of unnecessary nomenclatorial mistakes, records of distribution and occurrence were far out of line with published work on these beetles. Although the author stated that three species were found in the United States, and that life histories were almost entirely undescribed, actually eight species were known from the States at the time, and seven life histories had been published previously. Several forms which he enumerated as species were invalidated by evidence given in his own work, and to have given it standing he should have supplied or published elsewhere satisfactory descriptions of the new forms he mentioned but concerning which his text was insufficient and unclear.

As the informed entomologist who reviewed this work remarked, "Even a slight acquaintance with the literature of the subject would have saved [the author] from errors which are surprising in a man who claims to have devoted eleven years to his subject." Is it not to be regretted that so much time and money were expended on work so deficient for want of adequate taxonomic background? For "it is the systematist," said Raymond Pearl, "who has furnished the bricks with which the whole structure of biological knowledge has been reared. Without his labors the fact of organic evolution could scarcely have been perceived and it is he who today really sets the basic problem for the geneticist and the student of experimental evolution."

THE NATIONAL MUSEUM'S CONTRIBUTION TO SYSTEMATIC STUDIES

The U. S. National Museum is one of the world's great centers for systematic research. The studies that the Museum is unable to accomplish with its own staff it tries to encourage others to undertake. That is how it happened that the late Dr. J. A. Cushman became interested in working up the Museum's collections of Foraminifera. In his day he knew more about the classification and distribution in time and space of Foraminifera than perhaps any other man. His great knowledge of these shelled protozoans was derived in great measure from the vast collections that had been dredged up from the seven seas and stored in the National Museum, largely unstudied, before his time.

When these microscopic organisms came into prominence as primary indicators of oil-bearing strata, particularly in the Gulf of Mexico region, Dr. Cushman was the authority to whom the oil companies turned for help in applying this information. His special taxonomic knowledge of the group enabled him to predict from the species brought up in drillings the proximity of a given sample to oil-bearing

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strata within several hundred feet. His determinations were worth millions of dollars in revenue to the oil companies and in taxes to the United States Government. Though other techniques, electronic and geophysical, are now frequently employed in prospecting for oil, the Foraminifera are still important in identifying and correlating strata and in subsurface mapping in oil-producing areas.

The foregoing is perhaps the most outstanding example of the eventual successful application of purely systematic studies and the naming of species to economic ends. It can safely be said that most, if not all, systematic work has a dollars-and-cents value, perhaps not today or tomorrow, but certainly in time.

BIOLOGICAL CONTROLS

In looking over some recent literature dealing with biological controls, I saw reference to the classical example with which I became acquainted in my earlier days in the Government service some 40 years ago. It was the story of the identification of an insect that played the role of a villain threatening the destruction of the sugar industry of Mauritius back in 1910, and how it was circumvented in the best tradition of the popular "who-done-its" by a systematic entomologist. The villain was a destructive white grub that bored in the roots of the sugarcane, killing the plant. It appeared very suddenly in such alarming numbers and spread so rapidly that the threat of the ruination of the plantations of sugarcane, the big money crop of the island, could not be ignored. With such information as was at hand, the best guess was that the borer was the larva of an African genus of beetle represented on the island by two species and the only remedies that suggested themselves were to dig up the root stumps to destroy the larvae or to catch the beetles as they flew about at night in search of food. The invader, lurking unknown in introduced cane cuttings, and finding itself a favorable environment without enemies, in reproductive capacity far outstripped all human efforts to control it despite the fact that in less than 6 months more than 27 million insects were accounted for. Meanwhile, the aid of the specialists in the British Museum was sought. With the extensive reference collections and library there available, it was soon determined that the beetle was not an African one, but a New World form, of which, however, no record or specific description could be found. In an ensuing search through the large collections of that Museum three specimens of this selfsame beetle, labeled "Trinidad," turned up. The fact that this native of the West Indies had never been mentioned in literature implied that it was of so little economic importance that it had failed to attract the attention of any entomologists stationed in the islands. What kept its numbers down at home?

With specimens for comparison, a trained entomologist soon located both the beetle and its larval stages in cane roots on Barbados. It further developed that there it had two natural enemies. The only one in evidence at the time was a so-called blackbird which eagerly followed field hands rooting up cane stumps, to eat the grubs turned up, but unable to reach those beneath the ground. The other natural enemy, a tiny, inconspicuous wasp, was discovered by a neat bit of detective work on the part of the entomologists. Attached to one of several Barbados root borers transmitted to the British Museum was observed a tiny white grub. In the manner of its attachment it suggested the larval stage of a small wasp common in Barbados, one of the family of solitary wasps known to parasitize beetle larvae but not heretofore the cane borer. The wasp lays her eggs upon the borers after paralyzing them with her sting so that they will serve as food for her own young on hatching. Introduced into Mauritius, this little wasp soon turned the tables on the cane borer.

One cannot leave the subject of biological controls in the field of agriculture without touching upon one of the most remarkable successes of all time. This particular one was made possible by the taxonomic studies that preceded, and were undertaken in connection with it. It was the conquest of the prickly pear in Australia by the cactus moth borer, *Cactoblastis*.

Cactuses are peculiar to the New World. As horticultural curiosities, and also as hosts of the cochineal insect, they were introduced shortly after their discovery into many other lands. The dates of the early introductions of the prickly pears, or Opuntias, into Australia are not known. Some planted as hedges and in gardens escaped to run wild in the surrounding country. As with the cane borer in Mauritius, in a favorable environment and without natural enemies to keep them in check, they spread at a tremendous rate. The rapidity of their increase has been called one of the botanical wonders of the world. In a period of 20 years the land area preempted by these prickly pears increased from 10 million to 50 million acres.

It was imperative that something drastic be done if the Opuntias were not to take over the land. Millions of acres had become veritable wildernesses of prickly pears. The Australians soon discovered that the cost of eradicating cacti by hand, poison, or mechanical means so greatly exceeded the value of the land that it was prohibitive. Some less costly method would have to be employed if the land was to be reclaimed. Biological control seemed to offer the greatest hope. Forthwith, the systematic literature of the world was searched for all pertinent information—the kinds, distribution, and habits of the prickly pears, and especially the literature relating to the animals and plants that have been reported to live in or upon them. Australian entomologists searched the world, so to speak, for the known and

yet unknown enemies of prickly pears, studying those preserved in museum collections, as well as the living ones in the field. The most favorable places for these investigations were Argentina and the United States, where the great natural stands of "pears" existed. Some 150 to 160 different kinds of insects injurious to the cacti were found, of which 50 proved to be new to science. Twelve of the most promising ones were introduced, and of these one, *Cactoblastis cactorum*, described in 1885 from South America, proved so successful that further introductions were unnecessary. From an original shipment of about 2,800 *Cactoblastis* eggs in 1927, 10 million were reared in the next 2 years. In the course of 6 years 3 billion eggs were released. The cactuses literally disintegrated before the onslaughts of the *Cactoblastis* grubs feeding within their tissues. Within 15 months after the first trial liberation, huge stands of cactus lay rotting on the ground and in the next 7 years the last large area occupied by the pears collapsed. By 1940 less than 100,000 acres were believed to be infested with patches of dense or moderately heavy cactus growth, whether of regrowth or seeding origin, as compared with the hundreds of square miles of a few years before.

In Queensland, the worst-affected state, it would have cost from four to five hundred million dollars to have cleared the infested areas of prickly pears by poison and mechanical means. Following a careful study of the problem, and, I would emphasize again, especially the taxonomic literature bearing on it, by introducing and distributing eggs of *Cactoblastis*, the Commonwealth Prickly Pear Board accomplished the task at a cost of less than a million dollars. Thus, the formerly useless acreage regained for settlement because of its suitability for grazing, dairying, and agricultural purposes became an asset valued at 40 to 50 million dollars, to say nothing of the worth of new improvements and the future yield of the land, which, in time, will amount to many times its present value. Moreover, the benefits of the Australian experiences extended to South Africa and India, where prickly pears had also been giving considerable trouble.

The Australian entomologists give due credit to the work of the taxonomists who preceded them in the study of cactuses and cactus insects for their share in the accomplishment of this latter-day miracle, but who could have foreseen 65 years ago that the then published description of an insect found to be new by an Argentine zoologist making known to science the animal life of his part of the world would, half a century later, be instrumental in saving a continent from a pest run wild?

INSECT QUARANTINE

To prevent such unwitting introductions as this cane borer, the prickly pear, and other pests, our Department of Agriculture has a

farflung inspection service at all ports of entry and at border stations. Indicative of the importance that the Department attaches to the necessity of having all "immigrants" of agricultural import promptly identified is the fact that it maintains insect, plant, and phytopathological identification services. The division of insect identification, located in part in the National Museum in Washington, comprises a staff of about 40 entomologists and technical assistants, and elsewhere in the Department an equally alert staff of taxonomic botanists and plant pathologists. They handle many thousands of identifications each year and in the course of making them have detected many harmful insects and other forms of life which might otherwise have become serious agricultural pests.

EPIDEMIOLOGICAL APPLICATIONS

Malaria ranks as one of the great scourges of mankind. We hear a great deal of the wonder drugs developed to overcome it, but very little of the role that taxonomy played in furthering its control. From the time that Ross first discovered that the causative parasites were transmitted by anopheline mosquitoes, it was thought that the problem could be solved quite simply by a reduction of the mosquito population—by treating their breeding places with larvacides, by introducing the little mosquito-eating fish *Gambusia*, by clearing out aquatic vegetation, and by drainage. The results in the States, and in Panama in the course of the construction of the Canal where expense was no object, were most gratifying, but when the Rockefeller Foundation tried to apply these methods in southern Europe, the same successes were not achieved. The carrier abroad was a different species, to be sure, with different habits and capable of breeding at the edges of running water, where its North American congener was a pool breeder. Nevertheless, it was impossible to establish any correlation between the incidence of intense malaria and the relatively few anophelines found in houses. On the other hand, there were localities with incredible numbers of the anophelines, tens of thousands in a single stable, and no malaria whatever; there were swamps without malaria, and a great deal of malaria without swamps.

It was not until two important and, at the time, unrelated discoveries were brought to bear on the problem that the apparent anomalous behavior of the common malaria mosquito abroad was cleared up. The first was the precipitin test, permitting the exact identification of blood, both human and animal, a serological and purely toxonomic procedure by means of which, no matter where a mosquito was lurking at the time of its capture, its host or hosts could be determined. The other discovery, which to my mind is one of the most important discoveries in the history of malariology, and certainly in its European

aspects, was the discovery by Falleroni that females of the apparent European carrier, which he carefully raised, deposited five different types of beautifully ornamented but consistently different eggs, and that a given female always laid the same type of egg. Today it seems incredible that 7 long years elapsed before this significant discovery was properly appraised and applied to the taxonomy of mosquitoes.

By means of these discoveries, what had been formerly considered a single but unpredictable and widely distributed form, was found to be in reality several distinct species and distinguishable races. Thus, the hitherto inexplicable behavior of the European malaria mosquitoes was resolved with the aid of taxonomy, and the way cleared for effective control.

SPECIES SANITATION

The exact knowledge of the species of mosquitoes found in any given area is of greatest importance in preventing the waste of effort and funds on unnecessary control measures and permitting full attention to be paid to the dangerous species. Species identification insures a maximum of effective control at minimum cost; we have, therefore, today "species sanitation," as it is called, as the accepted practice in mosquito control.

A notable instance where species sanitation was most successfully carried out was in the Natal, Brazil, area from 1938 to 1940. It was here that the late Raymond Shannon, formerly with the U. S. Department of Agriculture, and, at the time, with the Rockefeller Foundation, made the startling discovery in 1930 that the dread African carrier of malaria, *Anopheles gambiae*, was on the loose in the New World. Probably shipborne, it brought about, in all, what is said to have been the worst malaria epidemic in history—some 300,000 cases, with enormous mortality, in a comparatively limited area.

At once steps were taken to eliminate this exceedingly efficient carrier from the immediate vicinity of Natal. This was accomplished in the next 12 months, but, rather strange to say, no efforts were made to look farther afield for this highly dangerous insect. It apparently made the most of the opportunity so afforded. Nothing is known of its ravages in the interim. In 1938, however, it caused a serious epidemic of malaria some hundreds of miles inland. This time there was no hesitation. All possible means of control were directed against this much to be feared species. Nothing was left undone to completely eradicate it. In 2 years of intensive effort complete success was apparently achieved. No trace of *Anopheles gambiae* seems since to have been found in Brazil. A few airborne individuals, however, have been detected in planes from Africa and promptly destroyed. Here again, species identification proved to be the impor-

tant thing. It made species sanitation possible, and definitely effective, in a comparatively short space of time, and today enables the Brazilian Government to keep this dangerous enemy out of the country.

THE BLACK DEATH

The story of the plague—bubonic plague, the highly fatal Black Death of the Middle Ages—and of its spread and control in India, Ceylon, and elsewhere parallels that of malaria, and, like it, turns upon the critical recognition of species of insects—in this case, fleas.

Much of our knowledge of the dissemination of plague by fleas we owe to two men, L. Fabian Hirst, health officer at Colombo, Ceylon, and Nathan Charles Rothschild, an authority on the kinds of fleas, who discovered that the prevalent rat fleas of India and the Orient did not constitute a single species, as previously believed, but were three very closely allied species. It was Hirst who first suggested and then demonstrated that these fleas had quite different biting habits and different appetites for human blood, and thus varied in their effectiveness in transmitting plague from rat to rat, and rat to man. Their discoveries established the geographic distribution of the different species of rat fleas as one of the most important factors governing the spread of plague, and for the first time furnished a logical explanation for the relative immunity of certain parts of India and Ceylon to both epidemic and epizootic bubonic plague.

This discovery was the natural outcome of the purely zoological researches of Rothschild and others on the systematics of fleas.

IN TIME OF WAR AND IN NATIONAL DEFENSE

Though not accorded recognition in the headlines of the daily press or rewarded with oak-leaf clusters, the taxonomists made many noteworthy but unheralded contributions to the waging and winning of the late great war with their prompt identification of the many things about which vitally important information was urgently needed.

In war we have much the same problems in medicine, epidemics, disease, and health as in times of peace, only more intensified and more urgently calling for solution or alleviation. The immobilization of armies by attacks of malaria in the European theater and the casualties, if we may call them that, from the same cause and insect-borne diseases in the Pacific became so serious that it was of utmost importance that the mosquitoes, fleas, ticks, and other pests or vermin be identified without delay. Those that could not be named by the sanitary and medical units in the field were given the very highest priority to Washington for immediate determination.

During World War II a well-known news commentator, for want of a more timely subject perhaps, took it upon himself to ridicule a systematic treatise of the fleas of North America. It is the type of technical work that is of utmost value to the specialist desiring to make prompt and accurate determinations. He described this Government publication as a waste of paper, containing no useful information because it did not tell how to free your dog of fleas. But it was just the sort of book that would have enabled Rothschild to distinguish the species of flea that was the chief carrier of bubonic plague in India from the less harmful kinds. Moreover, this publication has in it the very information which enables one to identify this particular oriental plague carrier, which, by the way, has become established in this country, but happily, so far as we know, is not here infected with that most serious of diseases.

A Museum friend of mine, though not a scientist, was utterly shocked by the low regard that the commentator had for work so important. He wrote the commentator a letter which I believe is still pertinent, and I quote part of it:

> Having for many years been connected with a scientific establishment, and not being a scientist myself, I have come to realize the real value of such scientific works as you disparaged, and for the first time in my life I am moved "to write to the editor."
>
> This impulse was perhaps strengthened by the fact that the very next morning [after your broadcast] I was pointedly reminded of it by the receipt from the medical officer at one of our outlying bases of a *single* specimen of flea which he particularly desired to have identified with reference to its function as a possible carrier of disease. Only by knowing the exact identity of an insect can information of this character be given promptly, and the scientific entomologist turns instantly to such works as you ridiculed just as you would seize "Who's Who" or the Encyclopedia Britannica, or some report of the Department of Commerce for data you might need.
>
> A steady stream of mosquitoes, ticks, and the like is pouring into Washington each day by airplane under highest priorities from our farflung battle fronts, in order that the local specialists may make prompt identifications, thereby furnishing the medical officers in the field the guidance necessary for applying the most effective control measures.
>
> The mere knowledge of the precise name of "resident" fleas and other insects will enable the medical and sanitary services of our Armed Forces to quickly ascertain which of several towns in plague-infested areas are the safest for quartering men.
>
> Such works as the one under discussion are a distinct contribution by the home front to our forces on the battle front. In this connection I am moved to quote a line from one of Kipling's "Barrack Room Ballads":
>
> "Making fun of uniforms
> That guard you while you sleep
> Is cheaper than them uniforms
> And they're starvation cheap."

Men, expendable I assume, were landed from submarines on more than one occasion to reconnoiter the places and the islands to be attacked. They were also instructed to bring back what they could of the animal life encountered. As important as was the knowledge of the numbers and disposal of the enemy was the identity of the insect vectors in calculating the risks of attack and casualties from disease, which, more times than we care to admit, laid out more men than the enemy. The identification of dangerous insects in the war areas can be speedily accomplished only because of the stores of knowledge that the taxonomists have accumulated over the years. They supplied much exceedingly valuable information in other directions also.

Something had to be done about floating mines drifting into our coastal waters to menace shipping. Our patrol fleet needed to know the paths they traversed through the sea, so that they might be intercepted before their hostile mission could be accomplished. It was also imperative to determine where the far more dangerous German submarines sinking tons of shipping in the western Atlantic and Caribbean areas had their bases for overhaul, refueling, and the replenishment of stores. From the surfaces of the mines and submarines were scraped marine growths and from the ballast and trimming tanks of the few submarines that were captured intact were recovered traces of bottom mud and sediments pumped into the tanks as the submarines were anchored near, or rested on, the bottom of the shoal bays of their rendezvous. These growths and the sediments, their mineral constituents and contained organisms, were carefully examined and named by appropriate specialists. When the identifications were checked against the known distribution of the various materials it became possible to plot the probable paths of the mines and also to trace the submarines to their bases where they could be destroyed.

You may well remember the paper balloons with which the Japanese so ingeniously took advantage of the currents of the upper atmosphere for dropping bombs on the States during the war with a minimum of effort and cost to themselves. Until recently it was not known that during the 6 months that the Japanese continued this unique barrage over 9,000 such balloons had been launched and evidence had been found that 300, perhaps many more, had reached this country, some traveling as far east as Michigan. These balloons and the bombs they carried might have been frightfully dangerous. They could kill and maim, start devastating forest fires, and, had they been so employed, would have been capable of spreading disease and noxious insect pests. How were we to stop them? The balloons were so constructed that after the last of their bomb load was dropped an explosive charge destroyed the balloon. To keep the Japanese from

learning of the success of their efforts, the strictest censorship was imposed, but word was also quietly sent out to appropriate State officials that an intact balloon must be recovered at all costs, so that it could be carefully examined. One was fortunately secured by an Oregon sheriff. The resulting identification of the sand ballast that the balloon carried, along with some of the remains of microscopic plants that were found in the sand, pointed to five possible launching sites. Armed with this information, our Air Force promptly bombed all five sites and, in so doing, must have hit the right one or ones, for soon thereafter this menacing offensive ceased.

FISHERIES BIOLOGY AND CONSERVATION

I do not have space to tell of many examples in other fields of study in which the name of a species or organism solved a biologic problem. But because of their special pertinence I should like to cite three little instances that bear on the economics of fisheries.

Some months ago an American specialist on sipunculid worms was asked for copies of his technical publications by an Alaskan cod fisherman who had found that where these worms occurred he always made good hauls of fish. He wanted to plot the distribution of the worms in order to do better and to extend his operations.

A matter of weeks ago an ardent sport fisherman brought in a mantis shrimp about which he wanted to know its mode of life, its distribution, and where it could be obtained in quantity. Of course, to make a search for information, the species had to be identified. In turn, we learned something also—that this stomatopod was the favorite food of certain desirable panfish much sought after by fishermen in the Chesapeake Bay area.

In the Carolinas, where shad enjoy a certain amount of legal protection, the State conservation agent must be able to distinguish between four or five species of fish, all superficially more or less alike, if he is to catch the violators of the law and avoid congesting the courts with the innocent. So, even in the enforcement of conservation laws, a knowledge of the species involved must be had.

SOME BOTANICAL APPLICATIONS

Recently I was discussing some of these things with a friend of mine who is a systematic botanist. He spoke of cortisone and yams, and mentioned how much and how often the plant taxonomists are being called upon these days for information regarding not only the names of plants, but also their phylogeny and systematic relationships. If a plant contains a rare alkaloid or drug, what about its relatives? Knowledge of kinship has facilitated many such investigations.

The lore of ancient, primitive, and often unlettered peoples contains much of interest and value to us if only we can find the scientific names for the animals and plants of which they had learned the properties, good or bad, useful or harmful, by long and often sad experience. Curaré is one of these.

Botanists these days work with maintenance crews in keeping clear fire lanes and electric-power and telegraph rights-of-way for the purpose of identifying the plants, so that the appropriate herbicides may be used to kill off unwanted vegetation. The result desired and achieved is a dense growth of low shrubbery that will so occupy and shade the ground that all other growth will be inhibited, yet itself will not hinder or impede the passage of inspection, maintenance, and repair crews. Manual as well as mechanical clearing of ways, uphill and downdale, in these days of high labor and operating costs, is an expensive proposition, which, at best, only temporarily controls the situation. Spraying, too, can be a costly affair, as well as ineffective, if indiscriminate, without regard to the kinds of plants involved.

Again we are moved to remark that wherever one turns, a thorough knowledge of the kinds of organisms, whether of plant or animal origin, sooner or later proves of real value and often of considerable economic importance in the most unexpected ways and places. And finally, may we repeat what George Gaylord Simpson once so well stated: "It is impossible to speak of the objects of any study, or to think lucidly about them, unless they are named. It is impossible to examine their relationships to each other and their places among the vast, incredibly complex phenomena of the universe, in short to treat them scientifically, without putting them into some sort of formal arrangement. . . . Taxonomy is at the same time the most elementary and the most inclusive part of zoology, most elementary because animals cannot be discussed or treated in a scientific way until some taxonomy has been achieved, and most inclusive because taxonomy in its various guises and branches eventually gathers together, utilizes, summarizes, and implements everything that is known about animals. . . ."

The Geological History and Evolution of Insects[1]

By F. M. Carpenter
Harvard University

[With 3 plates]

The purpose of this paper is to present briefly that conception of insect evolution which appears to be indicated by our present knowledge of the geological history of the group. Though some of my colleagues may not agree with my position on certain details, I believe the concept I offer will be acceptable, at least in its general aspects, to those who have given serious thought to the fossil record.

My index to the publications on fossil insects includes some 3,000 papers, contributed by 700 authors. Only two general, compilative treatises have appeared; one by Samuel Scudder in 1886 [1],[2] and the other by Anton Handlirsch in 1906–1908 [2]. Both of these authors had unique ideas on insect evolution, especially Handlirsch, whose views unfortunately are the ones usually found in textbooks of zoology, paleontology, and evolution. The material that forms the basis for the extensive literature in this field comprises the countless thousands of specimens, perhaps 500,000,[3] contained in the museums and university collections in Europe and North America. Up to the present time about 13,000 species of fossil insects have been formally described. The geological formations that have produced these specimens range from the Upper Carboniferous through to the present.

The first aspect of the evolution of insects that I shall consider is a general one. We can recognize four important stages in their history, our present insect fauna consisting of some representatives of all

[1] Based on the Sigma Xi address given at the meeting of the American Institute of Biological Sciences, Cornell University, September 1952. Reprinted by permission from American Scientist, vol. 41, No. 2, April 1953, copyrighted 1953 by the Society of the Sigma Xi.

[2] Figures in square brackets are references at end of text.

[3] This figure includes the 100,000 or more amber insects originally at the Albertus University of Königsberg, but apparently entirely destroyed by bombing during World War II.

stages. The first of these stages was a wingless insect, exemplified in our existing fauna by two orders, the Thysanura (silverfish) and the Entotrophi. The existence of such a phylogenetic group of wingless insects, termed the Apterygota, is based on the premise that wings evolved *after* the origin of insects and not *with* their origin—a conception that has been almost universally accepted by zoologists for fully 60 years. The opposite view, based on the belief that the first true insects were winged and that all wingless species are secondarily so, was advocated by Handlirsch [2, 3]; it was a corollary to his conviction that insects arose directly from trilobites, the lateral lobes of which became functional wings. So far as I am aware no one who has given serious thought to the subject, with the exception of Handlirsch, has accepted this idea. It is true that the wingless Apterygota are known only as far back as the Triassic period and that the winged insects, or Pterygota, extend to the Upper Carboniferous. However, apart from a few Baltic amber inclusions, only two specimens of Apterygota have been found in all geological strata. Their fragility and the very absence of wings, of which most fossil insects consist, make their chances of preservation as fossils very slight indeed. This is an instance in which the structure of living material furnishes more evidence than the geological record.

DEVELOPMENT OF WINGS

The second stage in the evolution of the insects began with the development of wings. The time when these appendages started to appear is not established, but three specimens of insects with fully developed wings have been found in the lowest of the Upper Carboniferous strata. Since these specimens belong to different orders, we can only conclude that wings began to evolve in the Lower Carboniferous period. However, even if the Upper Carboniferous record is accepted as the time of wing development, it is clear that the insects attained flight fully 50 million years before the reptiles and birds did—a period of time during which the insects, so far as is known, were the sole inhabitants of the air as aerial creatures. By the time flying reptiles and birds had evolved, the insects were well established in their new environment. It is intriguing, though futile, to reflect on the possibility that if the insects had not taken to the air before the vertebrates, they might never have successfully attained flight. The significance of flight for insects was undoubtedly great during the late Paleozoic. This was the age of amphibians and small reptiles. Scorpions, spiders, and spiderlike arachnids, belonging to extinct orders, were abundant. All these predators unquestionably subsisted to some extent, and probably to a great extent, on the wing-

less insects, which had no means of escape. It is not surprising, therefore, that the ability to fly changed the direction of insect evolution and that in our present insect world only one-tenth of 1 percent of the species are Apterygota.

The process by which wings were acquired by insects[4] has been a question of much speculation, for they are not modifications of previously existing appendages. However, significant evidence has been provided by the study of fossils. All the more generalized Pterygota of the Carboniferous period, and even some species of the Permian, possessed a pair of membranous flaps, arising from the dorsum of the first thoracic segment. These flaps contained veins and were covered with minute hairs like those of the true functional wings borne on the second and third thoracic segments. There is every indication that the true wings began, like membranous prothoracic flaps, as lateral tergal expansions. However, so far as we know, the prothoracic flaps never developed into functional wings. In most insects the flaps have completely disappeared and in others they have been absorbed into a pronotal disc.

The first winged insects, or Paleoptera, which we have been considering, had a simple wing articulation and were incapable of flexing their wings back over the body at rest; hence, they were preserved as fossils with their wings outstretched. Dragonflies and mayflies—the sole living representatives of the Paleoptera—exhibit the same limitations in wing structure. The third stage in insect evolution began with the modification of certain plates of the wing articulation so as to permit wing flexing; these insects are known as the Neoptera.[5] The survival value of wing flexing was great, for it enabled the insects, between flights, to hide among foliage or under objects on the ground. The fossil record shows that this stage was reached by early Upper Carboniferous time, when many of the paleopterous insects were predaceous and of great size, though no flying vertebrates had yet appeared. Later, when the flying reptiles, or pterosaurs, and birds appeared in the Mesozoic, the neopterous insects had all the advantage. The paleopterous insects, which had been dominant during the Carboniferous and Permian, began to wane and the Neoptera to flourish. This trend in insect evolution has continued up to the present time to such an extent that 90 percent of the existing orders, including 97 percent of the species, are now neopterous.

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[4] That the Pterygota are of monophyletic origin seems almost certain. Lemche, however, has advocated [4, 5] a polyphyletic origin, even claiming that such insects as the Grylloblattidae and the females of Zoraptera and of certain lampyrid beetles are primitively wingless (nonalate). The evidence for his conclusion seems insufficient (see, for example, Carpenter, 1948 [6]).

[5] The phylogenetic groups which are here termed the "Paleoptera" and "Neoptera" were recognized independently by Martynov [7, 8] and Crampton [9].

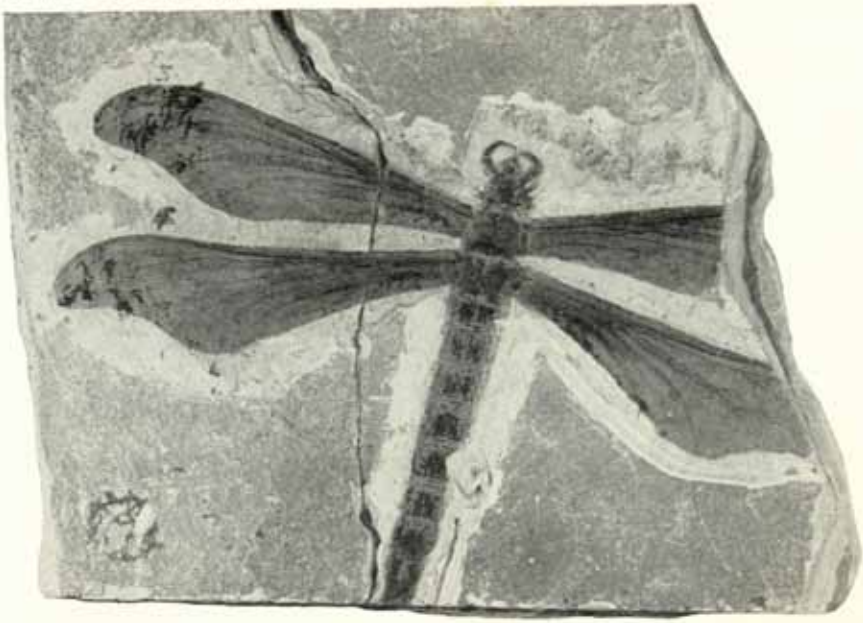
METAMORPHOSIS

The first of the neopterous insects were closely related to stoneflies and locusts and possessed incomplete metamorphosis, that is, they passed through a series of nymphal stages which gradually approached the adult form. These are designated as the hemimetabolous Neoptera. The fourth step in insect evolution was the development of a more complex type of metamorphosis, in which the insects pass through a series of larval stages bearing little resemblance to the adult. Eventually, they enter into one or two quiescent stages, during which extensive morphological and physiological changes take place. These, the holometabolous Neoptera, presumably had several advantages over the hemimetabolous types. The immature forms, being very different from the adults, could occupy different environments and feed on different types of foods. The tissues of other organisms, both animal and plant, were thus invaded by larval forms as internal parasites, the adult insects remaining free-living and capable of flight. The holometabolous insects make their first appearance in the Lower Permian strata. The existence of two orders, the scorpionflies or Mecoptera and the Neuroptera in the Lower Permian, shows that complete metamorphosis must have begun before the end of the Upper Carboniferous period. Starting from the beginning of the Permian, when only about 5 percent of the known species of insects had complete metamorphosis, the percentage of species has progressively increased to the present maximum of 88 percent.

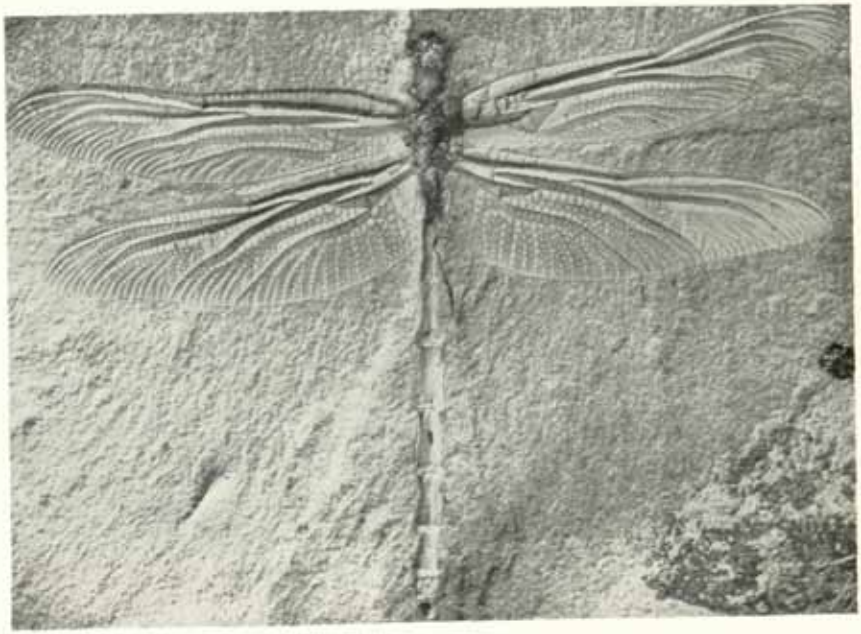
A simple phylogenetic diagram, shown in figure 1, superimposed on the geological time scale, serves to summarize this general aspect of insect evolution. The three modifications—origin of wings, wing flexing, and complete metamorphosis—mark the points of separation of the phylogenetic lines. Since holometabolous insects are known to have existed from the Lower Permian strata, the upper phylogenetic division must have taken place before the end of the Upper Carboniferous; and since neopterous insects are known from the lowest of the Upper Carboniferous strata, the middle division, or wing flexing, must have taken place in the Lower Carboniferous, which is beyond the present record of the insects. The first phylogenetic division must have occurred even earlier.

FOSSIL RECORD

Turning from this phylogenetic treatment of the insects, I shall next consider their history as it is now actually known from the fossil record. This discussion will involve some mention of extinct orders and an explanation of my point of view on this controversial subject. The artificial and arbitrary nature of higher taxonomic categories is



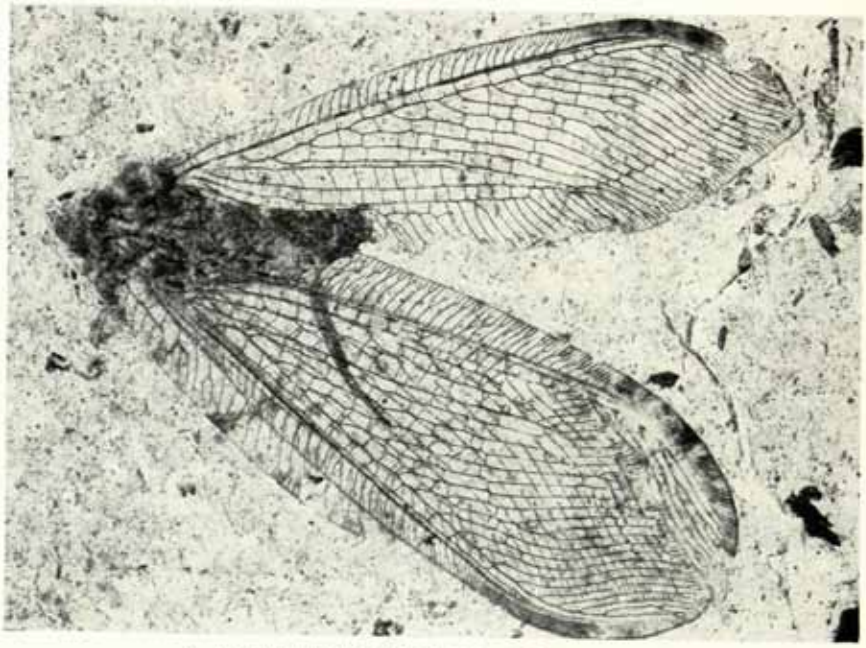
1. MISCHOPTERA NIGRA BRONGNIART.
A megasecopteron from the Carboniferous of France. × .7.



2. PROTOLINDENIA WITTEI (GIEBEL).
An odonatan from the Jurassic of Bavaria. × 1.2.

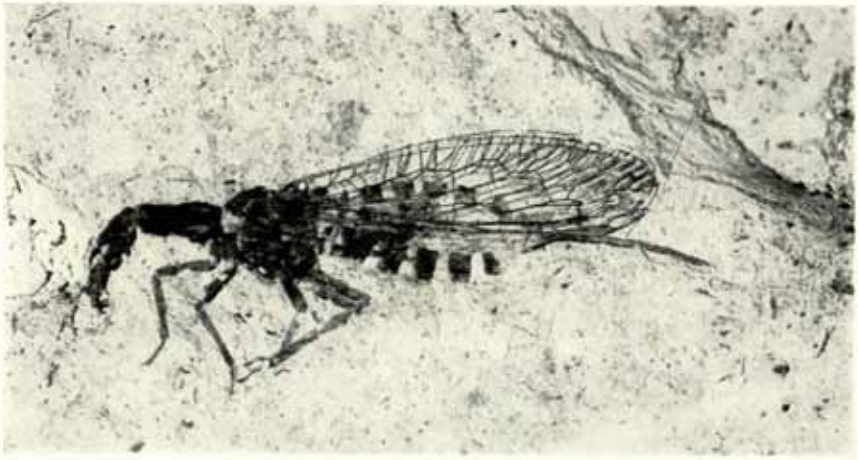
1. CLATROTITAN ANDERSONI MCKEOWN.

An orthopteron with a large stridulatory organ, from the Triassic of New South Wales. × 7.



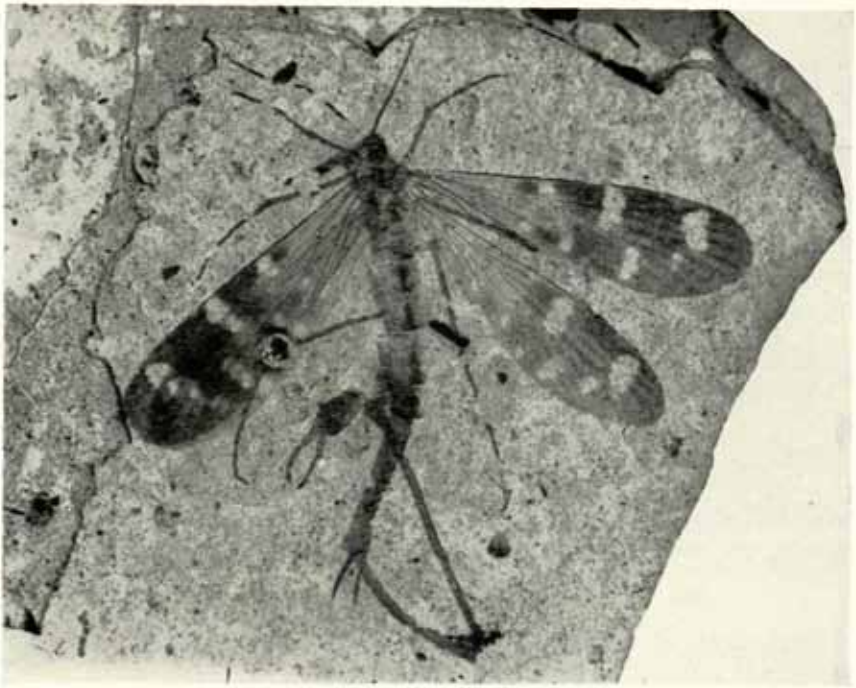
2. LITHOSMYLUS COLUMBIANUS (COCKERELL).

An osmylid fly (Neuroptera) from the Miocene shales of Colorado. The family Osmylidae does not now occur in North America. × 3.3.



1. RAPHIDIA MORTUA (ROHWER).

A snakefly from the Miocene shales of Colorado. The genus *Raphidia* does not now occur in North America × 5.



2. HOLCORPA MACULOSA SCUDDER.

A scorpionfly from the Miocene shales of Colorado. × 2.5.

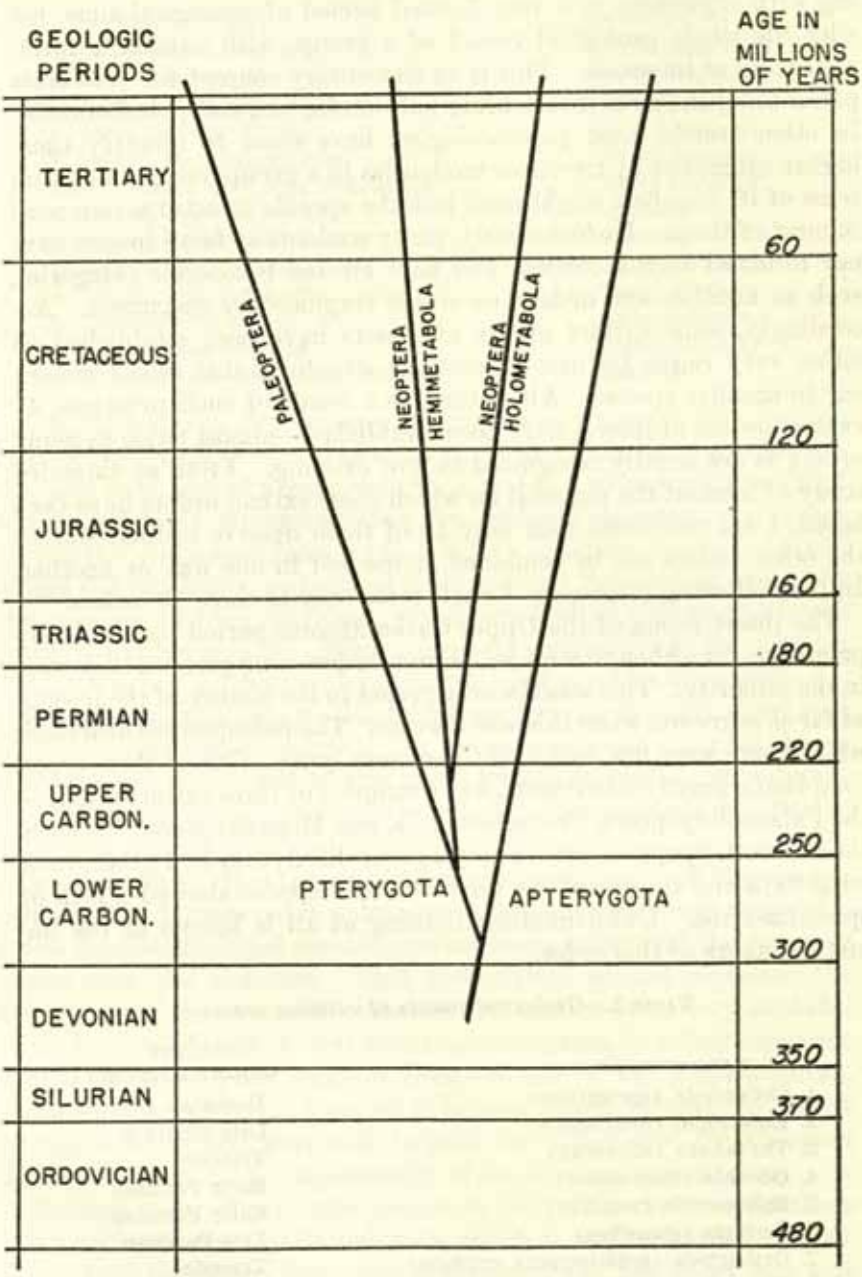


FIGURE 1.—Main lines of insect evolution, as described in the text.

well known to systematists. Such categories are established for dealing with organisms in a very limited period of geological time, not with the whole geological record of a group, with annectent forms appearing at intervals. This is an elementary concept for vertebrate paleontologists, most invertebrate paleontologists, and paleobotanists. In other words, most paleontologists have come to identify these higher categories by trends or tendencies in a group, recognizing that some of its members might even lack the specific structures indicated in most of them. Unfortunately, many students of fossil insects have not followed such a concept and have erected taxonomic categories, such as families and orders, on single fragmentary specimens. Accordingly, some extinct orders of insects have been established on either very vague features or peculiar structures that might not occur in another species. Altogether, as a result of such practices, 44 extinct orders of insects have been established—almost twice as many orders as are usually recognized as now existing. From an extended study of most of the material on which these extinct orders have been based, I am convinced that only 10 of them deserve ordinal status; the other orders can be combined or merged in one way or another. In the following discussion, I shall refer only to these 10 orders.

The insect fauna of the Upper Carboniferous period was basically primitive, for although some neopterous orders were present, they were in the minority. This was the only period in the history of the insects, so far as is known, when this was the case. The paleopterous orders, of which there were five, included three main types. One of these types, comprising mayfly-like insects, was a complex of three extinct orders—the Palaeodictyoptera, Protephemerida, and Megasecoptera. Of these the Palaeodictyoptera were the most generalized; they had prothoracic wing flaps and in general the Carboniferous species showed a lack of specializations. Unfortunately, nothing at all is known of the immature stages of this order.

TABLE 1.—*Geological ranges of existing orders*

NAME OF ORDER	EARLIEST GEOLOGICAL RECORD
1. Collembola (springtails)	Devonian [?]
2. Entotrophi (bristletails)	Late Tertiary
3. Thysanura (silverfish)	Triassic
4. Odonata (dragonflies)	Early Permian
5. Ephemerida (mayflies)	Early Permian
6. Perlaria (stoneflies)	Late Permian
7. Orthoptera (grasshoppers, crickets)	Triassic
8. Blattaria (roaches)	Late Carboniferous
9. Isoptera (termites)	Early Tertiary
10. Dermaptera (earwigs)	Jurassic
11. Embiaria (embiids)	Early Tertiary
12. Corrodentia (book lice)	Early Permian

TABLE 1.—*Geological ranges of existing orders*—Continued

NAME OF ORDER	EARLIEST GEOLOGICAL RECORD
13. Mallophaga (bird lice)	[No fossils known]
14. Hemiptera (bugs)	Early Permian
15. Anoplura (sucking lice)	Pleistocene
16. Thysanoptera (thrips)	Late Permian
17. Mecoptera (scorpionflies)	Early Permian
18. Neuroptera (ant lions, dobsonflies)	Early Permian
19. Trichoptera (caddis-flies)	Jurassic
20. Diptera (flies, mosquitoes)	Jurassic
21. Siphonaptera (fleas)	Early Tertiary
22. Lepidoptera (butterflies, moths)	Early Tertiary
23. Coleoptera (beetles)	Late Permian
24. Strepsiptera (stylops)	Early Tertiary
25. Hymenoptera (bees, ants, wasps)	Jurassic

The little-known Protephemerida require no comment here, but the Megasecoptera show several unusual features. They had very long abdominal cerci, lacked prothoracic flaps, and had more highly modified wings and body structures than the Palaeodictyoptera. In some species the wings were falcate (pl. 1, fig. 1), in others petiolate; in still others the prothorax was armed with spines. Noteworthy, also, was the presence of wing markings, which are evident even in specimens preserved in black shale. What colors were originally in the wings is not known, but a definite color pattern is indicated in the fossils.

As paleopterous insects, the Megasecoptera presumably developed by incomplete metamorphosis; the presence of true nymphal forms definitely associated with adults, in the British coal measures, substantiates this conclusion. It should be noted, on the contrary, that Forbes [10], has expressed the belief that the Megasecoptera were actually holometabolous. It is true that, although most species of Megasecoptera are found preserved in paleopterous fashion with wings outspread, a few families included species that unquestionably held their resting wings over the abdomen. That these latter species represent the beginnings of the true neopterous line of evolution seems very doubtful to me in view of their several specializations; also, that they represent a distinct order, quite removed from the rest of the Megasecoptera, seems equally unlikely. I am led to believe, therefore, that the species of this order which were able to hold the wings over the abdomen developed this ability independently of the true neopterous types.

Another order of paleopterous insects, very different from the three just mentioned, was the Protodonata, which closely resembled dragonflies. Like the latter, they were predaceous, and had spiny legs and large mandibles. All the Protodonata were large and some members of one family, with a wing expanse of 2½ feet, were the largest insects

known.[6] Nymphs of the Protodonata are entirely unknown, but in view of the similarity of the adults to true Odonata, we infer that the immature stages could not have been very different.

The third type of paleopterous insect in the Carboniferous fauna has no counterpart in an existing order. Although named the Protohemiptera, they were closely allied to the Palaeodictyoptera, since they possessed prothoracic wing flaps and other characteristics of the latter. But the mouth parts of the Protohemiptera were modified to form a long suctorial beak, resembling that of certain Diptera, or flies, though differently formed. The Carboniferous members of this order were so much like the Palaeodictyoptera that some of the insects whose head structure is unknown and which have been considered Palaeodictyoptera, were, I believe, Protohemiptera. The members of this order presumably fed either on plant juices from the large club mosses and tree ferns, or on the blood of amphibians and reptiles.

The neopterous insects of the Carboniferous include a vast and confusing assemblage related to the locusts and stone flies. Most of the species belong in the extinct order Protorthoptera, with a few aberrant ones in the Caloneurodea, and still others, obviously true roaches, in the Blattaria. The Protorthoptera show great diversity of structure. The more generalized species had membranous forewings and cursorial legs; others had leathery wings and either saltatorial or prehensile legs. Essentially, the Protorthoptera possessed the same amount and the kind of diversity that exists among the true Orthoptera, yet it is highly doubtful that any of these Carboniferous forms gave rise directly to the living groups they resemble.

The roaches were another interesting order in the Carboniferous. Although in numbers of individuals and described species they exceeded all other Carboniferous insect orders, I am convinced that their abundance is very misleading. The swampy areas inhabited by the roaches supplied the best of conditions for their preservation as fossils, whereas other insects might encounter such optimum conditions only rarely. This condition would account for a disproportionately large number of roaches preserved as fossils. The extensive series of described species of roaches is due to the fact that Handlirsch and others have ignored the extreme instability of wing venation in both living and extinct types. Apart from their numbers, the most notable feature of the Carboniferous roaches was their close resemblance to species now living. Recently, however, an unexpected structure has been discovered in some Carboniferous roaches from Belgium: a long, projecting ovipositor, fully as long as the abdomen [11]. In all living roaches the ovipositor is vestigial or rudimentary, and the eggs

[6] These particular insects are the only extinct insects, so far as is known, that were larger than existing species. The inference has been drawn from the Protodonata that all Paleozoic insects were very large, but this is not the case.

are either laid in large capsules or else they hatch and form nymphs in the body of the female parent. The ovipositor in some of the Carboniferous species indicates a very different method of egg laying.

From this survey of the Carboniferous fauna it is apparent that the insects had acquired surprising diversity and specializations by the Upper Carboniferous period, though some really generalized species were also included. Nevertheless, I am convinced that we have not yet begun to appreciate the extent of the Upper Carboniferous insect fauna. This conviction is based in part on the nature of the fauna in the lowest Permian strata and in part on the known diversity of the Carboniferous insects, even though represented by relatively few species. If the same number of living species were collected at a few isolated localities over the world, we could not expect to obtain from them a good idea of the complexity of the world fauna as it exists today. It is not beyond the limits of possibility, therefore, that the extinct orders of Carboniferous insects were in their time comparable in extent to the major orders now living.

The insect fauna of the early Permian period was distinctive, for it was a combination of nine extinct orders and seven living ones. None of the extinct orders, except the Protodonata, are known to have lived beyond the Permian. The Palaeodictyoptera and Protohemiptera had apparently reached their maximum development in the Upper Carboniferous, only a very few having been found in Permian strata. The Megasecoptera, on the contrary, flourished all through the period. The Protodonata, also, were more numerous than in the preceding period, and very large species, like those previously noted, have been found in Permian beds in Kansas, Oklahoma, and several parts of Europe. Since no flying vertebrates were yet in existence, these large predatory insects must have ruled the air for many millions of years, for they persisted well into the Mesozoic. They may have been an important factor in the extermination of soft-bodied and weak-flying insects, such as the Palaeodictyoptera and Megasecoptera. The Permian Protorthoptera continued to show diversity of form. Among them, for example, are some whose cerci or posterior appendages in the male were modified to form pincers, or claws, resembling those in some of the living Orthoptera.

Three additional extinct insect orders make their first appearance in the early Permian. One of these, the Protelytroptera, which were related to the earwigs, were the first insects known to develop true protective forewings, or elytra; also the hind wings were greatly expanded and contained hinges which enabled the wings to fold up beneath the overlying elytera. Another extinct order of the early Permian, the Protoperlaria, was related to the stoneflies; the adults were generalized with prothoracic wing flaps, but the nymphs were

adapted for an aquatic life. The final extinct order, the Glosselytrodea, appeared in the late Permian; they were characterized by highly modified elytra with unique venation.

The living insect orders of the early Permian, in addition to the roaches, comprised the mayflies, dragonflies, bark lice, true bugs, flies, and Neuroptera. With the exception of the Neuroptera, these Permian representatives were more generalized in most respects than any existing members of their orders. The Permian mayflies, for example, had homonomous wings, whereas in all living species the posterior pair of wings are much reduced, both in size and venation. The Lower Permian was apparently close to the time of origin of most of these orders, for basic characteristics of related orders are combined in some species. A surprising feature is that these first insect representatives of existing orders are smaller in size than most present species of their orders, and some of the fossil species are as small as the smallest now living.

Before the end of the Permian, three more living orders of insects appeared. One of these, the stoneflies, included a species which can be assigned with confidence to a living family. The other two orders comprise the thrips and the beetles. The dominant insects of the late Permian were true bugs, or Homoptera, which were clearly adapted for feeding on plant juices.

As is evident from this survey, the Permian insects were a remarkable assemblage. During no other geological period has such a diverse insect fauna existed. A striking contrast is found in the Triassic, at the beginning of the Mesozoic, in which the disappearance of all extinct orders, except the Protodonata, transformed the facies of the Triassic fauna to a semblance of that at present. True orthopteran insects first appear in Triassic beds. Among them were several species having well-developed stridulatory structures on the forewings of the males. The insects had a wing expanse of about 9 inches, and stridulatory area of the wing was fully as large as that in any living insect, as shown in plate 1, figure 2.

By the beginning of the Jurassic the Protodonata became extinct, possibly because of the flying reptiles, or pterosaurs, which appeared early in the period. Earwigs, caddis-flies, true flies, and the Hymenoptera are found in middle Jurassic strata. The flies or Diptera were almost exclusively midges or cranefly-like, there being none of the higher Diptera, many of which are now conspicuously associated with flowering plants. Similarly, the Hymenoptera were either relatives of sawflies or parasitic types; the aculeates, such as bees and wasps, were absent. Many of the Jurassic insects belonged to families now living (see pl. 2, fig. 1). Looking at such specimens one finds it difficult to realize that they were contemporary with the pterosaurs, dinosaurs, and *Archaeopteryx*.

The Cretaceous insect fauna is virtually unknown, since very few specimens have been found. The gap is an unfortunate one, for a rapid development of the flowering plants and of the vertebrates took place during this long period. It is not surprising that insects of the early Tertiary period consist almost exclusively of families now living and to a large extent of living genera. The Lepidoptera and Isoptera first appear in early Tertiary rocks, but the nature of the earliest representatives shows that these groups arose in the Mesozoic. The insects of the Tertiary are better known than those of any equivalent interval of geologic time, largely because of the Baltic amber, which was formed from the resin of pine trees about 50 million years ago and which has preserved types of insects that would almost certainly not occur in rock formations. For example, two specimens of fleas, presumably from a rodent inhabiting the amber forest, have been found in the amber. The amber inclusions have also enabled more exact comparisons with living insects than ordinary preservation would permit. There are several instances of genera being recognized and established for amber species and subsequently being found in existence. More remarkable still is the occurrence in the amber of certain species of insects, mostly ants, which are apparently identical with some species now living. The Baltic amber has also furnished proof of the existence of social habits among the insects of that time, for the ants that occur there include, in addition to males and females, major and minor workers. The extent to which the complex habits of living ants had already been acquired in the early Tertiary is shown by the presence of plant lice attended by ants in search for honey dew, and by the presence of mites attached to the ants in the same manner as is characteristic today. It is worth noting, however, that by no means all of the families of insects had acquired such evolutionary stability by the early Tertiary period. The bees preserved in the amber, for example, belong to extinct genera.

A study of Tertiary insects also contributes to our understanding of the geographical distribution of living families and genera, many of which occupied very different regions from those now inhabited (see pl. 2, fig. 2; pl. 3, fig. 1). An example of this is shown in plate 3, figure 2, which depicts a peculiar scorpionfly from mid-Tertiary shales in Colorado; it belongs to a group now restricted to parts of Asia. Hundreds of examples of such changes could be given [12]. The best known of these is the occurrence in the Colorado Tertiary of tsetse flies (Glossinidae), now confined to Africa. Incidently, the suggestion has been made by several mammalogists that trypanosomiasis, a protozoan disease now transmitted by the tsetse flies in Africa, might have been a factor in the extermination of some of the Tertiary mammals in North America.

A number of inferences might be drawn from the geological history of the insects as we now know it, only a few of which have been indicated above. Certainly there is one justifiable conclusion, namely, that our existing insect fauna is but a small fragment of the total insect aggregation that has occupied the earth during the past 250 million years. Understanding of insect evolution depends to a large extent on a knowledge of the extinct insect population. The investigation of the fossil record has only begun, and progress is slow, but the significance of the record increases with each discovery.

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The Coelacanth Fishes[1]

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[With 1 plate]

Now that most of the excitement over the discovery of a second specimen of a living coelacanth fish has died down for the time being and Prof. J. L. B. Smith's preliminary account of the creature has been published in Nature (January 17, 1953, pp. 99–101), we may make an assessment of its importance.

The landing of the first coelacanth late in 1938, it will be recalled, created one of the biggest sensations for many years among zoologists, and rightly so, for it showed the continued existence of an archaic type of animal that scientists thought had disappeared some 70 million years ago, at the end of the age of the great reptiles: the dinosaurs, the marine ichthyosaurs and plesiosaurs, and the flying pterodactyls. So far as we then knew, the last coelacanths swam in the shallow seas which at that remote period covered what is now the south of England, when the white chalk, the characteristic feature of the cliffs of our southeast coastline, was being formed as ooze on the sea floor.

The impact of this discovery on the mind of the general public was extraordinary, for fishes do not often make news items in daily papers, and probably it can be justifiably claimed that no fish was ever considered more newsworthy.

The circumstances of the discovery of the second coelacanth just before Christmas of 1952 were equally dramatic, but in a different way and one more likely to appeal to popular imagination—it will be remembered how Professor Smith, who had for 14 years sought for it up and down the coast of East Africa, flew some 2,000 miles to the remote Comoro Islands in a successful attempt to beat the weather and the forces of decomposition. His haste to reach the second coelacanth was dictated by the need to ensure that this specimen should not suffer the fate of the first—that specimen was little more than

[1] Reprinted by permission from Discovery, April 1953, Norwich, England.

a stuffed skin by the time it came into his hands—for he wanted to be able to preserve the whole fish so that its internal organs should be available for scientific investigation.

If anything, this event aroused even more interest than the first, although the experts had been waiting for it to happen, for it was considered most unlikely that the first specimen (which Professor Smith called *Latimeria chalumnae*) was the very last of its kind. Sooner or later another specimen of *Latimeria* seemed certain to be caught as a result of the intensive search that its appearance had provoked. But what we had not expected was that the next specimen should belong to an altogether different kind, now named *Malania anjouanae*, and the existence of a third and smaller species is hinted at. For a single isolated animal to have been overlooked is understandable enough, but when it comes to two or three, constituting a small fauna, it is quite another matter and suggests further inquiry into the reasons for their separation.

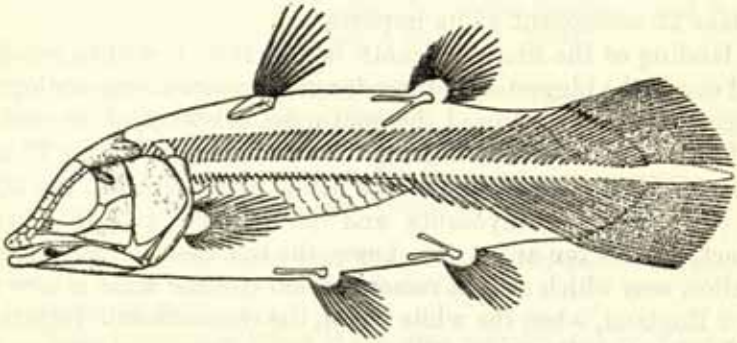


FIGURE 1.—The last known fossil coelacanth, *Macropoma lewesiensis*, from the Chalk of southeast England. In this restored figure the scales have been omitted to show the bony air sac lying under the backbone. (After Smith Woodward, "Fossil Fishes of the English Chalk," courtesy of Palaeontographical Society, London.)

The name *Coelacanthus* was first given by the great Swiss naturalist, Louis Agassiz, in 1839, to a fossil found during work on one of the early railway cuttings at Ferryhill, about 7 miles south of Durham. It came from the Marl Slate, which is of Permian age and therefore 200 million years old, and the name is derived from the Greek, κοῖλος hollow, and ἄκανθα a spine, because the fin rays (i. e., the slender bones supporting the fins) were ossified only superficially, leaving large internal cavities in the fossils. Since the time of Agassiz many different genera of coelacanths have been described from various formations and areas, starting from the Upper Devonian and ending, as we once thought, in the Upper Cretaceous, a span of some 230 million years.

During this vast period of time the coelacanths changed very little in general appearance (fig. 1 and pl. 1, fig. 1). Many of the fossil

forms were quite small fishes, some only a few inches in length like the Carboniferous *Rhabdoderma* and the Triassic *Whiteia*, but one, *Mawsonia* from the Cretaceous rocks of Brazil, probably exceeded in size the living specimens, the larger of which was 5 feet long.

Their most striking feature is provided by the paired fins (the first two lower fins seen in fig. 1 and pl. 1, figs. 1 and 2), which correspond to our arms and legs and which are borne on muscular scaly lobes instead of being fanlike and coming straight from the body, as in more familiar fishes. A similar single fin is to be seen just behind the vent about midway between the hinder pair and the tail, and another lies opposite it on the back. This last fin is the posterior dorsal fin; there is another one in front of it and placed halfway toward the back of the head, the anterior dorsal fin, but this always lacks the scaly lobe.

The form of the tail is also peculiar. There is no marked constriction in front of the fin; the scaly body just narrows rapidly and evenly, dividing the fin rays into two equal parts above and below it, and in many coelacanths it continues beyond them to form a small supplementary tail (pl. 1, fig. 1). There was one other extraordinary feature. In fossil fishes as a rule little or nothing is found of their "insides" since the contents of the body cavity—heart, liver, intestines, and so on—were soft and decayed rapidly, but in the coelacanths the air sac was sheathed in bony scales and therefore largely rigid. In all probability this organ was a functional lung in the ancestors of the coelacanths, and is so in their living nearest relations, the lungfishes (Dipnoi). In most modern fishes it persists as a long membranous bag which acts as a hydrostatic organ, the gaseous content being adjusted to keep the fish buoyant at any particular depth. Its remains are sometimes seen as a silver streak in the breakfast herring.

Latimeria, the specimen caught in 1938, shows all the external features characteristic of the coelacanth group, some in an exaggerated form. The small supplementary tail is well developed, and the lobes of the scaly-based fins are much lengthened, in fact considerably more so than in the fossils, so that they stand well away from the body, looking very much as if they really were on the way to becoming walking limbs. This fish was 5 feet long, weighed 127 pounds, and was steel-blue in color.

The new fish, which is a male, is some 6 inches shorter. It looks similar except that it lacks the supplementary tail fin and the anterior fanlike fin on the back (pl. 1, figs. 2 and 3). It was the absence of these two typical coelacanth features that was apparently the chief reason why Professor Smith referred it to a different genus, *Malania;* but if one looks carefully at the published photograph of it (pl. 1, fig. 2) one sees an unnatural-looking dip in the back where the front

fin should have been, and as Professor Smith says, the scales there are irregularly arranged so that the absence of the fin may be due to an injury when young. Moreover, the tail is very blunt, and not only is there no supplementary fin projecting beyond it (cf. pl. 1, fig. 1) but the fish lacks that scaly extension of the body, which in all other coelacanths separated the upper and lower halves of the tail fin. Instead there appears to be an obvious irregularity in the tail where this extension could have been (pl. 1, fig. 3). This suggests that the absence of the extension is also due to damage. It is true that other differences between the two fishes are said to exist. For instance, the scales are described as being smaller in *Malania*, and Professor Smith states that the suspension of the lower jaws is different; but the first point is not clear in the photograph and the second seems rather unlikely: the head has evidently been badly knocked about, and the lower jaws seem to be thrust forward unnaturally. Anyway, until full details are forthcoming, we must reserve judgment as to whether the two fishes really are so different or whether *Malania* is not just an unfortunately mutilated edition of *Latimeria*.

There is one special character of these two fishes that has attracted much attention, and that is their extreme oiliness, which has been linked by some people with the theory that the mineral oils, such as petroleum, were derived from the decay of vast numbers of fishes and other creatures that have lived and died throughout the ages. Although this explanation of petroleum formation is favored by many geologists, it must be emphasized that the composition and qualities of animal oils and mineral oils are very different and, so far as I know, there is as yet no process known by which the one can be converted into the other.

The two most popular ideas about the coelacanths are that they are either "living fossils" millions of years old, or else "missing links" that will somehow throw light on man's remote ancestry.

THE DATE OF THE FIRST COELACANTHS

First of all let us get it quite clear that the individual fishes are not abnormally old, probably no older than any other fishes of similar size, and are 5, 10, or perhaps 20 years at the most. Nevertheless the term "living fossil" does serve one useful purpose, as it emphasizes the fact that these coelacanth specimens belong to a type of animal that has survived long beyond its appropriate era. According to our ideas they ought to be extinct but are not. Perhaps a few remarks about geological time and evolution will make this point clearer.

Life as we know it on this planet is at least 600 million years old. It started first with the smallest and simplest types, and as the eras passed, higher and more complex animals and plants developed in a

more or less orderly sequence. The coelacanths are first found near the middle of the sequence, some 300 million years ago, and it may help us to appreciate the vastness of this ancestral record when we recall that man did not appear for another 299 million years, for the earliest known remains accredited to the genus *Homo* are rather less than one million years old.

From the discovery of their fossil remains we know approximately when each type appeared and how long it persisted. The fossils do not give us the time in years; that is done by physical methods, such as the lead ratio in radioactive minerals whose rate of disintegration is known; but once that has been fixed for a particular series of rock, then the fossils allow us to correlate it with other series with similar faunas or floras elsewhere. Thus fossils do allow us to identify and date the rocks in which they are found.

But our knowledge of the succession of life as applied to each individual type of animal or plant is empirical, the result of experience and something that cannot be calculated. We cannot foretell, for instance, how long any newly discovered form will continue, and we do not know why some creatures have persisted through countless ages, sometimes with little change, while others have made a brief and widespread appearance in the geological record, only to disappear as suddenly as they came. It is this last type that is most useful to the geologist, for they can be used to identify a particular stratum and so enable him to make precise correlations of strata over large areas.

The causes of extinction in nature are not well understood. Many animals and plants, of course, did not actually die out, but instead changed into more advanced forms by the process of evolution. Others undoubtedly did become extinct, and sometimes whole groups like the great reptiles, the dinosaurs, faded out.

A common explanation of extinction in animals is that with limited food supplies the more primitive types were unable to compete with the more highly developed; in some cases the latter may have actually preyed upon them, especially their young, as the early mammals are said to have preyed on the untended eggs of the great herbivorous dinosaurs—and of course when they became extinct, then their flesh-eating relatives that fed on them had to disappear also. But earth movements, resulting in the gradual rising or sinking of the land, must have been a prime factor; for the changes in the level of the land surface may well have affected the climate adversely, and that in turn would affect the animals (especially cold-blooded animals like reptiles) or their food supplies. The possibility of epizootic diseases must also be considered. On more than one occasion the big game of Africa has been decimated over wide areas by rinderpest, and such

an occurrence could well put "paid" to a weakling species. Anyway, it was thought until 1938 that this group of fishes had gone with the dinosaurs, and their sudden reappearance after an interval of 70 million years gave the scientific world—and other people too—something to talk about.

It is this long absence from the geological record that makes the reappearance of the coelacanths so interesting, for in the animal kingdom as a whole so-called "living fossils" are not uncommon. Indeed the coelacanth's own, if distant and rather degenerate, cousins—the lungfishes— still exist on three continents. The whole native fauna of Australia is an archaic survival that has been saved from extinction by that continent's isolation. We also have the textbook case of the tuatara, the sole survivor of a group of lizardlike reptiles, the Rhynchocephalia, that flourished in Triassic times, more than 150 million years ago.

However, not all living fossils are by any means the struggling survivors of once important groups—the all too successful cockroaches represent a type of insect that goes back to the time of the great coal forests, while some of the living sharks and skates have a respectable ancestry of more than 100 million years.

There is, however, one important difference between the history of most of the animals that have been mentioned and that of the coelacanths. Whereas most of the former became adapted to a certain type of environment and stuck to it, the coelacanths have continually changed their habitat. The first primitive types of the Devonian rocks (the diplocercids) were marine, but the succeeding forms of the Carboniferous period were mostly inhabitants of the fresh waters. Later, in Triassic times, they went into the shallow seas, venturing into rather deeper waters as time went on. So one of their claims to zoological fame is *adaptability without obvious structural change.*

How common coelacanths were in the past it is not easy to say, for fossil numbers do not always by any means reflect the rarity or otherwise of the living animal owing to the varying chances of preservation and discovery.

On the whole, coelacanths are rather rare as fossils, although occasionally in a particular locality they have proved to be not uncommon; in one instance, many hundreds of fossil coelacanths were found in Triassic rock that was being excavated for the foundations of a new building at Princeton University.

The accompanying diagram, which also gives a useful time scale, shows the relative numbers of known different kinds at various periods, and the rise and decline in actual numbers of individuals probably follows the same pattern. The absence of the coelacanths from the geological record for the last 70 million years is most intriguing, and

suggests that during this time they lived in the somewhat deeper parts of the seas, to which they had retreated in the face of competition, and where sedimentation would have been slight and the chances of their remains being preserved would therefore have been slim. A similar suggestion was made regarding the living forms when the *Latimeria* specimen was caught 14 years ago, for it is clear that they inhabit regions not commonly fished. However, this suggestion has been questioned since we now have reason to believe that a few are caught every year in the shallow, rocky waters around the Comoro Islands. Yet the landing of two or three specimens a year in a particular area which is regularly fished does not necessarily mean that the focal point is in that area. Fish do wander, and they also make seasonal migrations—both specimens, we may note, were caught in December.

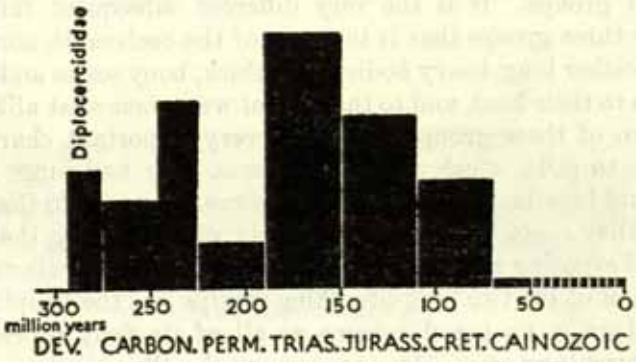


FIGURE 2.—Diagram showing the relative number of species of coelacanths recorded from the different periods in the geological succession. The small number shown in the Permian is probably unreal, owing to poor conditions for preservation during that period. (After Prof. F. E. Zeuner, courtesy of Discovery.)

It is difficult to understand how any creatures so unchanging as the coelacanths could be considered as "missing links," since it is the essence of a biological link that it should connect two different types, and that is just what coelacanths did not do. But they do belong to a curious archaic type of fish—the fringe-finned fishes (Crossopterygii)—that differ in many ways from those with which most people are familiar.

The average person knows perhaps a score or two of fishes, and these are all very uniform in structure, in spite of great variation in shape and color: they are nearly all of the type known as teleosts. More interesting to the scientist are the lungfishes, bowfins, and garpikes, but these are rarely kept except in the larger aquaria in zoos.

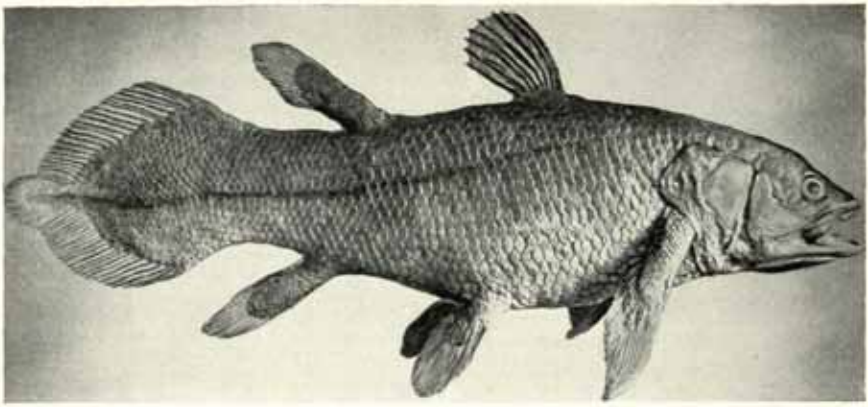
Not all fishlike creatures are really fishes. Apart from the whales, dolphins, and porpoises, which are mammals, and the extinct ichthyosaurs, which were reptiles, there are the eel-like lampreys and their kin, which belong to a much more primitive group.

True fishes belong to three very distinct types whose common ancestors have never been found. One type—the elasmobranchs—is represented by the sharks and skates, with their skeleton of gristle instead of bone, five or more open gill slits, and skin of shagreen. The second type—the Actinopterygii—includes the teleosts which form the great majority of living fishes, with a bony skeleton, the fanlike fins, gill slits hidden by the large gill cover or operculum, and the body covered with usually small, thin scales. The third type—the Crossopterygii—comprises the coelacanths and their relatives; these are thick-scaled and lobe-finned, with the skeleton part gristle, part bone.

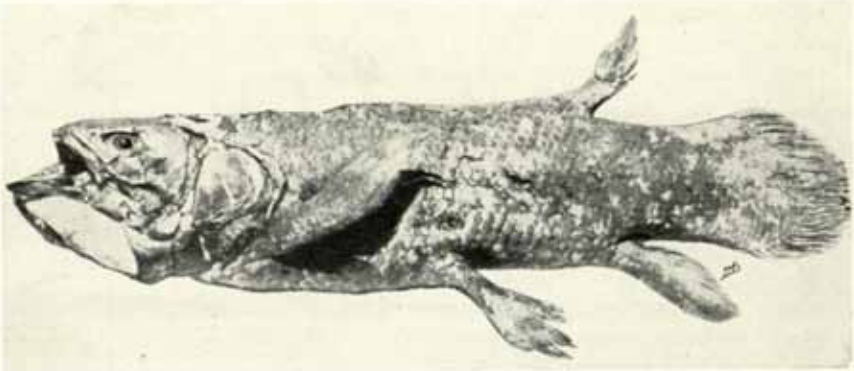
When we found the first traces of the Crossopterygii, in Devonian strata some 300 million years ago, they were already divided into three different groups. It is the very different subsequent fate of each of those three groups that is the crux of the coelacanth story. They all had rather long, heavy bodies with thick, bony scales and lobed fins common to their kind, and to that extent were somewhat alike. However, two of these groups had other very important characters: in addition to gills, which all fishes possess, they had lungs by which they could breathe air directly, and internal openings to their nostrils so that they could breathe air regularly while keeping their mouths shut and exposing no more than the tip of their snouts above water.

The first of the two lung-breathing groups was the Rhipidistia, for which there is no popular name as all of its fishy representatives disappeared long ago. However, among the Rhipidistia was a small progressive element which used their limblike fins and their ability to breathe air to scramble ashore when the pools in which they lived started to dry up in the hot seasons and to move overland to fresh waters. In the course of time they became more and more adapted to spending part of their life on land, their paired fins actually developing into true legs. When this stage was reached they were no longer fish, but primitive Amphibia. From some of these early Amphibia evolved the scaly reptiles, which are entirely independent of water except for drinking, although some, like the crocodiles and the turtles, have returned to an aquatic mode of life. Still later, a branch of the reptiles gave rise to the mammals. Thus it will be realized that it was the Rhipidistia which were our remote ancestors (fig. 3).

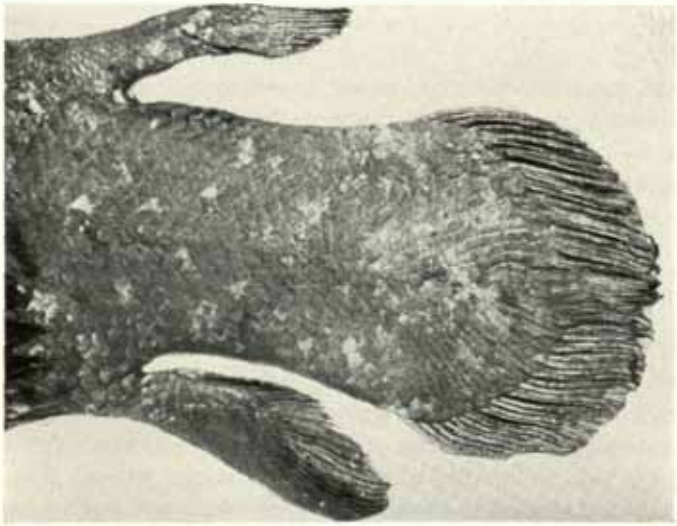
The second air-breathing group of fish apparently lacked the ability to evolve further and became somewhat degenerate. They stayed in their drying-up pools and just used their lungs to tide themselves over until the next wet season. Nevertheless, by their ability to endure unpleasant conditions they have so far avoided extinction. Lungfishes (Dipnoi) are still to be found in pools, swamps, and intermittent rivers in parts of Australia, Africa, and South America.



1. Restored model of *Latimeria chalumnae*, the first living coelacanth found. About 5 feet long.



2. *Malania anjouanae*, the second specimen of a living coelacanth, caught December 1952. About 4½ feet long. (Courtesy of Prof. J. L. B. Smith and Nature.)



3. The tail and hinder fins of *Malania* in greater detail. (Courtesy of Prof. J. L. B. Smith and Nature.)

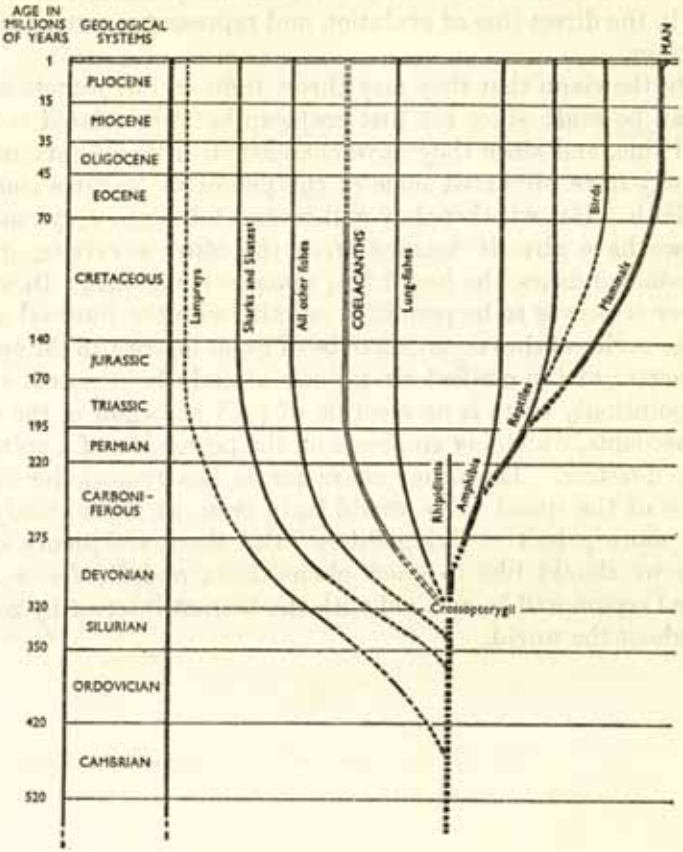


FIGURE 3.—Diagram showing the relationships of the coelacanths to other backboned animals and their distribution in the geological succession. Time in millions of years. (Courtesy of Discovery.)

The third group of fringe-finned fishes were the coelacanths, and their story is the least eventful of them all: it shows remarkably little in the way of evolutionary change. The coelacanths had two great disadvantages compared with their relations. They had no through passage from their nostrils into their mouths—whether they once had one but lost it early, or whether they never had such a passage the records do not show—and, as we have already noted, their lung or air sac was sheathed in bony scales. What purpose this served, scientists would like to know. It must have had a function of some importance, for it was a conspicuous feature in the fossils for about 200 million years: it may have acted as a resonator, increasing their perception of sound waves, as the air sac does in some modern fishes. We do know, however, that the coelacanths neither went up the scale of life nor down—they just remained coelacanths. They

were related to our far-off ancestors, the Rhipidistia, but they were never in the direct line of evolution and represent a sort of biological backwater.

As to the claim that they may throw light on our remote ancestry, this can be said: since the first coelacanths were related to the ancestral line, and since they have changed so little in outward form, they may have preserved some of the primitive features common to them both. But whether they will in fact tell us so very much more than we have already learned from the other surviving group of fringe-finned fishes, the lungfishes, remains to be seen. In any case, whether it proves to be primitive or otherwise the internal anatomy of these curious fishes is certain to be of great interest to the specialist. The matter of the ossified air sac has already been noted, although disappointingly there is no mention of such an organ in the preliminary accounts, which lay emphasis on the possession of a spiral valve in the intestine. The latter character is less remarkable than the absence of the spiral valve would have been, as it commonly occurs in the more primitive living fishes. But there are plenty of other details we should like to know about them, and Professor Smith's detailed report will be awaited with the keenest interest by zoologists throughout the world.

Reprints of the various articles in this Report may be obtained, as long as the supply lasts, on request to the Editorial and Publications Division, Smithsonian Institution, Washington 25, D. C.

Barro Colorado—Tropical Island Laboratory[1]

By Lloyd Glenn Ingles

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[With 6 plates]

Near the forest edge two rufous motmots, their voices an octave apart, greet the dawn with short bursts of hollow hoots. High overhead a pair of red-lored parrots squawk raucously, making a noise out of all proportion to their numbers, as they plunge swiftly down to become silent in the verdure of the forest. Then, far up the ridge from the giant branches of a towering Bombacopsis tree, comes the first deep-throated roar of a howling monkey and another sultry tropical February day begins. This day finds us on Barro Colorado Island in the middle of Gatun Lake beside the world's greatest highway, the Panama Canal. Many years ago, as the Chagres River was dammed to form the lake, 6 square miles of fine tropical forest on higher ground became Barro Colorado Island. How the persistent efforts of James Zetek, its resident director, William Morton Wheeler, Thomas Barbour, Frank Chapman, and other fine scientists finally culminated in getting the island set aside under the auspices of the Smithsonian Institution as a tropical wildlife reserve, with a laboratory for many kinds of tropical research, in a story all its own. Here a scientist, or any person interested in nature, may come, live under comfortable conditions, walk over machete-cut trails through the forest, and study anything he wishes. Nearly 700 publications based on research done on the island speak well for its importance as a scientific institution.

It was here my wife Elizabeth, our 5-year-old son John, and I settled down for an entire winter after an arduous trip by car as far as Nicaragua over the Pan American Highway. Barro Colorado is not a jungle or a tropical rain forest in the technical sense because it does have a dry season during the winter months when only 10 to 15 inches of rain falls. The rest of the year, however, there are over 100 inches of rain, but the decrease during winter months gives this forest a dif-

[1] Reprinted by permission from Pacific Discovery, vol. 6, No. 4, July–August 1953.

ferent character from those tropical forests that experience no dry season; hence it has been classified as a tropical seasonal evergreen forest. In these beautiful primeval woods as many as 60 to 80 species of trees and shrubs may grow on an acre.

All these forest elements are bound and laced together by hundreds of large woody lianas and smaller herbaceous vines, making a canopy so tight that only scattered small spots of sunlight reach the ground at any one time. Under this protective canopy one may stand for several minutes after the start of a heavy shower before he feels a single drop that finally gets through the mass of leaves above him. In the deepest parts of these woods there is twilight at noonday and lightning bugs or fireflies may be seen emitting their tiny lights. Here a photoelectric light meter will measure less than 0.2 foot-candle at noon even on a cloudless day. It is a forest where the biologist sees organic pressures for survival at their highest. It is a forest where nearly every plant form, where nearly all animal behavior traits are used by some other species with its own special adaptations to attain its own survival. Thus the interrelationships and dependencies of this biotic community are infinitely more intricate and more complex than those of temperate regions. One has to walk only a few yards over any trail to see these interrelationships. Here, for example, is a strangler fig (pl. 1, fig. 1) over 50 feet above the ground with its root system running down into the earth by going along and around the trunks of three other trees. One of these supporting trees is entirely gone, leaving a hollow tube formed by the anastomosing roots of the fig. Another of the fig's victims is dead and rotting away as it is held upright by the entwining roots of its murderer. The third tree is still living but is doomed to die by strangulation just like its neighbors. On the place once occupied by these three trees, one over 3 feet in diameter, there will eventually stand one giant fig tree on its three sets of strong tubes of roots which give the trunk of the fig a big advantage over other trees by holding it up 50 feet or more above the forest floor. From its elevated position it grows on up into the bright sunlight above the upper canopy of the woods. The strong fig will also be used by other lesser kinds of plants to get their food-making fronds and leaves into more and more sunlight. Already there are long lianas swinging down from its leafy crown and on its larger branches grow ferns, orchids, and bromeliads. Some of these epiphytes have leafy cups that catch and hold rain water in which a peculiar fauna lives. Certain species of mosquitoes and amphibians, for example, live and reproduce only in these tree gardens high above the ground.

The fig itself started from a tiny seed that perhaps was left on a limb of one of these trees by a bird or a monkey many years ago. After germinating it grew as an epiphyte until its long roots followed down the three trunks to the ground. Once in the moist earth the tree grew

rapidly and its entwining roots sent out many laterals to embrace its hosts and eventually to choke them to death.

Only a few feet from the strangler fig stands a stilt palm. This remarkable tree may be less than 6 inches in diameter and yet it extends its leafy crown 60 to 70 feet out into the upper canopy. But what enables a stilt palm to stand up? From the lower part of its slender trunk many bracing roots grow out several feet above the ground. Thus the strangler fig and the stilt palm solve in different ways their problems of getting up into the light.

Under the stilt palm across the dark forest floor a column of army ants moves along swiftly. These ants represent one of over a dozen species found on the island and have been studied for many years by Dr. T. C. Schneirla, of the American Museum of Natural History. The raiding columns of these ants catch, kill, and carry back to their bivouac all kinds of arthropod animals, especially their larvae and pupae, to feed the busy colony. Accompanying each army ant raid are five or six species of antbirds which do not eat the ants but catch the insects that are flushed by their advancing columns. Dr. Alexander Wetmore, noted ornithologist and former Secretary of the Smithsonian Institution, told me that when he wanted to find certain species of birds he simply followed a column of army ants to its advancing front and almost certainly the birds would be there.

In the forest practically all the mammals are adapted by structure and behavior to living in the trees or on the ground, with a number that spend considerable time in both. Of the tree-dwelling mammals certainly none is more spectacular than the capuchin monkey (pl. 1, fig. 2) which is found all over the island in troops of 15 to 25 individuals. These troops may be strung out a hundred yards or more through the treetops. It is not unusual to see one of these active little monkeys jump and fall 20 to 40 feet into a lower tree. Never did we see one miss its landing. One evening we watched at close range a troop advancing along the margin of the lake. One old male interested himself in making the large iguanas that rest on branches over the water jump down into the lake. This monkey broke off every dead branch that it could find and threw it into the water. Whether the capuchin was clearing a new monkey trail of reptiles and dangerous limbs or whether it just liked to see and hear things splash in the water is hard to say, but I am inclined to believe the latter.

Another curious creature that is almost entirely arboreal is the three-toed sloth (pl. 2, fig. 1). This sloth appears to eat only the leaves of the Cecropia tree and is therefore practically never seen in temperate-zone zoos. One day in the deepest forest I heard a loud squealing and growling in the canopy almost overhead. While I was trying to locate the cause of the disturbance two male sloths came

tumbling out of a palm tree fully 30 feet above the ground. Each sloth had a firm grip on the other with its hind feet and it was quite apparent they had been fighting and had become so occupied that they had forgotten gravity was still an active factor of their environment. A few seconds later they began to recover from their fall. They let go their holds and wobbled and rolled awkwardly over the ground to the nearest lianas which they slowly began to climb. We needed pictures of a sloth so one was captured with a loop on a pole and was carried out to a clearing a half mile away where there was sufficient light for photography. The grayish green of their coarse hair and their slow method of locomotion on the under side of limbs make them difficult to find even where they are plentiful. The greenish color is the result of an alga growing on the hairs. There are also three species of moths and one beetle that are almost always found darting in and out of the coarse pelage. Whether the larvae of these insects eat the alga, the hairs, or the tiny sloughed-off bits of epidermis appears to be another problem of interrelationships in the intricate web of this tropical forest community that needs to be investigated much more thoroughly.

A mammal that seems to be equally at home in either arboreal or terrestrial environments is the three-toed anteater or tamandua (pl. 2, fig. 2). Its long prehensile tail enables it to use tree routes of travel and to work on insect nests far above the ground. With the powerful claws on its front feet it can open the hard, tough ant and termite nests without difficulty. Its most striking adaptation, however, is its long wormlike tongue that can be extended from the mouth 5 inches or more to extract insects out of the intricate and interlacing system of tubes found in termite and ant nests. While raiding a nest of termites or ants a tamandua would soon become covered with biting or stinging insects were it not for the way it uses the claws on its hind feet. These claws are arranged along the foot in the form of a comb with which the anteater keeps its pelage relatively free of insects by combing almost constantly with its hind feet as it continues to feed.

There are many strictly terrestrial mammals but none is more frequently seen in the forest than the agouti (pl. 3, fig. 1) or *ñeque* as it is called by the Panamanians who prize its flesh as a table delicacy. The agouti belongs to a group of South American-type rodents that have moved up through Central America since the Ice Age. It is commonly seen in daytime eating the fallen fruits of various forest trees and when surprised squeals loudly and dashes off to its burrow. No doubt the agouti provides much food for jaguars, pumas, and ocelots.

Near the laboratory at the edge of the forest is a breadfruit tree which was introduced long ago. One evening we watched a pack

of coatis (pl. 4, fig. 1) climb the tree to search for ripe fruit. Although a carnivore, the coati, which is related to the raccoon, has similar omnivorous habits. It includes considerable fruit in its diet. When one of the coatis found a ripe breadfruit it was dropped to the ground with a loud *plop*. At that instant all the other coatis immediately began descending the tree to partake of the meal, and to our surprise, three agoutis came out of the burrows and sat within three or four feet of the feasting coatis waiting to clean up any leavings. Thereafter we noticed that the agoutis nearly always appeared when one of the 3-pound breadfruits fell.

The largest mammal on the island is Baird's tapir (pl. 4, fig. 2) which lives in the deep forest and is seldom seen. Three years ago two young tapirs still wearing their longitudinal stripes were brought in to the laboratory from the mainland. They were fed and cared for until they were old enough to take care of themselves in their native habitat to which they gradually returned. Occasionally even now one or both of these tapirs will wander out of the woods into the laboratory clearing where they still look for "handouts" of potatoes and bananas. I shall never forget the beautiful sight they presented one morning as they walked slowly out of the forest into full sunlight not 25 feet away from the bird blind where I had my camera all set for a chestnut-mandibled toucan. It was a rare opportunity to photograph, in its native habitat, this large mammal which belongs to the same zoological order as the horse and the rhinoceros. An entomologist once came to visit the island and no one told him about the young tapirs. One day while he was busily collecting insects in a dark ravine he heard a high-pitched whistle and looked up to see two large mammals slowly approaching only a few feet away with their long snouts extended toward him. He quickly abandoned his work and climbed a small tree. The tapirs walked around the tree still whistling and finally one of them lay down at its base! He hardly expected anyone of us to believe his story when he returned to the laboratory that afternoon. He never told us how long he remained up the tree to avoid the big animals that only wanted him to give them a banana or a potato!

There are at least 15 species of bats known to occur on Barro Colorado and on the nearby mainland. So far as known each species is adapted to roosting and feeding in its own particular way. For example the Watson's bat makes its own roosting place by cutting the veins in the leaves of two species of small palms in such a way as to cause the leaf to droop, forming a "tent." The bats hang head down inside this little green tent and no doubt are somewhat protected from the bat falcon and other predators as well as from heavy rains in the wet season. The tent also serves to darken still more their roost in the deep woods where the palms grow.

Only a few examples of the interesting adaptation found in this tropical forest can be given here. Barro Colorado is a place that must be experienced to be fully appreciated. Pictures even in natural color can only give a poor notion of the curiously adapted forms that live in a tropical forest. They are but poor sketches and representations of the great number of interdependencies that make up biotic communities.

There are, of course, some annoyances and real dangers as one walks over the trails. Personally, I regard the constantly high humidity as the greatest annoyance. After only moderate exercise one becomes entirely wet with perspiration even in the dry season. It causes one's glasses to fog over at most inopportune moments. It causes fungus to grow on clothes, shoes, camera cases, and in camera lenses. It causes films to stick in even the best cameras. Some people, until they learn to deal with them, find the great number of chiggers and ticks a never ending source of trouble. Proper dress for the trails and proper bathing can, however, usually reduce these to an insignificant minimum. The dangerous bushmaster has never been seen on the island, although it is occasionally found on the mainland. The poisonous reptiles which may be seen along the trails are very few although I photographed a fer-de-lance and a coral snake on a trail on the same day. A bite from either would be grave disaster indeed. There are very few mosquitoes, no malaria, no houseflies.

The forest closes in on both sides and behind the laboratory. One does not see far into or through these woods; they are too dense. Only in front can a person look away across Gatun Lake, and there within a mile of the laboratory see the great ships of the world move silently along the Panama Canal. They are the only reminders of an outside civilization for on the island there are no television sets, no radios, no telephones, no cars, no newspapers, no dogs to bark, no cats to meow. There are only the native wild sounds of the forest, which, taken alone, may seem loud and raucous but which somehow blend with the whole to make something pleasing and soothing to the nervous system of civilized man.

Each evening about sundown the big chestnut-mandibled toucans mount the top branches of the tallest trees and with much bowing and waving of their enormous beaks break the solitude with their loud squawks and yippings. One does not mind this, however, because he has learned that the next number on the program will be the long, wailing, flutelike notes of the great tinamou which serve as vespers every evening on Barro Colorado. When the tinamou has sung his song the nocturnal chorus of the insects and amphibians has already begun. Many bats are darting about, and then the mellow hoots of a spectacled owl greet the night from the dark forest. There should be more Barro Colorados.

2. This capuchin monkey (*Cebus capuchin*) was tempted to come down to the forest floor with star-apple bait.

1. Strangler figs (*Ficus costaricana*) begin life as epiphytes and usually kill their victims. The one in the center of the picture is only a mass of anastomosing roots; the host has entirely rotted away. The one at the left still chokes its host.

1. Three-toed sloths (*Bradypus griseus*) are almost entirely arboreal.

2. The three-toed anteater (*Tamandua tetradactyla*) is both terrestrial and arboreal. It eats ants and termites which it extracts from deep burrows with its very long round tongue.

2. The little two-toed anteater (*Cyclopes didactylus*) is nocturnal and so is rarely seen.

1. The agouti or ñeque (*Agouti dasyprocta*) is frequently seen even in daytime in the deep forest. These South American-type rodents are very shy and can run rapidly.

1. The coati (*Nasu* sp.), like its relative the raccoon, is an omnivorous feeder and frequents the forests in small bands.

2. The largest mammal on Barro Colorado Island is Baird's tapir (*Tapirella bairdi*) These two were photographed early one evening on a forest trail near the laboratory clearing.

1. Few birds of the tropical forest show more color than the black-throated trogon (*Trogon rufus*). The iridescent blue-green head and bright yellow belly are bright flashes even in the deep shade of the forest.

2. Iguanas (*Iguana* sp.) are often seen climbing in the highest trees around the shore.

1. The Central American armadillo (*Cabassos centralis*) is rare in Middle America. This one, discovered by the author's wife, was the first ever seen on Barro Colorado.

2. The nine-banded armadillo (*Dasypus novemcinctus*) ranges all the way from South America into Texas. It is very common on the island.

Norsemen in North America Before Columbus[1]

By JOHANNES BRØNDSTED

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[With 10 plates]

THIS much-debated problem has two main aspects, one turning to old literature—the narratives of the Icelandic sagas about Leif and Vinland; another concerning archeological monuments and objects in North America and their probable contribution to the question: Were there Norsemen in North America, not only during the late Viking age, about the year 1000, when Leif founded his Vinland site, but also later on, through the centuries of the Middle Ages in the time before Columbus? Let us consider these two aspects closely.

WHAT DO THE SAGAS TELL, AND HOW SHALL WE INTERPRET THEM?

The saga stories about Leif Ericsson's and Thorfinn Karlsefni's discoveries of territories in North America in the years round about 1000—"Helluland," "Markland," "Vinland," "Straumfjord," and "Hóp"—have reached us in two parallel versions of rather late date (fourteenth century); one is to be found in Eric the Red's Saga (the so-called "Hawks Book"), the other in Olav Trygvason's Saga and the Greenland Saga (in the famous so-called "Flatey Book"). The main outlines and most important details of these old Vinland tales are given below in concentrated form. There are six of them (actually only four, as two are concerned solely with abortive voyages).

1. Bjarni Herjulfson's voyage.—Bjarni, son of a friend of Eric the Red, the Greenland colonizer, and his men in 986 aim to sail from Iceland to Greenland, but northerly winds and fog drive them off their course. After several days they sight a well-wooded land, which they

[1] Translation of the article (expanded) entitled "Problemet om Nordboer i Nordamerika før Columbus," which appeared in Aarbøger for Nordisk Oldkyndighed og Historie, 1950. Here printed by permission of the publishers.

approach and then sail out again. Two days later they see more timbered land; they sail close in and then out again. After 3 days' sailing on a northeast course they sight land for the third time, on this occasion a mountain island with glaciers. Once again they refrain from landing. Four days afterward they reach Greenland.

2. Leif Ericsson's expedition.—Leif, son of Eric the Red, buys Bjarni's ship and sets out from Greenland (apparently in the spring of 992) with 35 men with the intention of finding and exploring the lands seen by Bjarni. [Note that in contrast to the voyages of Bjarni and Thorstein (see below) this is a veritable voyage of discovery.] First he finds Bjarni's glacier island and goes ashore. There is nothing but stone between shore and glacier, a land "without good things"; he calls it "Helluland" (Stone Land). Thereafter they come to a flat woodland which Leif names "Markland." Two days later they reach an island with grass and much sweet dew. Between the island and a promontory on the mainland is a strait; they sail into it, and during ebb tide the ship goes aground in the sand. They go ashore at a river, get the ship off at high water, and decide to settle there for the winter and build houses of good timber from the large sycamores of the forest. In both river and sea there were bigger salmon than they had ever seen anywhere. There was no winter frost and the grass withered but little. Day and night there were of more equal length than in Greenland and Iceland. In the time of the short days the sun set in "Eyktarstad" and rose in "Dagmalastad."

Then Leif divides his men, some of them staying where they are, while others go scouting. One evening they miss the man Tyrk, a southerner (German), an old friend of Eric the Red's, Leif's adoptive father. They make a search and meet him a short distance away. Leif can see that Tyrk is out of his mind; he speaks in his native tongue, German, rolls his eyes, pulls faces, and then at length tells them he has found vines and grapes. It's true enough, he says, for he was born where there were vines in abundance. In the time that follows they gather grapes, cut vines, and fell timber, all to fill the hold of the ship. In spring they break camp and, on leaving, Leif calls the land "Vinland." On the way home they rescue a number of shipwrecked men from a rock and in due time arrive safely at Brattahlid, Eric the Red's farm in Ericsfjord, Greenland.

3. Thorvald Ericsson's expedition.—Leif lends his ship to his brother Thorvald, who sets sail with 30 men and reaches Leif's camp in Vinland. There they winter. The following summer they spend exploring the west coast of the land, which is fair and thick-wooded, with white sands, many islands, and shallow water. On an island they find a wooden granary, but otherwise no trace of human beings. That autumn they return to Leif's camp and then the following

summer examine the east and north coasts of the land. During a gale, while rounding a point, the ship breaks her keel; after a long time spent on repairs they set the broken keel up on the point and call the place "Keel Ness" (Kølnæs). They proceed eastward, into wooded fiords. They lie to alongside a headland, and Thorvald exclaims: "This is a fair land, here I will build my farm." Meantime, on the beach they discover three skin boats with nine men; they fight and kill eight of them. Later they are attacked by a large number of natives in skin boats, and these Scraelings shoot at them, but flee in the end. Thorvald, they realize, has been hit by an arrow and he dies of the wound. They bury him, at his desire on the headland, and put up a cross at either end of the grave. They call the spur "Cross Ness" (Korsnæs), and then return to Leif's camp for the winter. They gather grapes and timber for cargo, and in the following spring set sail for Ericsfjord in Greenland "with great tidings for Leif."

4. Thorstein Ericsson's voyage.—Thorstein, another brother of Leif, goes out with the same ship to bring Thorvald's body home. He fails, seeing no land at all throughout a whole summer's cruise.

5. Thorfinn Karlsefni's expedition.—The Icelander Thorfinn Karlsefni sets out for Vinland with three ships and 160 men. First they find "Helluland," then "Markland," and next, after sailing along strange, long, sandy beaches, the cape with the ship's keel, "Keel Ness." They anchor up in a fiord and from there send out as scouts two Scottish runners, man and wife, who return three days later with grapes and self-sown wheat. They go on, into another fiord with an island before it and so many sea birds that a man can scarcely set his foot between the eggs. Around the island runs a strong current, so they call the fiord and the island "Stream Fjord" (Strømfjord) and "Stream Island" (Strømø). Here they spend the winter with their cattle. There is grazing enough, but little human food. They are in need and pray to God. Thorhall the Hunter, however, appeals to Thor. A whale drifts in, an unknown kind even to Karlsefni, who is familiar with whales otherwise. It proves to be uneatable; they become ill and throw the whale meat into the sea. When spring comes they manage on birds' eggs, hunting, and fishing.

Thorhall the Hunter now begins to grumble and wants to go home to Greenland. He and nine men set out by themselves in a ship. On the voyage an easterly gale blows them to Ireland, where Thorhall loses his life.

The others proceed south and voyage far till they reach a river running into the sea through a lake; they can only get into the river at floodtide. This place they call "Hóp." Here in the depressions grows self-sown wheat, on the hillsides, vines. Every brook teems with fish. There where they find the highest tidewater they dig pits

and at ebb tide find halibut in them. The forest abounds with animals of many kinds. There they spend the winter. No snow falls; the cattle need not be brought indoors.

Here they encounter the inhabitants of the country, the Scraelings, at first in peaceable barter: red cloth and milk (which the natives had never before seen) for furs. But they quarrel (after a bellowing ox had chanced to scare the Scraelings). Then the natives come in large numbers in skin boats to make war on the Norsemen, and they terrify them by throwing large stones, sewn into painted skins, from tall poles. Men fall on both sides. The Scraelings fight with slings and stone axes; they are astonished at the Norsemen's iron axes.

After that Karlsefni judges it too dangerous to remain in the land of "Hóp"; he abandons the thought of making his home there and instead goes back to "Stream Fjord" (which is stated to be midway between "Hóp" and "Keel Ness"). There he leaves most of his people, takes one ship northward to look for Thorhall, returns after a vain search, and winters in "Stream Fjord." There his wife bears him a son, Snorri. Next spring they all go home via Markland, where they capture two Scraeling boys, whom they take with them. One of the ships, which turns out to be worm-eaten, founders, but Karlsefni's own ship returns at last to Ericsfjord in Greenland.

6. Freydis's expedition.—Some years later Freydis, a natural daughter of Eric the Red, makes an expedition to Vinland with two ships, accompanied by the two Icelandic brothers, Helge and Finnboge. They reach Leif's camp in Vinland and winter there. They quarrel; Freydis conceives a plan to murder both brothers and carries it out, and moreover kills all the women with an ax. Early next summer she returns to Greenland.

This is the essence of what the sagas have to tell about Norsemen from Greenland and Iceland discovering North America in the years about 1000. There was a time when some scholars were rather skeptical as to the details and the narrative descriptions contained in these old Nordic sources—they were stamped as unreal, literary-colored fairytale stuff; see, for instance, the famous Fridtjof Nansen in his book "Nord i Tåkeheimen," published in 1911. Nowadays, however, most historians are (rightly, I think) inclined to take many points, if not all, in the saga traditions about "Vinland the Good" as true facts. There the question arises: Is it possible from this literary material to indicate precisely where on the Atlantic seaboard this "Vinland" of Leif's, this "Hóp" of Karlsefni's lay? Many attempts have been made, all different in their results. And so, in the following pages when I, too, try to find a solution to the problem, my purpose inter alia is this: to show how difficult the task is, how defective the

material, how uncertain its statements and, consequently, how approximate the final conclusion must be.

Any attempt at localization should start from, and base itself upon, two different categories of statements in the old sagas: on the one hand their astronomical and nautical information, on the other their culture-geographical content (i. e., what they have to tell us about Vinland's scenery, climate, vegetation, fauna, and inhabitants). Are we in a position to let all these different dicta convincingly indicate just one incontestable part of the Atlantic coast of America? That is the point.

Within the astronomical sphere one oft-commented-upon remark seems to be of special importance, namely the above-cited passage in the Greenland saga about sunrise and sunset in Vinland. In this land, so the saga says, the sun in the short days went down in "Eyktarstad" and rose in "Dagmalastad." Only a few scholars doubt the trustworthiness of this statement; the majority regard it—no doubt rightly—as a genuine reiteration of an actual observation made on the spot. Subject to the condition that it is genuine, we now have a possibility of calculating the geographical latitude of the observation place, Vinland, provided, be it noted, we know what is meant by "Eyktarstad" and "Dagmalastad."

For "Eyktarstad" two sources are available to us (apart from ancient usage among Norwegian peasants of our time: a passage in Snorri's Prose Edda ("autumn lasts from the equinox till the sun sets in Eyktarstad"), and a place in the Icelandic ecclesiastical law "Grey Goose," where we read that it is "eykt" when "Utsuðrs Æt" is divided into three parts and the sun has passed through two of them. But what is "Utsuðrs Æt"? If we take this Old Norse term to be the name for the octant of the compass card between 22½° and 67½°, the situation of Leif's Vinland may be reckoned as being not more northerly than latitude 50° N. (i. e., the Gulf of St. Lawrence and Newfoundland). But if "Utsuðrs Æt" is taken to mean the entire quadrant between south and west, we get Vinland's northernmost limit shifted more to the south, to latitude 38° N. (Chesapeake Bay, Va.). The St. Lawrence position was postulated in the 1880's by the astronomer Geelmuyden in Copenhagen and the historian Gustav Storm in Christiania (Oslo); the Virginia identification is upheld by the Norwegians Mjelde and Brøgger, among others. In neither of these is any southern limit given for Leif's Vinland.

"Dagmalastad" in the ecclesiastical sources is determined as "tertia hora," the third hour when the sun is in the southeast (9 a. m.). Reuter, however, as a result of his researches, claims that the pagan "Dagmalastad" is not southeast but east-southeast, and that "Eyktarstad" is simply the west-southwest point of the horizon. Thus, according to Reuter, the passage in the Greenland saga about Leif's

Vinland means that here, on the shortest day of the year, the sun rose in the east-southeast and set in the west-southwest. Accuracy on the point, however, is impossible owing to the obliquity of the earth's axis; even at the Equator there will be a slant of 1°. Accordingly we must reckon with an error of observation which is less the more to the south we imagine the situation of Leif's observation spot to be. If we place his Vinland in Florida (26° N.), the error is only 3°, in south Georgia (31° N.) it is 5°, and so forth.

In other words, the results of the astronomical interpretations and calculations are not strictly encouraging: Leif's Vinland cannot be more northerly than Newfoundland and more southerly than Florida. Wide limits, most certainly! One might almost have set them up oneself in advance.

But then, the nautical reports? Well, these are quickly disposed of. The incredibly short times given for the expeditions of Bjarni and Leif in the sagas ("two days," "three days," etc.) are impossible to accept for voyages in waters with such enormous distances as those between Greenland and America. There is much in the saga descriptions to suggest that seafarers then had to adjust their speed and course to currents and ice conditions such as those we know today. From Ericsfjord in Greenland's East Settlement Leif and the other Vinland travelers proceeded north, to the West Settlement, westward from there out to the open sea, and then southward, with the cold north-south offshore current which runs between the east coast of America and the Gulf Stream. These were voyages that took time. The fact that the Vikings always wintered in Vinland also indicates that the trip could not be done in 10 days or so. Reuter has calculated that the Vinland-farers had about 7,000 kilometers to sail and that they were 5 or 6 weeks doing the distance. This is quite credible, but the calculation is so rough and approximate that it cannot be applied in working out just where Vinland may have been. And let the same be said of other authors' interpretations of the saga voyage records.

Then let us have recourse to the culture-geographical clues in the saga accounts. What are we told about Vinland's scenery and climate, its vegetation and animals, its inhabitants, that may help toward localization? First of all we must remember that from north to south we are concerned with various "lands": "Helluland," "Markland," and "Vinland," named by Leif, then what Thorfinn Karlsefni found on his further voyage, i. e. "Stream Fjord," and farthest south, the land of "Hóp." For we must not overlook the fact that whereas the expeditions of both Thorvald and Freydis came to Leif's camp in the Vinland he had discovered and named, the position is different as regards Karlsefni. It is true that he visited the more northerly of the coastal tracts where Leif went ashore: "Helluland" (which most likely is

Baffin Island) and "Markland" (which may be the Labrador coast, or Newfoundland, or Nova Scotia); he saw Thorvald's "Keel Ness" too. But after that he came to two new localities: "Stream Fjord" (including "Stream Island") and, after having "traveled long," the land of "Hóp," southernmost of all. It is possible that Stream Fjord was in the vicinity of Leif's camp in Vinland, but scarcely Hóp, which must have been more to the south. First, then, let us examine what is written about Leif's Vinland.

It was a well-timbered land with large sycamores good for house building. There was no winter frost: the grass withered but little. There were vines and grapes. They cut the vines down (why, I wonder?). They caught big salmon in both river and sea. Thorvald explored the west coast of the land, which was wooded and had white sandy beaches, many islands, and shallow waters; there he found a native's granary of wood. In the following summer he discovered to the east wooded fiords and fair land, where he decided to settle, but was slain while fighting Scraelings in skin boats. About Freydis's sojourn in Vinland we are told that one winter's night, when the grass was wet with much dew, she sat on a tree trunk outside the house, talking to Finnboge.

So Vinland was timbered and had a mild climate. Otherwise, the land is characterized too little to permit of identification; and this also applies to its inhabitants. But it is important, as A. W. Brøgger points out, that it has both salmon and vines. On the North American east coast the southern range of the salmon is Connecticut, approximately latitude 41° N., and the most northerly area on the same coast where the vine grows passably well is Massachusetts, in latitude 42°. Following this line we obtain at length an approximate location on Vinland in the region around New York, and rather south than north of that place, if we are to satisfy more or less the condition of absence of winter frost. From this angle perhaps Chesapeake Bay in northern Virginia is preferable; for in localizing we must allow a certain elasticity, in view of the fact that there may have been slight climatic fluctuations in the thousand years that have elapsed since our events.

But in this case, where were "Stream Fjord" and "Hóp"? The saga relates that Karlsefni first found Thorvald's "Keel Ness" and near it a fiord, where his Scottish runners discovered vines and self-sown wheat, the latter undoubtedly being maize. Then they turned into another fiord, "Stream Fjord," with an island, "Stream Island," off its mouth, and there an unknown species of whale drifts in to the starving explorers, probably a southern kind, possibly a cachalot. Where these coast lands may have been we cannot say; possibly not so very far from Vinland. The vines and the maize, the unfamiliar whale, and the circumstance that seals apparently are lacking (they

would have been welcome to the hungry men), all warn us against a northern localization. Reuter suggests, and it may be likely enough, that "Keel Ness" was at Cape Hatteras (between Virginia and North Carolina), and "Stream Fjord" at Cape Fear, some distance farther to the south.

But then, it is from this "Stream Fjord" that Karlsefni "fares long" to the south, till he reaches the land of "Hóp." Here we are given various informative indications—in the depressions self-sown wheat (maize), on the hills vines, in the sea halibut; no winter snow, the cattle are left out; trading and fighting with natives who are ignorant of milk and who battle with large slingstones dispatched from tall poles (and on the whole armed with stone weapons).

The saga describes these natives in "Hóp" as small and hideous, with ugly hair styles, large eyes, and wide jawbones. The big eyes show that they must have been Indians, not Eskimos. The term "Scraeling" given by the Norsemen to the natives both there and farther north, according to Finnur Jónsson was usually derogatory, meaning something wretched; William Thalbitzer believes it to be of Eskimo origin. I think it necessary to assume that the Scraelings whom Karlsefni encountered in "Hóp" (as well as those who killed Thorvald east of Vinland) were Indians, whereas the two boys picked up by Karlsefni's men as far north as in "Markland" were Eskimos. Trying to identify the "Hóp" Indians with any present-day tribe (for example, the skin-wrapped slingstones have been traced to the Algonquin Indians in New England) is futile, I think, when we consider the long wanderings of the North American Indians during the past thousand years. The "Hóp" natives had never seen milk, which suggests that their territory was south of the range of the reindeer. And it may be remarked that in the days of the Spanish conquests the buffalo was unknown in Florida and, on the whole, east of the Mississippi. The fact that one of Karlsefni's ships becomes so worm-eaten that it founders is a feature pointing southward.

Judging from all the evidence, we must look for "Hóp" a good way south of Vinland. I imagine we shall reach Georgia (about 32° N.) or possibly, as Reuter thinks, right down to Florida.

I do not think it possible to indicate *with any precision* from the saga sources the whereabouts of "Vinland," "Stream Fjord," "Hóp," and the other localities. A study of the modern literature rising around the topic will show that various scholars have reached results, but no two of these results coincide fully. As a matter of fact, almost all possible North American coastal regions have been suggested, the localizations oscillating between Labrador in the north and Florida in the south, between Newfoundland in the east and the Hudson Bay coast in the west (Chesterfield Inlet and the mouth of Nelson River).

This great uncertainty is the natural outcome of the incredibly elastic possibilities of interpretation contained in the texts of the sagas in the matter of the correct understanding of their various data: nautical, spatial and day-and-night dividing, as well as climatical, botanical, and geographical. Whereas there is tolerable agreement on where the Helluland and Markland of the sagas are roughly to be placed, i. e., Baffinland and Laborador-Newfoundland, it is quite another matter when we are to fix the spot where Leif Ericsson landed and where Karlsefni's colony was. We may safely say that on these points the discussion will go on ad infinitum, unless the basis is widened and new knowledge is added.

There is one thing, however, on which modern Vinland research seems to be unanimous: that there was actually a "Vinland." According to Sophus Bugge, the word "Vinland" appeared in the now missing runic inscription from Hønen in Norway, which he dated to the middle of the eleventh century. This is the first time Vinland is mentioned in our sources, half a century after it was discovered by Leif. Adam of Bremen's mention of it follows shortly afterward. Occasionally, Vinland is still referred to in the written sources of medieval Europe apart from the sagas. This being so, the assumption is most reasonable that the Norsemen in Greenland had intercourse with and tried to exploit this American land, "Vinland the Good," wherever its situation may have been. It is often pointed out that voyaging from Greenland to America was shorter and less hazardous than from Norway to Iceland. The prospect of obtaining timber and other good things must have induced the Greenland Norsemen to maintain communication with America. I am wholeheartedly in accord with the view which a priori considers it extremely likely that the Greenland Norsemen kept up a certain intercourse with Vinland.

But how regular was this intercourse? Did it have the character of actual colonization, or did it consist merely of sporadic and casual visits? I scarcely think we should imagine it as being highly frequent. Greenland, the motherland, was a small and weak (and successively weakening) community. The "home bases," to adopt modern terms, even if we include in them Iceland and, indirectly, Norway, in the long run were unable to cope with the task of sustaining a viable colony in a region so remote and so large as the American Continent, a region which, be it remembered, was not uninhabited like Iceland and Greenland when the Norsemen first arrived, but was populated with many and, no doubt, mostly hostile tribes (see the sagas). What is more, it has not been possible to find any trace of intrusions of European material culture among the Indians of North America, such as the introduction of grain or cattle; nor do we find any influence in clothing (weaving) or iron extraction. If there was any colonization by Scandinav-

ians it was not intense enough to leave any such traces among the native population.

The Norsemen in North America in the Middle Ages did not make the imprint on the history of world culture that Columbus and his successors did. All the same, it is of great interest to endeavor to establish where and when they had their American bases.

Leaving now the literary sources we turn to archeology.

WHAT DO AMERICAN MONUMENTS AND OBJECTS SHOW, AND HOW SHALL WE INTERPRET THEM?

At the suggestion of Lithgow Osborne, president of the American-Scandinavian Foundation, New York, I was requested in the summer of 1948 to travel to the United States for the purpose of making a systematic study, based upon journeys and personal examinations, of as much as possible of the archeological material in the States and Canada likely to throw light on the question of whether Scandinavian Norsemen lived in North America in pre-Columbian days. The work was to be done under the auspices of the Foundation and with a grant from the Viking Fund, New York. I accepted the offer and spent about three months in the United States and Canada in the autumn of 1948. There I had the opportunity of making myself acquainted with material that was both voluminous and varied. My studies and judgment of this American material are crystallized in the following report. I thank the American-Scandinavian Foundation for most active support and the Viking Fund for its generous financial aid. My thanks are also due to President Lithgow Osborne for his effective help and cooperation; to Dr. Henry Goddard Leach, former president of the Foundation, for much guidance and good advice; and to my friend Dr. Hugh Hencken, of Cambridge, Mass., then president of the Archeological Institute of America, for great hospitality and helpfulness.

It seems natural to begin the report with an examination of three monuments, arranged chronologically according to their alleged age: the *Beardmore find* at Toronto, Canada, claimed to date from the close of the Viking age; the *Newport Tower*, held by somebody to have a medieval origin; the *Kensington runic stone*, now at Alexandria, Minn. (a replica in the U. S. National Museum, Washington, D. C.), giving itself in its inscription to the year 1362. The rest of the American *epigraphic material* forms a natural association with the latter monument. I have, then, discussed briefly under *Sites* some occurrences in situ in New England, with a separate exposé on the *mooring stone* phenomenon. This is followed by a reference to the various North American *objects* supposed to date from pre-Columbian times.

THE BEARDMORE FIND

Preserved in the Royal Ontario Museum of Archaeology at Toronto, Canada, is a find from a spot near the village of Beardmore, Ontario, about 7 miles from Lake Nipigon. It consists of three east-Norwegian Viking-age iron objects (pl. 1). With the kind permission of Prof. T. F. McIlwraith, keeper of the Royal Ontario Museum's department of ethnology, I have made an examination of this find.

1. A fragmentary iron sword, broken above the middle of the blade. Both the pommel and the point of the blade are missing. The total length of the original blade may be estimated at about 0.70 m. and the whole length of the sword at about 0.85 m. The sword had been covered with rust which had been removed in the museum by electric means, for which reason only parts of the original surface of the blade and of the edges remain. This sword may be placed to type M in Jan Petersen's "De Norske Vikingesverd," 1919, page 117 et seq., figures 98 and 99 (from about A. D. 850–950).

2. A flat band of iron, 19 cm. long, 2.7 cm. wide. One end is rolled up; at this end the band is rectangular in cross section and narrow, very thin at the extreme end and pierced with a round hole. At the other end, too, the band narrows into a rectangular rod which, however, is bent over in a swan's-neck curve. There is a fracture at this end, whereas the other is intact. The latter end seems to have been forced out to the side. On this object again the original surface has disappeared as a consequence of the electric treatment.

This object is generally considered to be a shield handle—which it certainly is not. There are no holes for rivets, and Norwegian Viking shields never have handles of iron. It is more likely that the band was once the upper part (the hoop) of the object which Norwegian archeologists call a "rangel" (rattle) and which is often found in east Norwegian (less often in west Norwegian) men's graves of Viking times. (See O. Rygh, Norske Oldsager, 1885, Nos. 460–464; Jan Petersen, Vikingetidens Redskaper, 1951, p. 42 et seq.; here fig. 1.) These rattles consist of a bent-over round or flat iron bar (the hoop, fig. 1) on which are hung several rings and sometimes small bells, i. e., objects that rattle or tinkle when shaken. The object may have been placed on the end of a stick or furnished with a suspension hook. If we can imagine that the now-broken end of the iron band originally was long enough to reach the coil at the other end and was secured in the hole there, we have the upper part (the hoop) of a rattle.

William Feltham, one of the persons alleged to have seen the Beardmore find shortly after its discovery, describes our object thus: ". . . what looked like the handle of a shield with three prongs." The

"rattle" at that time may have had the corroded fragments of the rattle rings hanging on it, and these bits may have resembled prongs.

Nothing certain is known of the use of these rattles. They seem to have had some connection with riding and traction harness and are sometimes explained as the sleigh-driver's or the horseman's magic rattle for keeping evil spirits at a distance.

3. Ax blade, iron, 17.5 cm. long. This was covered completely with rust, the removal of which by electricity has deprived the ax of the whole of its original surface. The type is Jan Petersen's L (see his fig. 43); period: second half of the tenth century and beginning of the eleventh.

4. Three small flat fragments of iron, more or less indeterminable. Possibly, but not certainly, remnants of the edge of a shield boss. I must say, however, that as it now appears in the museum at Toronto the find does not seem to comprise indubitable shield-boss fragments.

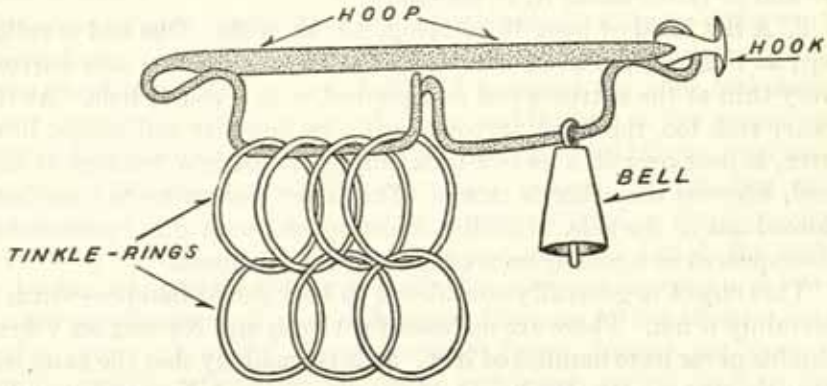


FIGURE 1.—"Rangel" (rattle) from a Norwegian Vikingtime man's grave. About two-fifths natural size. (After O. Rygh, Norske Oldsager, No. 461, Christiania, 1885.)

As the whole of this find now appears it may very well stand for a Viking-age grave find from east Norway (more precisely Østfold) or possibly from the Trondheim region, but hardly from the west country (where "rattles" are seldom found). In 1939 Prof. A. W. Brøgger, of Oslo, after seeing a photograph, remarked that the objects of the find "correspond extremely well with the common custom of the Østfold in the 10th century." If we take the Beardmore find to be the equipment of a Viking of the beginning of the 11th century, it must be said that this sword was not of the latest fashion, but rather out of date. Chronologically the sword and the ax do not harmonize very well, but it is quite possible, nevertheless, that they were used by the same man in the period round about A. D. 1000.

Three questions now present themselves: Are these objects genuine Norwegian Viking-age relics? Are they contemporary in the sense

that they were presumably used by the same man? Were they found in Canada's soil? The first two questions may be answered in the affirmative. What about the last one?

In the Canadian Historical Review for September 1941 (p. 254 et seq.) there is a survey of evidence drawn up by O. C. Elliott, of Kingston, Ontario, coupled with statements of views by C. T. Currelly, former director of the Royal Ontario Museum, and Mr. Elliott. Whereas Currelly accepts the authenticity of the find report, Elliott is more skeptical and is inclined to the belief that the objects came from Norway and were brought to Canada in recent time. The reports of the find are briefly as follows.

James Edward Dodd, of Port Arthur, a railroad man and prospector, tells that he was sampling a vertical quartz vein near Beardmore on May 24, 1930. A large birch stub was in his way and he blasted it out with dynamite. This revealed the iron objects. Six and a half years later (December 3, 1936) Mr. Dodd sold his discovery to the Royal Ontario Museum, on which occasion he gave the following details: "3½ feet down . . . Under big birch stub, 2½ feet in diameter . . . Dome of rust, slightly flat, about the size of a goose egg, over 'handle-bar' . . . Thrown out and left on surface of ground till 1933."

A good two years later (February 3, 1939) Mr. Dodd says, in an affidavit made before a solicitor of Port Arthur:

> While shovelling out this loosened earth to lengthen the trench, my shovel struck some pieces of old iron, which were thrown out on top of the dump. I paid no attention to these scraps at the time, merely wondering if they were Indian relics . . . The relics lay on the dump for a day or two and were carried to the cabin on the claim where they lay on the banking of the cabin till I left for Port Arthur in a few days . . . a sword which I broke in two as I was taking it out of the ground . . . I had seen in the trench also what looked like a shallow bowl but this shattered when my spade touched it . . . I took the relics to my home at 296 Wilson Street, Port Arthur, in May or June 1930, and they were never out of my possession till I sold them to Dr. Currelly.

John Drew Jacobs relates three times (December 9, 1936, June 1937, and undated) that he saw in the rock a very distinct imprint of the sword: "The stain of the complete shape of the sword as it had lain was very plainly marked on the rock and this stain could not have been made unless the metal had lain on the rock for a long period of years." But he was unable to find any impression of the ax on the rock.

According to Currelly, Dodd told him that "lying over the bar of metal was something like a bowl that was rusted into little fragments. He [Dodd] had just shovelled them out." In 1937 and 1938 Professor McIlwraith and Mr. Curran, respectively, together with Dodd, discovered at the find spot small iron fragments "which might be part of the 'boss'."

On August 16, 1936, Dodd had said to Elliott:

After the shot of dynamite had gone off I saw something sticking out of the schist . . . I pulled at it but the other end was embedded in the rock. In trying to get it out I broke it. I pried the piece that was in the rock and it finally came loose. I was surprised to find that it was a sword handle with part of the blade attached. The piece I had broken off was the rest of the blade. I thought maybe it was an Indian's sword and threw the two pieces up on the dump where it lay almost three months. Later on I found an ax near where the sword was found . . . Looking over the ground carefully I came across an oval-shaped brownish depression in the rock about 10 inches long and 5 inches wide, and right across the middle was a strap of metal like a handle. I tried to remove this carefully but it was so badly decomposed that it fell apart, leaving only the handle.

Generally speaking, these find reports sound trustworthy, even if one can pick out some less important discrepancies between the various statements. Then something happens. Eli Ragotte, in 1938, maintained that he saw the iron objects at Mr. Dodd's house as long ago as 1928, although, confronted with the relics at Toronto, he had to admit that they were not the same as those he saw at Port Arthur in 1928.

A more serious attack comes after that. J. M. Hansen, a contractor at Port Arthur, declared in 1938 that the Dodd iron relics, that is to say the Beardmore find, appear from the photographs he has seen "to be pictures of objects very similar to objects" which he received in 1928 from a Norwegian lieutenant, John Bloch, as security for a loan. Bloch had brought the objects with him from Norway. Hansen had placed the objects in the basement of his house which he had rented to Dodd at Port Arthur. Thus Dodd's allegation that he found them at Beardmore might merely be pretense. He may have taken them from the basement of the house, for they were missing from there when Hansen looked for them in 1931; since then they have been lost.

This is the crucial point. Did Dodd commit a fraud? Bloch died at Vancouver in 1936. His friends say that he never made any mention of being possessed of Norwegian iron weapons of the Viking age, but this Hansen explains by suggesting that Bloch, who wished to see his native land again, was anxious not to disclose that he had illegally taken antiques from Norway to Canada.

Mr. Hansen has not seen the Beardmore find in the museum at Toronto; he knows of it only from photographs and on that basis he declines to say categorically that its iron objects are the same as those that he received from Bloch; but he believes they are. It would be helpful if Mr. Hansen could have an opportunity of seeing the Beardmore find, either at Toronto or at Port Arthur.

Mr. Elliott formulates the problem as follows (Canadian Historical Review, September 1941, pp. 270–271):

> Did Mr. Dodd discover a Norse grave containing a set of Viking weapons on May 24th, 1930? Or did John Bloch bring a part of his father's collection with him when he emigrated from Norway to Canada in 1923? Is it possible that the issue is being confused by two sets of similar weapons?

Dr. Currelly (ibid.) sums up his opinion in the following manner:

> As I see the situation, the objects were seen beside the place where they were found; they were also seen in Mr. Dodd's house by a number of people before he moved to Mr. Hansen's house. John Jacob saw the imprint in rust on the rock. The statements of all the people who saw them are met with only Mr. Hansen's statement that he left them lying in his house, and that he set a value of $150.00 on them; this statement was made only after Mr. Dodd had been trying to sell the things for some years, and was not backed by a single statement that anybody had ever seen them in Mr. Hansen's possession.

Dr. Currelly concludes by reasserting his belief that the objects actually were found near Beardmore and that Dodd is speaking the truth.

Against this Mr. Elliott argues (ibid.) by referring to the many contradictions which certainly do exist in the various statements on the matter.

It is of no significance that the objects are *east* Norwegian, a point to which Professor Brøgger seems to attach importance. Weapons move about widely, and there is nothing strange or inacceptable in a Viking in Greenland or America having weapons even of Danish or Swedish origin. Nor is there, I suppose, any reason for doubting that iron objects could last for a thousand years in Canadian soil, as they can in Scandinavian.

There is reason for drawing attention to the very far-advanced corrosion of these iron objects at the time when they were sold to the museum at Toronto (1936). If Lieutenant Bloch brought them with him from Norway, the assumption would surely be that they were in fairly decent condition; otherwise he would not have chosen these particular things from his father's collection. But it is rather improbable that in the time between 1923 (Bloch's arrival in Canada) and 1936 (the sale to the Toronto museum) they took on such a thick coat of rust, inasmuch as they were preserved indoors during these 13 years. But if we assume that they were found at Beardmore by Dodd, the thick rust seems feasible.

My opinion is that the Dodd report of the find, trustworthy as it sounds, is true. What the truth is regarding the Bloch weapons I shall not attempt to say. Theoretically there *may* have been "two sets of similar weapons," but it is hardly likely. As Mr. Elliott correctly remarks, the Beardmore case will probably never be cleared up completely.

And here is the all-important point. Although some investigators—including myself—accept the probability that a grave (or a deposit) containing Norwegian Viking weapons was found at Beardmore in 1930, and even if from this the conclusion may be drawn that in the beginning of the eleventh century Norwegian Vikings penetrated North America deep enough to reach the area east of Lake Nipigon (perhaps via Hudson Bay and James Bay), this does not conceal the fact that it has been impossible to produce *clear evidence* in support of it; we have merely a certain degree of probability. And in that case we lack justification for employing the Beardmore find as a reliable archeological document for the present.

THE NEWPORT TOWER

Newport Tower is a picturesque ruin of a small cylindrical stone tower built upon round-arched arcades, situated in Touro Park, Newport, R. I. (pl. 2). Its historical data were discussed at length by Philip A. Means (1942). The town of Newport was founded by Gov. William Coddington in 1639. The tower is first mentioned in documents dating from 1677.

No fully modern, scientific survey has ever been made of Newport Tower by a professional architect. John Howland Rowe's unpublished work of 1938 ("The Rowe report," as it is called in Means's book, whose plans and elevation, figs. 5–8 and 16—figs. 2–6 in this paper—are taken from it) will scarcely satisfy the requirements of modern archeology. It would be very desirable if a trained architect, preferably in company with an archeologist, could undertake this survey. Until this is done I do not consider we can accept the recent calculations of the *unit of measurement* of this building.

Newport Tower, about 25 feet high, is both primitively and skilfully built. The material is field stone—some natural and some slightly dressed granite, sandstone, and slate. The stones are laid in a grayish-white, coarse lime mortar mixed with rubble; the mortar is of shelly lime, gravel, and sand. Thin, sometimes split flags of sandstone or slate are employed in the flat arches that connect the pillars (as well as in the relieving arch over the fireplace and the arch over one of the windows); they are laid radially but without the use of a keystone at the middle. The plaster, which presumably once coated the entire tower inside and out, is of the same lime mortar but with a smoothed surface.

The tower is oriented according to the cardinal points of the compass. Each of the eight pillars has a big base stone of dark rough-hewn sandstone (see pl. 3, left). It rests not directly upon the foundation stones but on a low cylindrical drum placed on a thick layer of plaster, which in turn rests on the foundation stones (see theoretical sketch, fig. 7). The heaps of rocks forming the pillar

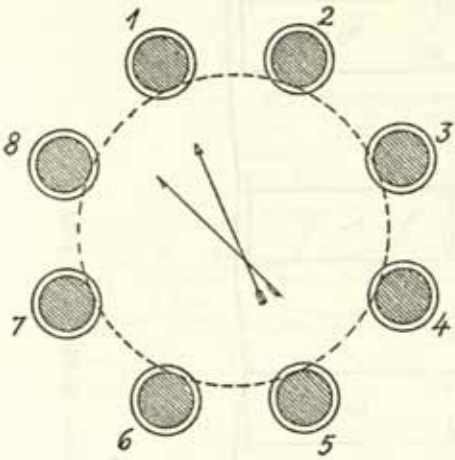


FIGURE 2.—Ground plan.

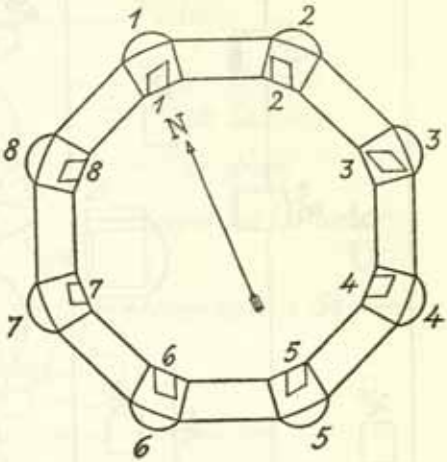


FIGURE 3.—Level of lower beam holes.

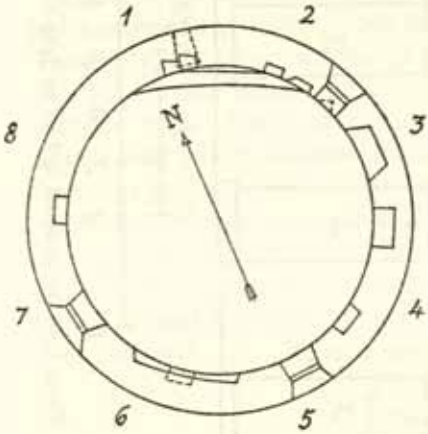


FIGURE 4.—Windows, niches, etc., in first-floor chamber.

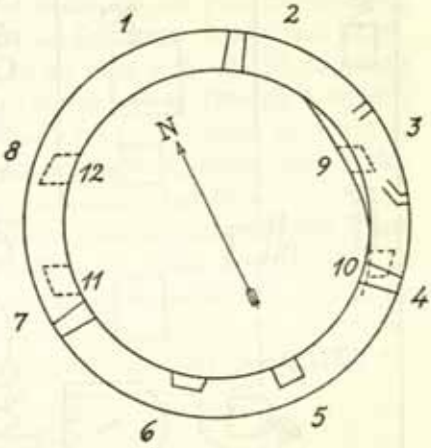
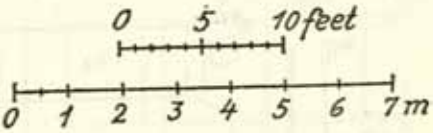


FIGURE 5.—Windows, niches, etc., in second-floor chamber.



FIGURES 2–5.—Newport Tower plans designed in 1938 by John Howland Rowe. (After Means, 1942.)

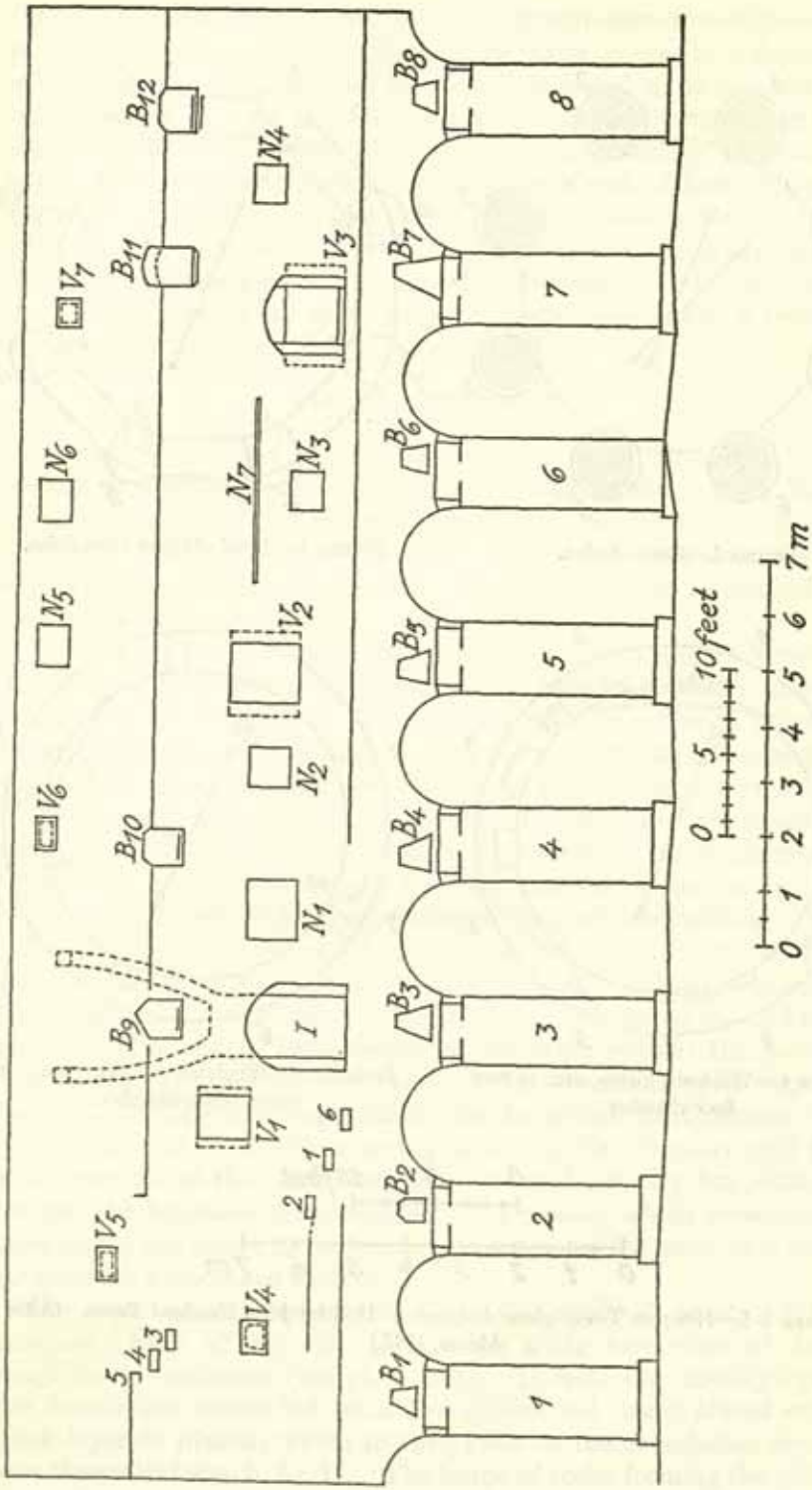


FIGURE 6.—Newport Tower elevation designed in 1938 by John Howland Rowe. (After Means, 1942.)

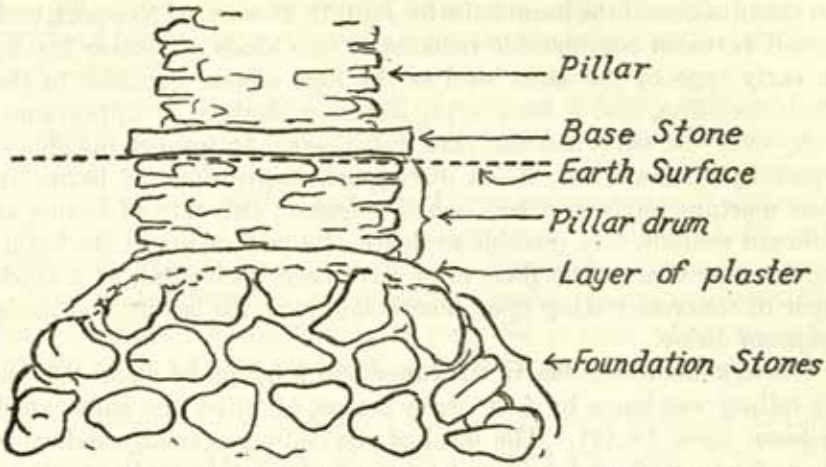


FIGURE 7.—Theoretical sketch of Newport Tower pillar foot.

foundations were arranged in an annular trench, which thus must have been the first element in the building of the tower.

There are no capitals, in the proper sense, on the pillars—nothing but a rather thin impost block or capstone for the arches to rest upon. These are placed eccentrically inward so that part of the capstone juts out like an "offset" for as much as about 0.30 m. (see pl. 4, upper, extreme left). Some of the pillar heads may be studied on plate 4, upper, and lower, extreme right, and on plate 3, center and right, from the inside. The arches are low and somewhat flat.

Inside the tower we see that above each pillar is a trapeziform beam hole (pl. 3, center and right). These holes must be regarded as having been part of the original design and construction. They once enclosed the ends of long beams, for they correspond pairwise: 1–6, 2–5, 3–8, 4–7. This is shown by the theoretical sketch (fig. 8).

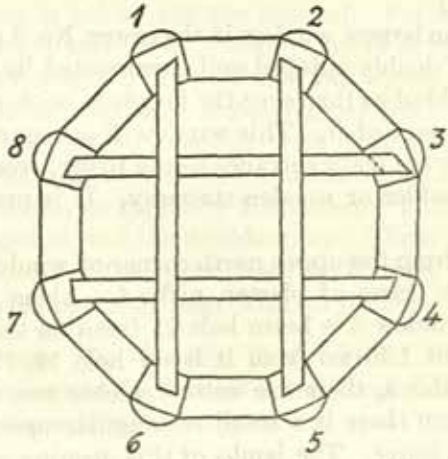


FIGURE 8.—Theoretical sketch of lower beams of Newport Tower.

An examination of the beam holes by John H. Benson, of Newport, and myself revealed considerable remains of two kinds of mortar inside, an early type of the same kind as the lime mortar common to the whole building, and a later type, differing slightly in appearance, lying over the early mortar here and there. It seemed possible—especially in beam hole 2—to distinguish impressions of beams in both mortars, early and late, which suggests two sets of beams at different periods, i. e., possible evidence of a restoration of the building at some time. The floor must have been horizontal, of a thick layer of concrete resting upon boards laid over the beams, and made fireproof below.

The first-floor chamber in the tower had a height of about 2.25 m. Its ceiling was borne by four heavy beams, of which the ends rested in beam holes (9–12). The level of the ceiling is clearly indicated by a fairly wide ledge running round the inside wall at about the height of the upper edge of the beam holes (see pl. 7, upper).

The fireplace (see pl. 5, upper) is an open recess in the wall above pillar 3, that is, in the east side. Running upward from the two rear corners of the fireplace are two flues which, describing a slight bend, pass up inside the wall and emerge just under the upper edge of the tower (see fig. 6) where a projecting stone is placed over each of the two holes.

Near the fireplace, going clockwise, we find the niches 1–2. About 0.50 m. from niche 2 is window 2, double splayed and surmounted by a lintel. About 1.50 m. from this window is niche 3 and above it a horizontal, fairly deep slot about 2 m. long, which Rowe already considered to have been intended to take a table top. This slot and niche 3 are shown in plate 5, lower. Mr. Holand considers that the table, if it was one, must have been an altar table, and niche 3 below it "a cavity for the reception of sacred relics." (See his "America: 1355–1364," p. 79 et seq., 1946.)

Then follows the largest window in the tower, No. 3 (see pl. 4, lower, and pl. 6). It is doubly splayed and surmounted by a flat relieving arch of the same kind as that over the fireplace, with no keystone. It has a lintel over part of it. This window 3 is regarded by Holand (op. cit., p. 47) as the main entrance to the tower, accessible from the outside only by ladder or wooden stairway. It is probable that this was so.

About 0.75 m. from the upper north corner of window 3 is a rectangular cavity with traces of plaster, niche 4. About 1 m. above the same corner of window 3 is beam hole 11 (seen on the right in pl. 7, upper), and about 1.40 m. from it beam hole 12. Directly north, exactly above pillar 1, there are neither niches nor windows, but a little distance from there is a small rectangular opening, window 4, shown in plate 7, lower. The jambs of this opening are straight, not

splayed. This small window 4 must have been the only means of watching the region north of the tower for the inhabitants of the first-floor chamber.

Next we find traces on the wall of an inner stairway running from the first to the second story: six rather small, rectangular step sockets in an oblique line (see fig. 6 and pl. 7, lower). Then follows window No. 1, not doubly splayed, just left of the fireplace (see pl. 5, upper).

The second-floor chamber had three small windows (5–7), only slightly splayed inward. Between windows 6–7 are niches 5 and 6.

None of the essential architectural details—floors, windows, fireplace or stairs—can reasonably be regarded as later additions to the first building. To me the tower seems to be an original whole.

Now where shall we look for a similar primitive building fashion? Not in Iceland, where the people built with earth and wood. Nor in Greenland, where stone was used, it is true, but generally without mortar. But we do find a similar technique in medieval buildings in the Scottish isles. And yet, a comparison with Newport Tower shows that its masonry is a trifle more irregular and primitive.

However, this kind of masonry cannot be used as any chronological criterion, or the consistency and appearance of the mortar either. Both phenomena are, so to say, timeless; we see how the same technical mode of building held out among the poor populations of the Scottish isles right up to the present day. Thus neither the masonry nor the mortar of Newport Tower lend themselves for use as chronological evidence.

In its style Newport Tower undoubtedly contains medieval features. The pillars themselves and the flat arches of the arcades and over the fireplace are typically Romanesque elements. The double splay in some of the windows is also a common Romanesque feature.

Concerning the fireplace, the question has been asked whether the lack of a chimney is not an antique element. Perhaps it is, but this chimneyless vent, conditioned primarily as it is by the cylindrical form of the tower, subsidiarily by the secondary use of the tower as a windmill, cannot be taken as a chronological foothold. For even if the builders were ever so familiar with chimneys, practical considerations may have prevented the inclusion of one here.

Thus there remain, as typically Romanesque architectural details, the pillars, the arches, and the double splay. These medievalisms are so conspicuous that, if the tower were in Europe, dating it to the Middle Ages would probably meet with no protest.

For what purpose was Newport Tower built? Three answers to this question have been to the fore: Windmill, watchtower, and church. First let us take the windmill theory.

The following arguments have been advanced in support of the idea that Governor Arnold built the tower in 1677 or shortly before as a *windmill:* (1) Peter Easton's mill at Newport, built in 1663, collapsed during a hurricane on August 28, 1675; therefore it is reasonable that Newport Tower was put up in replacement. This, of course, is a possibility. (2) Governor Arnold is assumed to have known the famous architect Inigo Jones's round stone mill on pillars at Chesterton, Warwickshire, England, and to have built Newport Tower from it. But now Philip A. Means has shown that Inigo Jones's tower at Chesterton, built in 1632, was originally intended for an astronomical observatory and was only later converted into a windmill; with this the argument is deprived of its weight.

That the tower is known to have been used as a mill tells us nothing of its *original* purpose.

As a counterargument to the mill theory, reference has been made to the dangerous open fireplace in the first-floor chamber. But if we think of Newport Tower not as a mill alone but as a combination of mill and watchtower, this objection may be rejected, the fireplace in that case being used only when the building was used as a watchtower, not as a mill. The deciding argument against the windmill theory, however, is the fact that the tower rests on pillars and arcades. This would be an anomaly in the case of a windmill.

Can the tower originally have been a *watchtower*, maybe a fortified one? The argument against this last, as against the mill, is the pillars and arcades; in a fortification they would be not only unnecessary but a direct weakness. In a common nonfortified tower, however, arcades would seem very natural. So that, disregarding the question of defense, the watchtower theory is not unreasonable.

May the tower originally have been a *round church*—or rather, the central part of one? This would provide a natural explanation of pillars and arcades. The eight pillars, placed in a circle and connected by arches, form a design exactly like that of central ecclesiastical buildings; moreover, the exact orientation according to the cardinal points is of religious significance; again, the outward projecting capstones of the pillars, the so-called "offsets," although credited with static significance, may also have served as bases for a light, sloping roof over an ambulatory. We do not know whether or not there was such a structure (possibly with an apse), the archeological excavations having been insufficient on this point. The possibility has also been suggested that an ambulatory was planned but never executed, that the building was an unfinished emergency church.

Is the character of the tower as a *fortified building* particularly obvious? No, this cannot be said about it, although it would certainly be useful as a place of refuge in times of disturbance. Curiously

enough, the tower is almost blind on the north (inland) side, whereas there is a good view in the other directions, out over the sea. As it stands, the tower seems to presuppose a pacified hinterland on the north.

In recent times a fourth theory has been advanced: Newport Tower was a sort of *mercantile office building*, a medieval storehouse whose arcaded ground floor is nothing but a symbol of trade from Hanseatic days (see Th. Fliflet, in Nordisk Tidende, April 1949).

When was Newport Tower built? Archival documents take us back to 1677, and, in addition, Frederick Pohl and Hjalmar Holand have submitted two literary evidences—the Wood map (1634) and the Plowden petition (shortly before 1632; see Holand, "America: 1355–1364," p. 31 et seq., 1946)—which make it probable that the tower was in existence prior to 1639, the foundation year of the town of Newport.

This is all that literary sources can tell us, so let us return to the archeological, i. e., William S. Godfrey's excavations in 1948–49. What did they reveal? In 1948 nothing decisive, but in 1949 the following (see Godfrey, Archaeology, Summer 1950, Spring 1951; and American Antiquity, October 1951).

A culture deposit which, by the small objects it contained, was datable to colonial times, extended in *under* the foot of one pillar (but *over* the foundation stones), and there, under a pillar, was found a piece of gunflint and a fragment of a clay pipe. From this Godfrey concludes that "this layer was partly deposited before the first stones of the tower columns were put in place." Furthermore, in the earth filling the annular trench in which the pillar foundations are laid, and which Godfrey assumes was dug before the building of the tower, a glazed sherd (perhaps seventeenth century), and, on the bottom of the trench, the imprint of a square boot or shoe heel, and under it, in a depressed concavity, two small clay pipe fragments were found. Godfrey concludes: "Either Governor Arnold built the tower, or one of his contemporaries did."

These conclusions are somewhat controversial, however. Frederick Pohl and Hjalmar Holand point out that the former owner of Newport Tower, Gov. Will C. Gibbs, had an excavation made right to the bottom of one of the pillars; might the shoe imprint not originate from that excavation? And, in point of fact, neither glazed sherds nor square shoe heels are necessarily post-Columbian proofs. But *if* Godfrey succeeds, first, in dismissing the possibility of recent intermixture, and, second, in dating the named small finds to colonial days, then I consider that the proof against the medieval origin of Newport Tower will have been secured.

Who built Newport Tower? Here we have four hypotheses: The Norsemen, the English, the Dutch, and the Portuguese.

The Norse thesis.—The idea of ascribing the tower to ante-Columbian Norsemen is closely associated with the endeavors to place "Vinland" in New England. In 1839 C. C. Rafn suggested that the builder of the tower was Erik Gnupson Upsi, an Icelander and bishop of Greenland, of whom it is written in 1121 that he set out to find Vinland; F. J. Allen agreed in 1921. Vilhelm Marstrand (in an unpublished work) has a preference for the thirteenth century and names the Norwegian Olaf, also a Greenland bishop, as the presumptive builder. Hjalmar Holand chooses the fourteenth century and credits the building of the tower to the Norwegian Povl Knutsson, who, according to a Bergen document of 1354, was to sail to Greenland to rechristen the apostates there.

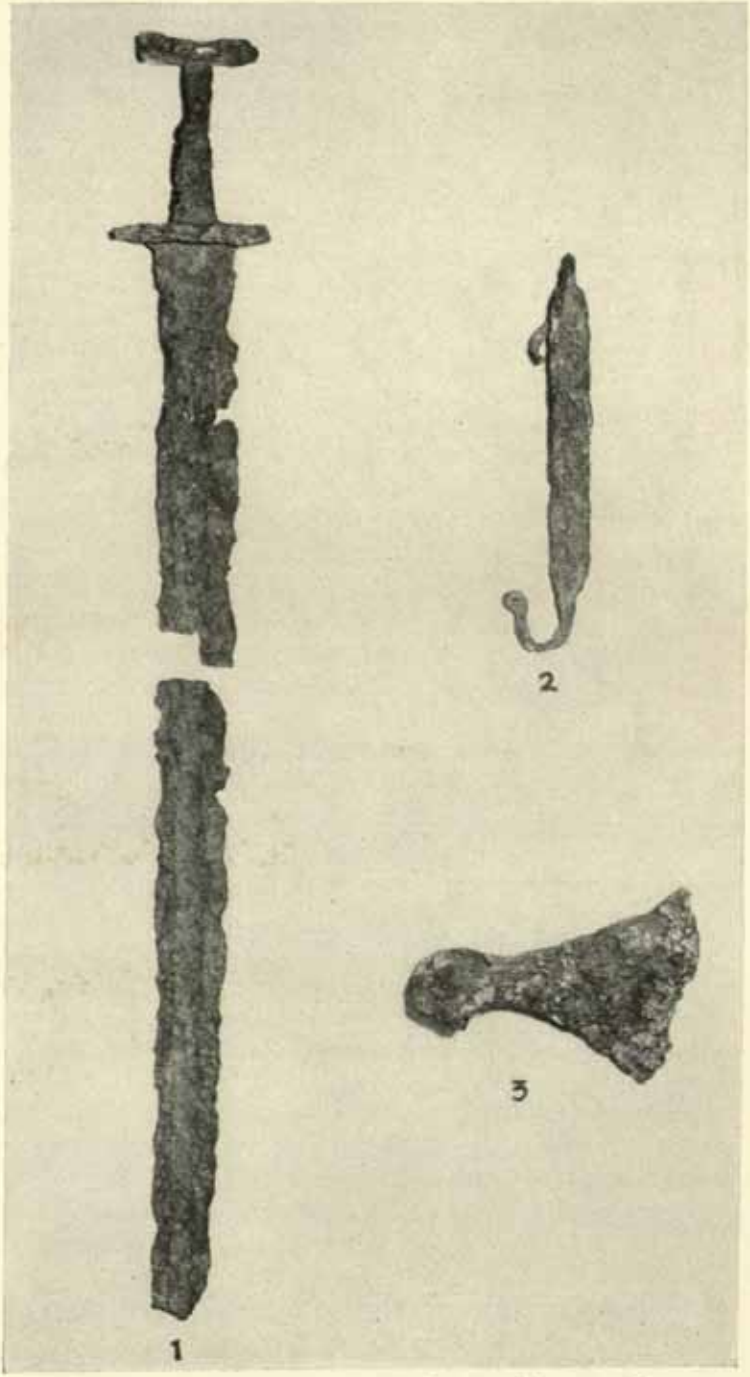
The English thesis.—Like the two that follow, this hypothesis is post-Columbian. If the English built the tower, they must have done so between 1639 (the foundation of Newport) and 1677 (when the tower is mentioned in the will of Governor Arnold). In that case it may have been built by Arnold, who came to Newport in 1651.

The Dutch thesis.—If the Dutch built Newport Tower, this must have taken place before the English founded Newport in 1639; in this connection reference may be made to William Wood's map and the Plowden petition, which have created some probability that the tower was there before the town was founded.

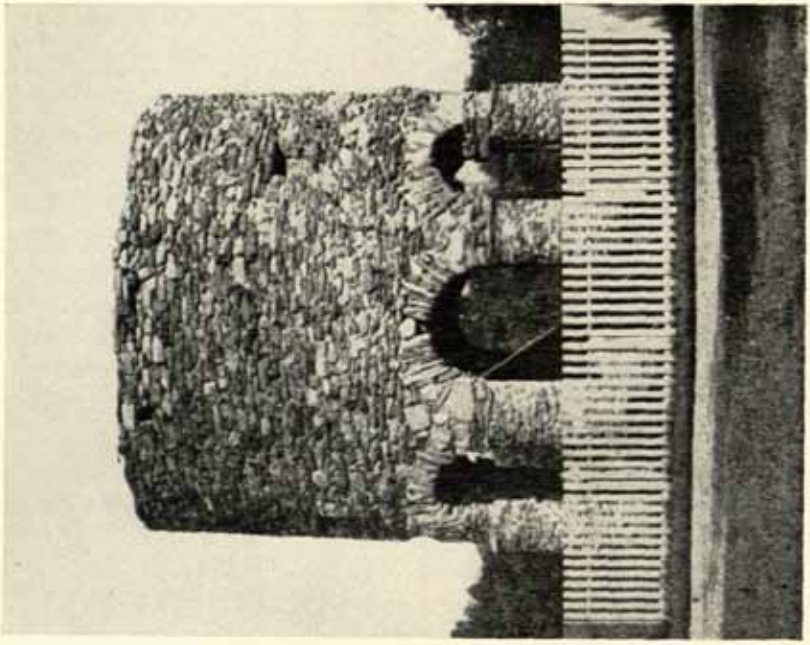
The Portuguese thesis.—The Portuguese, too, frequented the waters around Newport in post-Columbian days. Herbert Pell (Rhode Island History, October 1948) believes the tower was built by Portuguese under the direction of Miguel Cortereal as a watchtower and beacon for the purpose of keeping a lookout and sending light signals over the sea to aid in Miguel's search for his missing brother. The tower, Pell says, was hastily built by shipwrecked mariners; pillars and arcades were the outcome of considerations of speed and economy. According to Delabarre's interpretation of the Dighton rock inscription (see his "Dighton Rock," 1928), Miguel was chief of the Indians, for which reason the tower needed no lookout window onto the land behind on the north.

To conclude, we may summarize as follows:

The Norse thesis is upset if Godfrey succeeds in proving his assertion that the tower is post-Columbian in time. If not, the old thought is revived that Newport Tower is a remnant of a Nordic medieval round church. To me, however, it seems that the Godfrey excavations in 1949 have made a post-Columbian dating extremely plausible. The English thesis is weak if the tower is regarded as a round church (an English Puritan community in the seventeenth century would scarcely

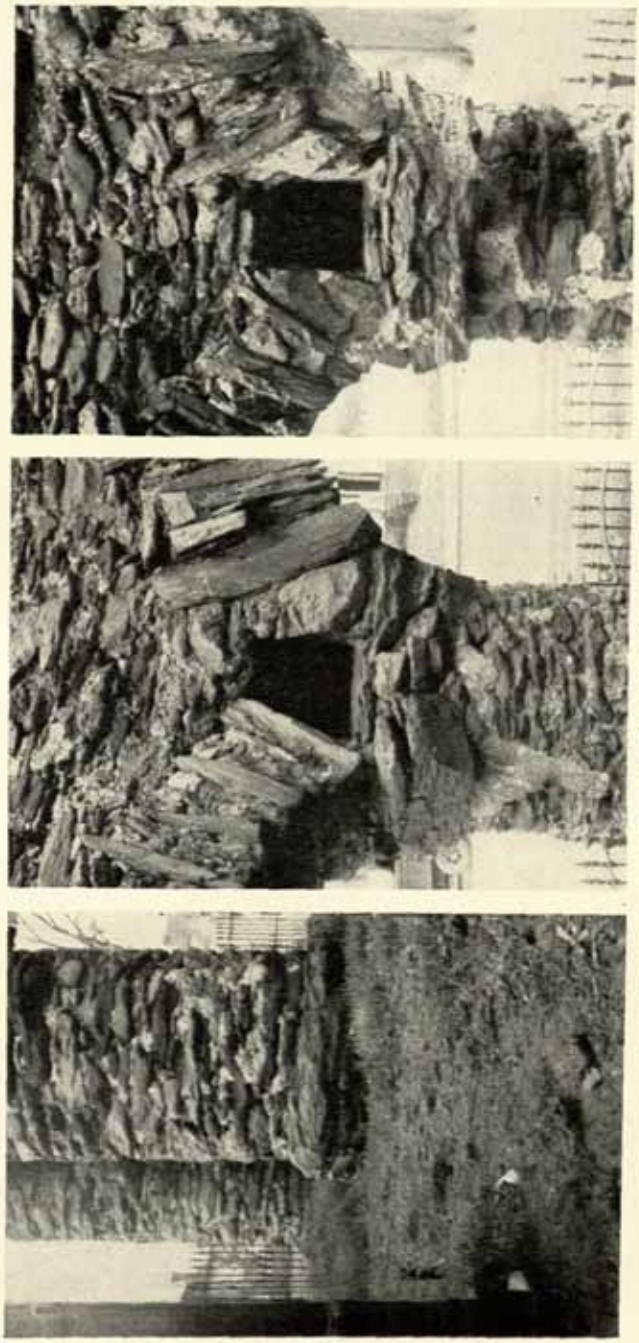


THE BEARDMORE FIND, IN THE ROYAL ONTARIO MUSEUM, TORONTO.
1, Sword. 2, Flat band (hoop of rattle). 3, Ax blade. About one-fifth natural size.



2. NEWPORT TOWER SEEN FROM THE SOUTH.
(Photographed 1948.)

1. NEWPORT TOWER SEEN FROM THE EAST-SOUTH EAST.
(Photographed 1855.)



NEWPORT TOWER.

Left, pillar 2 seen from the north; pillar 3 in the background. Center, beam hole 1. Right, beam hole 2. (Photographed 1948.)

1. NEWPORT TOWER.

Pillars 1 and 2 seen from the outside. Window 2 in middle background. (Photographed 1948.)

2. NEWPORT TOWER.

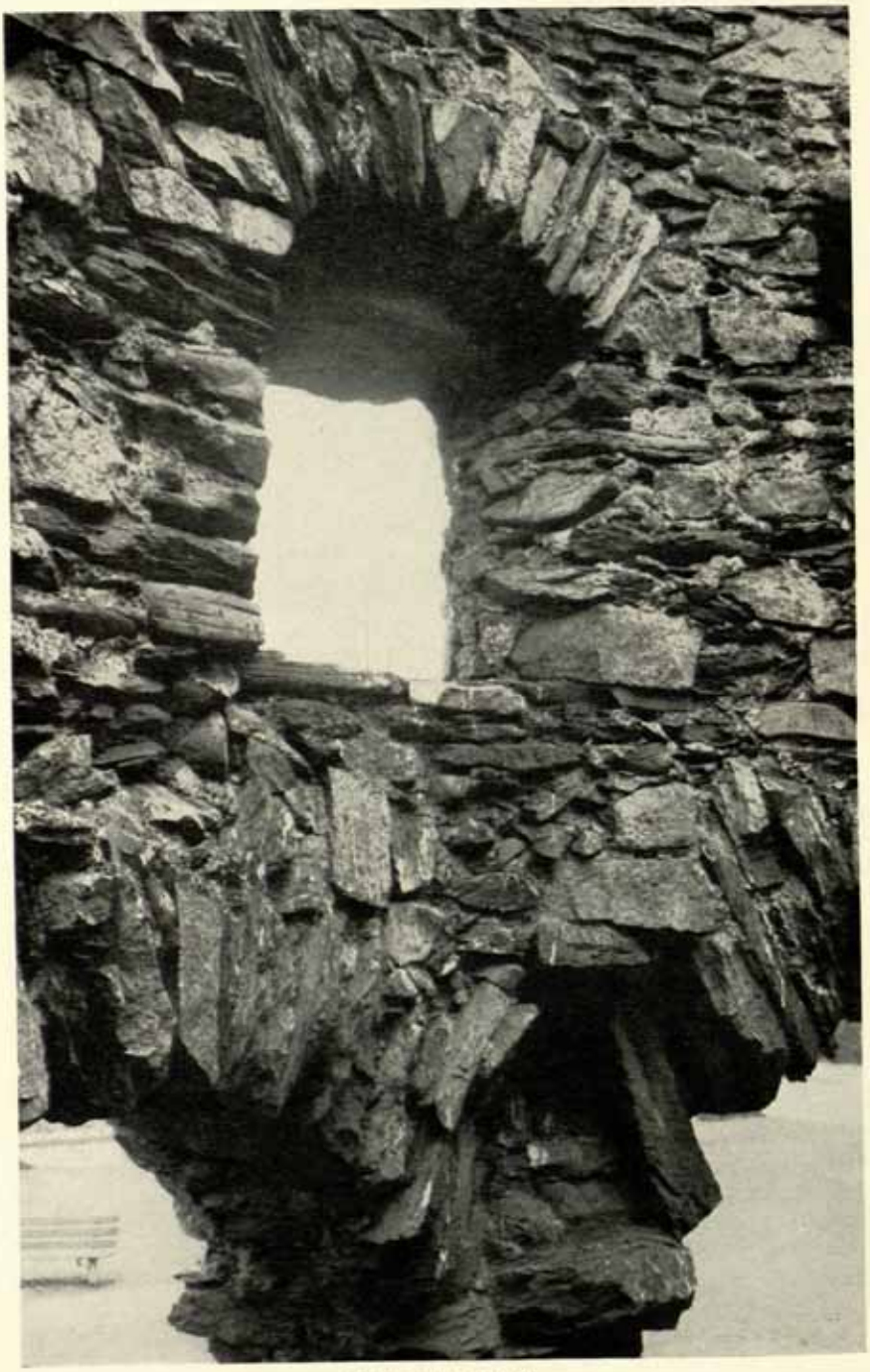
Pillars 7 and 8 seen from the outside. Window 3 in right foreground. (Photographed 1948.)

1. NEWPORT TOWER, INSIDE.

The fireplace, window 1, beam holes 9 and 10, and niches 1 and 2. (Photographed 1948.)

2. NEWPORT TOWER, INSIDE.

Niche 3 and, above it, the horizontal slot possibly intended to take a table top. (Photographed 1948.)



NEWPORT TOWER.
Window 3, seen from the inside. (Photographed 1948.)

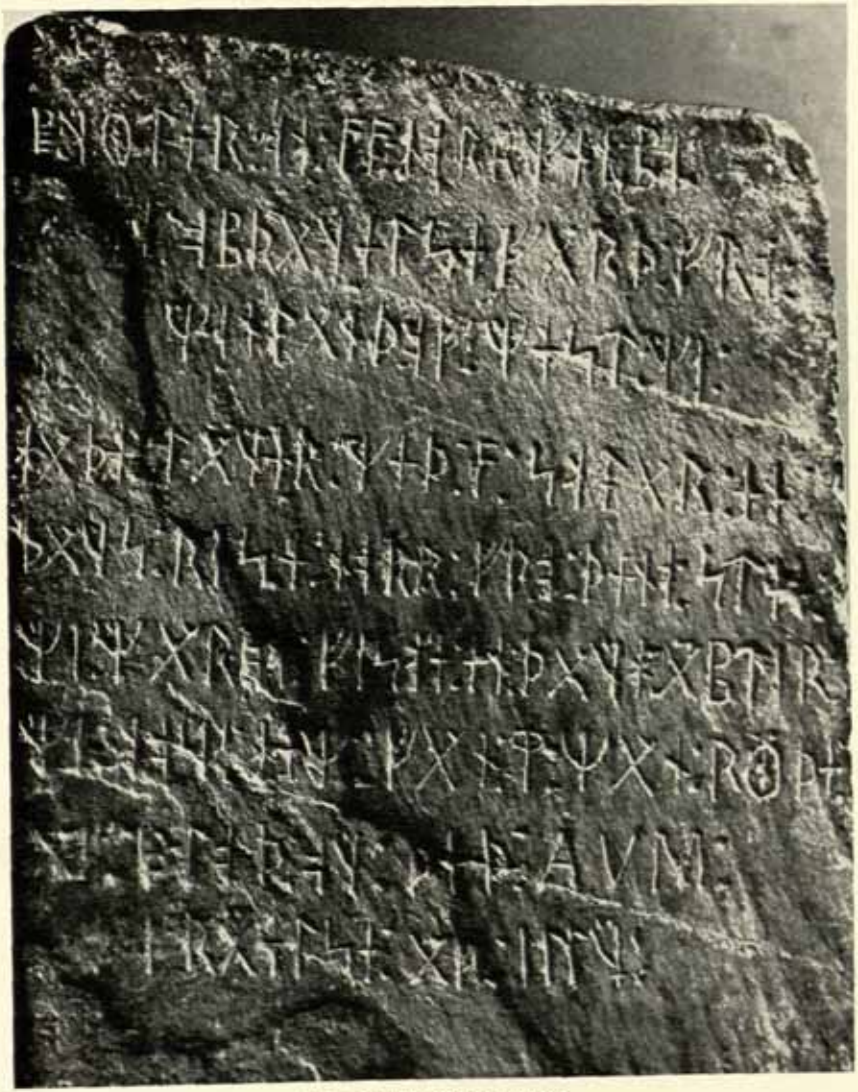
1. NEWPORT TOWER, INSIDE.

At the top, niche 6 (left) and window 7; center, horizontal ledge indicating ceiling level of first-floor chamber; right, beam hole 11; bottom, top of window 3. (Photographed 1948.)

2. NEWPORT TOWER, INSIDE.

Window 4. Over it, three step sockets (Nos. 3–5) of an inner stairway. To the right, below, step socket No. 2, with a pigeon in it. (Photographed 1948.)

THE KENSINGTON STONE WITH RUNIC INSCRIPTION ON FRONT (LEFT) AND EDGE.
About one-seventh natural size. (Photographed 1948. From the Smithsonian Institution.)



THE KENSINGTON STONE.

Part of the front bearing runic inscription. About one-seventh natural size. (Photographed 1948. From the Smithsonian Institution.)

THE KENSINGTON STONE.

Parts of the edge bearing runic inscription: Left, the top of the inscription; right, the bottom. About one-fifth natural size. (Photographed 1948. From the Smithsonian Institution.)

build its church to a Catholic round church pattern, or permit it to be used as a mill when it was only 40 years old). On the other hand, it is a reasonable assumption that Newport Tower was an English watchtower from about 1640. The Dutch thesis: It must be recognized as a possibility that the tower was a Dutch watchtower built about 1625. The Portuguese thesis: Herbert Pell's assumption is slender, based as it is upon a single special, acute situation. In theory, however, neither a Portuguese nor a Spanish origin can be rejected.

Everything taken into consideration, I am most inclined to regard Newport Tower as an *English watchtower* (*or beacon*) *dating from about 1640.*

THE KENSINGTON STONE

In November 1948 I made a close study of the Kensington stone in the division of archeology of the Smithsonian Institution in Washington, D. C. John Howard Benson, the Newport sculptor, gave me his valuable assistance. The photographs reproduced in plates 8–10 were kindly presented to me in 1948 by the Smithsonian Institution.

The stone is 0.75 m. high and 0.38 m. wide. In thickness it measures 0.14 m. at the top and 0.02–0.07 m. at the bottom. The material is a blackish graywacke with a grayish surface. The runes are carved on one side of the stone and on one edge. The rune-carved side, the "front," is naturally smooth, whereas the edge with the runes has been evened off with the point of a pick hammer. On the back there are longitudinal glacial striae. Below, the stone is hewn obliquely up from the back to the plane of the front and smoothed off, with the result that the bottom of the stone (the "foot") is rather thin. To all appearances the stone was shaped to stand upright.

The runes, about 2.5 cm. high, are cut with a chisel (width of edge 4–4.5 mm.) from two sides, generally down to an acute-angled bottom. Benson says: "In general it is a chisel-cut inscription, not a point-."

A large number of the runes have been worked over in recent times with an iron, thus causing the old surface of the character (the "skin") to disappear and making the rune deeper. Nevertheless, more than half of the runes are still intact and reveal a constant weathering (patina), often differing very little in appearance from the untouched surface of the stone. This weathering has a grayish tinge, quite different from the pale, almost white tone in the overworked runes.

I shall here mention two particular observations:

1. The second line on the front inscription begins (before the two dots) with the remnant of a rune, the vertical stem; the rune seems to have been either ᛁ or ᛏ.

2. At the foot of the stone is the letter H (see pl. 8, right), cut by Mr. Holand in 1908. On examining this 40-year-old H closely

we find that both its vertical stems are overworked, whereas the cross stroke is intact; and this cross stroke shows incipient weathering.

As will be known, the inscription on the Kensington stone, translated into modern English, reads:

Front:

Line 1 8 Goths and 22 Norwegians on
2 ? exploration-journey from
3 Vinland across West. We
4 had camp by 2 skerries one
5 day's journey north from this stone.
6 We were and fished one day. After
7 we came home found 10 men red
8 with blood and dead. A V M
9 save from evil.

Edge:

Line 1 Have 10 men by the sea to look
2 after our ships 14 days' journey
3 from this island. Year 1362.

For the transliteration and transcription of this text see figure 9.

This then is an account, without mentioning names, of an expedition of 30 men who, away in the wilderness, far from their ships at the sea coast, have suffered a bloody attack. Ten of the thirty were killed (scalped?), while the others were out fishing. They send a prayer to the Virgin Mary (A V M is deciphered as Ave Virgo Maria), and in conclusion the runes say that 10 men are by the sea keeping guard on the expedition ships. Moreover, that this happened in 1362.

The authenticity of this inscription has many assailants and perhaps still more defenders. There is no denying that the great majority of philologically erudite scholars are on the side of the aggressors. It must be understood that this is a specimen of linguistic text of which the genuineness or falsity can only be decided—if it can be decided at all—by people familiar with the Nordic language of the fourteenth century.

Before the philologists have their say, I shall briefly present and comment upon certain archeological considerations. They may be summarized into four points.

1. On the finding of the stone.—It is stated that the stone was unearthed by the farmer Olof Ohman while working to remove a tree stump. The stone was lying among the roots of the tree and they had grown at an angle to the shape of the stone; this can be explained only by assuming that the stone was already there when the tree above it was young and that in order to get down deeper the roots must have encompassed the stone and following its outline. Estimating the age of

FIGURE 9.—Transliteration and transcription of the Kensington stone inscription. (After Moltke and Anderson, 1949–50.)

the tree at about 60 years when the stone was found in 1898, simple subtraction takes us back to a time in the latter part of the 1830's, i. e., to a time several years before the white colonization of Minnesota began. This being so, we are told, the stone with its inscription must be genuine.

Against this the critics argue, and justly, that the details of the story of the find were formulated so long after the event that one can hardly be sure of their correctness. Next, and likewise justly, that the estimation of the age of the tree, long since disappeared, depends upon arbitrary judgment. For example, if the tree was only 30 or 40 years old, that would bring us well within the first colonization period. Thus there is no proof to be had here.

2. The inscription expression: "this island."—The finding place is a bank situated in a depression that dried up long ago. There is a possibility that 500 years ago this depression was a lake, over which the bank rose as an island. If this can be substantiated geologically, and if simultaneously it can be shown that there was no lake in the nineteenth century, this would be evidence in favor of the stone's genuineness. The question cannot be said to have been clarified so far, however.

3. Inscription technique.—It signifies nothing that the chiseling of the runes is quite different from the picking technique of the Nordic Viking-age runic stones (whose characters are cut with the point down to a rounded base). But one thing is of interest: the patina of the letter H, dating from 1908, on the foot of the stone. If it takes 40 years to produce a slight patina, it is permissible to conclude that full patina can be produced in the course of about 70 or 80 years. Therefore, if the runes are genuine, i. e., about 500 years old, the patina of course is easily explained; if they are false, say 80 or 70 years old, the patina *may* nevertheless have been laid in that period. In other words, the proof which the defenders of the inscription would derive from the patina of the runes is no proof.

4. Other finds.—On Mr. Holand's finds of iron weapons and fire steels in northern Minnesota, and of "mooring holes," see below. These finds are well worth considering, but to a critical judgment can scarcely provide more than some slight support for the authenticity of the Kensington inscription, but no proof.

I now call upon the Scandinavian philologists. At my request three Danish scholars have given opinions: the runologist Erik Moltke, the linguist Harry Andersen, and the linguist Karl Martin Nielsen. The contributions of the first two are published in Danske Studier, 1949–50. (For further contributions, see list of references at end of text.) Nielsen's opinion follows here in summarized form:

The Kensington stone inscription dates itself to 1362, but is considered by many investigators to be a falsification, made toward the close of the nineteenth century.

Orthography and phonetics.—The terminal vowels are weakened to *e* except in *æptir*, *þeno*, and perhaps *illu;* this does not agree with either Old Swedish or modern Swedish. *rr* in *norr*, *norrmen*, is modern Swedish orthography; the medieval usage was *r*. *west* is a borrowed form which makes its first appearance in early modern Swedish. *from* is unknown in Old Swedish. The spelling forms *rise* and *þeþ* are unknown in Swedish. The last three forms can scarcely be explained otherwise than as intrusions of English (American). In the orthography, however, the most decisive criterion is the use of *j* in *skjar;* in the Middle Ages *i* and *j* (the long *i*) are paleographic variants; no distinction according to sound values—*i* as a vowel, *j* as a consonant—appears until the sixteenth to seventeenth centuries.

Inflection.—The substantives lack case inflection and the verbs plural inflection. Sporadic examples may occur in Old Swedish, but consistent use is unknown. In particular, the use of the singular for the plural in the verbs is remarkable; according to Wessén this has its place in recent Swedish—including the spoken language, beginning with the seventeenth century. *wore* before the neuter plural *skip* is a modern Swedish form (Old Swedish *war*). *illu* (if this is the correct interpretation) is the only regular Old Swedish case form. *þeno* occurs only once in Old Swedish, as a dative neuter singular.

Syntax.—*10 mans*, genitive singular after a numeral is unknown in Swedish and is more probably an English plural form. *10 man*, singular after a numeral does not occur until modern Swedish (possibly through German influence).

Vocabulary.—The most discussed word in the inscription is *oppagelsefarþ* (expedition, journey), because *opdagelse*, *opdage* (discovery, discover) have no place in the Middle Ages. Supporters of the genuineness of the inscription assert that the medieval Swedish sources are of such a nature that the concept of discovery of new land does not occur in them; and S. N. Hagen, the latest to discuss the word, also attaches much importance to the fact that it was contained in East Frisian, a neighbor language to the Scandinavian, with transitive application in the sense of "bringing to light." None of these arguments are relevant, however. The East Frisian *opdagen*, which Hagen cites after Falk and Torp, is taken from a modern dialect dictionary; East Frisian is a Low German dialect and the occurrence of the word in Middle Low German (and Middle Dutch) is just as hypothetical as in medieval Scandinavian. If it were lacking only in medieval texts, this might be attributed to the character of the sources; but it also applies to the subsequent period—

in Sweden right up to the nineteenth century. In that period the literature of course makes mention of the discovery of new land, but the concept is covered by other words: *upptäcka* (or *uppfinna*) with the substantives *upptäckt*, *upptäckning*, *upptäckelse* (the subs. *opdagelse* is Danish, not Swedish). *Uppdaga* (*-as*) is also employed in the same period, but with other meanings: dawn, become light, come in sight. The position is the same in Denmark, except that the present meaning occurs somewhat earlier, in the eighteenth century. Seeing that the word is unknown in the Middle Ages in both Scandinavian and Germanic, and that it has other meanings in Early Modern Swedish and Early Modern Danish, whereas the concept of "discover" has other words, it is quite improbable that the Danish word *opdagelse* should appear in a medieval Swedish inscription.

Another deviation from Old Swedish is *þags rise* (Old Swedish *dagsledh* or *dagsfœrdh*) and *of* in *of west*, which must be assumed to be the English preposition.

Linguistically, then, the inscription reveals a number of unconformities with Old Swedish and they cannot be explained, as Holand avers, as a contrast between the inscription's character of the spoken language and the written language of the documents. Moreover, it includes words and forms which seemingly are due to English influence: *of west*, *þeþ*, *from*, *mans*. Of old forms there are but few: *œptir*, *þagh*, *þeno*, *ok* (and perhaps *illu*, unless this is a Swedish dialectal form or should be read *illy*).

Rune forms.—The following are normal: *b*, *þ*, *e*, *f*, *h*, *i*, *l*, *m*, *n*, *o*, *p*, *r*, *s t;* while the following are unusual: *a*, *g*, *j*, *k*, *w*, *y*, *œ*, *ø*. Some of the latter forms are explained by Holand as being due to influence from, or borrowed from, book minuscules—an influence that was more likely to be from majuscules than minuscules. The deciding point in the rune forms is the *ø*-rune with two dots as there is no precondition for such a form in medieval book writing; the Swedish *ø* does not come into use until after 1500.

As regards both linguistic and runic forms the inscription on the Kensington stone is thus a direct contradiction to a dating to the year 1362; and, besides the debatable points, there are three which must be taken as decisive: the use of a special *j*-rune, the *ø*-rune with two dots, and the word *oppagelsefarþ*.

The correctness of this conclusion now seems to be confirmed by a drawing of the inscription which Professor Holvik has recently brought to light and which he considers is a draft, not a transcript. [K. M. N.]

To my inquiry as to whether the Kensington inscription might not just as well be Old Norwegian as Old Swedish, Mr. Nielsen replied (letter of January 8, 1950) that although one or two phenomena in

the inscription may agree with West Scandinavian, there are definite traits which show that it must be East Scandinavian.

Both Erik Moltke and Harry Andersen in their opinions (Danske Studier, 1949–50) deny that the Kensington inscription is genuine, Moltke with runological, Andersen with philological arguments. Moltke points out that it makes use of characters (*ä*, *ö*, and especially *j*) which did not make their appearance until after the year 1500, and in his "Efterskrift" (loc. cit., p. 51 et seq.) mentions the runic document, referred to by J. A. Holvik (Concordian, No. 10, 1949), which is held to be nothing less than a draft of the inscription.

Whereas archeology to my mind fails to tell us anything positive for or against, some of the philological arguments against the genuineness of the inscription—especially the word *opdagelsefærd* and the use of the *j*-rune—must weigh heavily in the balance. Though I hesitate to say this is evidence of the modern origin of the inscription, the doubts of its genuineness expressed by most expert philologists are so strong that for the present we must reject the Kensington stone from the source material of research. As matters stand, one cannot reconstruct American pre-Columbian history on the evidence of this stone.[2]

OTHER INSCRIPTIONS

I have submitted to Erik Moltke photographs or drawings of some other inscriptions or inscriptionlike phenomena from North America, namely the following (see list in Aarbøger for Nordisk Oldkyndighed og Historie, 1950, p. 92 et seq.):

Bourne, Mass., stone.
Byfield, Mass., rock.
Clay Ferry, Mass., stone.
Deer Lake, western Ontario, stone.
Dighton Rock, R. I., rock (see above, p. 390).
Ellsworth, Maine, slate knife.
Grave Creek and Braxton, W. Va., two small stone tablets.
Hampton Beach, N. H., stone.
Horsford, Mass., stone.
Manana Rock, Maine, rock.
Marthas Vineyard, Mass., stone.
Merrimac River, Mass., fragment of stone pipe.
New Jersey, N. J., stone hammer.
Newport Tower, R. I., small stone.
No Man's Land, Mass., rock, modern.
Northmen's Rock, R. I., stone.
Sebec, Maine, stone.
Tiverton, R. I., rock.
Topham Beach, Maine, stone.
Tool Whittier Rock, Mass., stone.
Yarmouth, Nova Scotia, stone.

Mr. Moltke's opinion of them is as follows (extract from letter of August 15, 1949):

An examination of the inscriptions handed to me gives the result that the only ones in which there is any question of runes are the Kensington stone and the

[2] In the Washington Post, January 28, 1954, I find the following statement: "Proof that the Kensington Rune Stone is a hoax was claimed today by Dr. Erik Wahlgren, associate professor of Scandinavian and German at the University of California at Los Angeles. . . . Dr. Wahlgren said he recently traced errors in the inscription directly to an old encyclopedia found on the Ohman farm. He added that he had established that all materials, including the stone, necessary to the inscription were obtainable at the Ohman home."

inscription from No Man's Land which, judging from its whole character, is of recent time. All the others are natural grooves or inscriptions which without doubt can be described only as character inscriptions (χαρακτήρες) and presumably a couple of Indian pictographs, to which perhaps Tiverton and the now missing Tool-Whittier belong. Unfortunately, the material handed to me gives me no opportunity of judging of the genuineness of these inscriptions, for instance the interesting ones on the small amulets (?) from Grave Creek and Braxton. Without personal examination and knowledge of the localities it is difficult for me to say whether or not some may be signatures, as for instance Byfield 1.

After examining the various inscriptions I should say it is extremely doubtful if they can be connected in any way with the Scandinavian (or Greenlandic) runic inscriptions.

To this I would add that while the inscriptions seem to have nothing whatever to do with Scandinavian runes and thus from this angle must be considered worthless, these American phenomena may yet be of certain interest, regarded as Indian pictographs. Indeed, one or two (Byfield) may perhaps be explained as European signatures of Colonial times. It may be worth while starting a systematic modern photographic recording of this material by the methods created by Moltke himself.

SITES AND MOORING STONES

I had the opportunity of seeing the following sites:

North Salem, N. H.—Some partly underground stone structures. They have nothing whatever to do with the Scandinavian Viking age or medieval times. (See H. Hencken in the New England Quarterly, September 1939, and Will B. Goodwin, The Ruins of Great Ireland in New England, Boston, 1946.)

Marthas Vineyard, Mass.—A dolmenlike stone chamber. Doubtful as a grave. It might merely be some sort of play building of post-Colonial times.

Stony Creek, near Guilford, Conn.—Two sculptured stones (ornaments: scales, indentations, quadrifoil); a rock with sculpture (like a profiled base) and drilled holes; some house ruins, etc. These objects cannot now with any certainty be dated to pre-Columbian times. An excavation may possibly give some information. (Refer to Dr. Bert G. Anderson, assistant professor of surgery, Yale University, the discoverer of the site.)

Mooring stones.—A mooring stone is a boulder on the shore of a fiord or lake into which is drilled a hole for a bolt holding a ring to tie a boat. This mooring method is an ancient one in Scandinavia and Hjalmar Holand regards some of these mooring holes, namely, such as those discovered in Minnesota, as having been made by Norsemen in pre-Columbian days. (See his books, Westward from Vinland, p. 198 et seq., 1942, and America: 1355–1364, p. 135 et seq., 1946, and his article in Aarbøger for Nordisk Oldkyndighed og Historie, 1951, p.

227 et seq.[3]). Now, as Mr. Holand knows and admits, mooring holes are made to this day by fishermen on the North American Atlantic coast. But the presence of mooring stones in Minnesota is, says Holand, quite another thing: in this part of the continent the boats of the first white men in the nineteenth and twentieth centuries were small, flat-bottomed lighters, easy to pull on shore and needing no mooring stones. This is not a bad argument, and maybe these Minnesota mooring stones should be taken into consideration as indicating the presence of pre-Columbian Nordic people. When, however, Holand goes further, when he sees in these stones traces—indeed, the very route—of the men who cut the Kensington inscription, I must confess I cannot follow such an arbitrary view.

OBJECTS

While in the States in the autumn of 1948, I was shown some isolated objects, mostly of iron, which with more or less certainty were declared to be of medieval European origin. They were: A sword and hilt (Nos. 1–2); halberds (Nos. 3–5); spear heads (Nos. 6–7); axes (Nos. 8–17; fire steels (Nos. 18–20); tools (Nos. 21–22); twisted ring (No. 23); stone ax (No. 24); slate knife (No. 25). (See list in Aarbøger for Nordisk Oldkyndighed og Historie, 1950, p. 106 et seq., Nos. 1–25, and my comments, ibid., p. 111 et seq.)

There is reason for pausing at Nos. 1, 2, 3–5, 6, 8, 10, 11, 18, 21, and 24. These are the 12 specimens which, in my opinion, may possibly be of medieval Scandinavian origin. But in regard to none of them would I go so far as I have in the Beardmore case and accept their great age unconditionally. On the other hand, there are possibilities. This, however, says nothing of the eventuality that these 12 possibly genuinely medieval objects may have been brought to America in recent times—the same calamity that befell the Beardmore find. Only 5 of the 12 were found under circumstances that rule out such a possibility: Nos. 3, 4, 10, 18, and 21.

Accordingly, if I must characterize this material with reference to its weight as evidence of the white man's colonization of North America before Columbus, I am bound to say that it is weak on the whole. Strictly speaking, not even the five most likely finds provide any proof,

[3] In this paper Mr. Holand disputes the arguments presented in my report in the same periodical for 1950. Apart from his remarks on the Minnesota mooring stones referred to above, nothing in his article has changed my opinion. I bear tribute to Mr. Holand's ardor and acuteness, but sometimes his heavy conclusions do not harmonize well with the somewhat light premises. Let me quote from the paper cited above (p. 237) this sentence (translated from the Norwegian—the italics are mine): "Since in Minnesota there really are found five old weapons from Scandinavian medieval times that cannot have been brought in during recent times, *so we have in them five proofs of the genuineness of the Kensington stone* or, at all events, of the presence of Nordic people in Minnesota in medieval times."

because they can hardly be proclaimed as indubitably medieval Scandinavian objects. One can—and I for my part will do so—describe the material as "sympathetic" toward the idea that white men roamed in the places in question in pre-Columbian days, but it embodies no real proof capable, once and for all, of silencing all carping and scepticism. To each of the 12 points (not to mention the other 13) there is attached a certain measure of doubt.

CONCLUDING REMARKS

Looking over the foregoing pages, we must admit that our results are rather negative. First, the literary sources: All attempts at location of Leif's Vinland and Karlsefni's lands from the sagas have shown themselves unsuccessful. Second, as to the monuments and objects, let us sum up as follows:

The Beardmore find.—Owing to doubts as to the reliability of the report of the find, this must for the present remain as an uncertain, so far useless, document.

Newport Tower.—In all probability a post-Columbian building.

Kensington inscription.—The philological opposition to its authenticity too strong. Useless.

Other inscriptions.—So far useless.

Sites and mooring stones.—So far useless. The Minnesota mooring holes, however, seem to indicate the presence of pre-Columbian Nordic people.

Objects.—Some have had to be labeled as probably genuine European and medieval. But in our context such scattered objects form too slender a basis. No full evidence has been adduced that they were not brought to America in recent time; and even if such evidence were procurable in a few cases, one or two isolated relics of this kind do not weigh very much in the balance.

Now, what is required as adequately weighty evidence of the life and existence of Norsemen in North America in pre-Columbian times? The answer must be: above all a knowledge of *their dwellings* (or graves) on that continent. The moment we can find settlements with house ruins which in layout and construction and by the artifacts found in them can without a shadow of doubt be documented as being of Scandinavian origin, dating from the Late Viking age or the Middle Ages—or the moment we can find corresponding graves—the goal will have been reached. Then why not look for Norse sites of this kind? It has been done, the answer may be. Possibly; but not systematically and never by expert archeologists. I therefore propose that a search should be made.

A SUGGESTION

I suggest for consideration that money be found in America or Scandinavia to equip an archeological expedition with the object of exploring systematically certain previously selected tracts of land along the Atlantic coasts of New England and Canada for Norse ruins of the same character as those known and excavated in Greenland.

The expedition would have to be directed by Scandinavian archeologists with a practical knowledge of excavating Norse ruins in Greenland. Naturally, such archeologists are to be found first and foremost in Denmark, but also in Iceland, Norway, and Sweden.

Having regard to the immense stretches of country to be examined, the expedition must have an airplane at its disposal. Danish archeologists have previously had occasion to locate and map Greenland Norse ruins from the air.

It would be necessary to establish a collaboration between American and Scandinavian archeologists. Those taking part would have to select the most suitable regions and the points likely to be of particular interest.

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The Mountain Village of Dahr, Lebanon[1]

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[With 8 plates]

As one travels in the Near East through the mountains or plains that are under cultivation he is struck by the fact that isolated farm dwellings are hardly ever seen. The great majority of the population lives in the country, but they live clustered in villages and not in single farmhouses dispersed about the countryside. Those of us with a North American background tend to think of human agglomerations in terms of their economic bases. A city, a town, or a hamlet is situated where it is because the site was favorable and economic factors were propitious. A ribbon settlement is pressed against the highway in a fertile farming area, or a village has come into being at a crossroads, or a town has risen where there is an easy river crossing. But there are many villages in the world that have as bases factors that are, to us, noneconomic or even anti-economic, villages that have been founded in response to a desire on the part of their founders to be cut off from the world rather than in easy contact with it.

One such village is Dahr, which clings tightly to the limestone crags of the lower range of the mountains of Lebanon, 20 miles northeast of Tripoli. The site of the hamlet was originally forested with evergreen oak trees and used as a common grazing land for goats. From here came the logs used to hold up the heavy beaten-earth and straw roofs of the houses built in the valley, and from this woods came also the firewood and charcoal used in cooking and baking. A few hundred yards below was a never-failing spring. The actual founding of the village is shrouded in the mist of history. The oldest inhabitant said that it was hoary with age even in the time of his grandfather. Those who originally settled in Dahr were cer-

[1] The field investigations on which this paper is based were made possible by a Rockefeller Foundation grant to the University of Florida. The generous assistance of Dr. Neil Alter is gratefully acknowledged.

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tainly less affected by pressure of population than they were by the appearance of the tax collector. A long and difficult trail leading to an inconspicuous agglomeration of houses meant that it was not easily accessible to the tax collector and that consequently the inhabitants could enjoy a modicum of prosperity and peace of mind. The defense factor was also important. From a vantage point such as Dahr enjoys, it is easy to espy visitors from afar, both those who are welcome and those who are not. And like thousands of other villages, Dahr has, with the years, achieved a kind of protective coloring, forming an appropriate little piece in the mosaic of cultural and natural landscapes. Each house in the village seems to have been built where the fancy of the owner dictated. Villages in general seem to the western eye to be a confused, incoherent mass of mud or stone houses, huddled together without plan or order, in a maze of crooked, blind alleys, narrow, winding footpaths, and dark, forbidding passageways.

LAND

The possession of land, even in small, fragmented tracts, has literally and from time immemorial meant life to the Near Eastern peasant, because land has meant wheat, and wheat means bread—"the bread of life." "All else will pass away, the land remains," is an Arab proverb. The Arab peasant will go to almost any lengths to get land, and once he has it he will make terrible sacrifices in order to keep it, for land means bread, and bread is life; it is the life of the peasant today, and it has been for countless generations before him. His attachment to the land is a mixture of profound love and reverential awe; he is aware of its frailties, he knows just how far he can depend on it, and how it will react to his loving care through the beating rain, or the searing drought, or the battering hail; he reveres it because it has supported the long line of his ancestors before him, and it will in turn be a big factor, no matter how fragmented, in the support of his children after his death. For many centuries a man without land was a prey to the cruelty of the tyrant, just as last year's leaves are blown about at the vagaries of the wind. But a man with land was like a great oak tree, with roots deep in the ground; he could weather the storms, the acts of God, as well as the irrational acts of his fellowman, for roots in the land gave strength to him and to his family—they gave him "his daily bread."

The wealth of Dahr is land. The villagers own and farm some 200 unirrigated acres, but this is land that makes many of the abandoned fields of New England look rich and inviting by comparison. Here it is planted in wheat, barley, lentils, or millets, but the land is not in broad fields. A field is a tiny strip a yard or so wide, or a

hillside so steep and narrow in many places that the oxen used to pull the primitive wooden plows through the soil are with difficulty kept from falling onto the next terrace. But it is from these terraced strips that the villagers live. Four men in the village have between them in the valley 37 acres of irrigated land which is intensively worked and annually produces olives, figs, and grapes, and a winter cereal crop of wheat or barley, which, harvested in June, is usually followed by a crop of Indian corn or fast growing vegetables. Thus the entire base of arable land of the village consists of approximately 200 acres of unirrigated land, of which the greater part is left fallow every other year in order to enrich the soil and permit the accumulation of moisture in it, and some 37 acres of intensively cultivated irrigated land, on which heavy yields are obtained by the use of much animal fertilizer. There is also common land, which is estimated to be between 250 and 300 acres in extent, on which goats graze and from which thorny scrub is cut for fuel. Only one man from outside the village rents a few strips of village land, on halves. Two Dahr men rent some 15 acres of irrigated land in neighboring valleys. All the unirrigated land is in narrow strips and so full of stones that one wonders how the grain has a chance to grow at all. Terracing is extensively practiced; and one cannot but marvel at the human industry and patience necessary to construct the massive stone walls that separate and in reality support the long narrow strips, many of them less than a yard wide. Trying to determine how many people this unirrigated land would support in the United States is a waste of time, for there it would not be used at all.

THE VILLAGE

The village of Dahr itself is an agglomeration of 27 occupied stone houses, with a population in winter which numbers 137 persons. To be sure, many young men leave to work during the harvest season on the large estates along the coast, and whole families move for the summer months to houses near the irrigated lands below. The houses of limestone, with roofs of rolled earth or cement, are separated from each other by thick stone walls. There are no streets, just narrow and tortuous footpaths where both human beings and pack animals stumble over the loose stones. A house frequently shelters, besides the owner and his wife and younger children, a young married son who cannot yet afford to build a house of his own. Representatives of five generations in a single family will frequently be living in the same house, or agglomeration of rooms, for early marriages and many children are the rule. The lives of these villagers may seem to the foreigner to be colorless and dull, yet the people at the various stages in the life cycle, whether children, young adults, middle-aged, or old,

seem to be getting a lot out of life, in spite of the grim struggle to wrest their daily bread from the obdurate soil. If land is the wealth of Dahr, the stoicism and hard work of its inhabitants are its lifeblood.

THE STAFF OF LIFE

The dominant note in the simple pattern of village life is wheat, which is planted in the fall and forms green strips over the mountainside in winter. All winter long the grain fields are carefully gleaned of their green and edible plants by the women of the village. The wheat crop, upon which the people are dependent for their very life, is at all times very much in their minds. A late rain that falls at the time the grains are forming is always a welcome blessing, for it means an increase in yield. Any strong winds make the farmers' hearts heavy, and the scorching wind from the desert, the *khamsin*, is greatly feared, for if it blows for a few days when the wheat is green the grain will wither rapidly, and if the wheat is already ripe the hot wind will dry it out so much that it will shatter out of the head when it is cut. Even when the weather has been propitious, the grasshoppers may come in sufficient numbers to cut the yield by one-third or one-half, if not to destroy the crop entirely. The plague of grasshoppers 2 years ago did so much damage as seriously to discourage several of the villagers. And ants are an ever-present menace. They even rob the threshing floor, an endless belt of busy ants, each carrying a grain of wheat, making their way to the underground nest, while those that have deposited their burden are hastening back for another load, and in spite of strenous efforts to check their ravages a substantial loss from the meager harvest is sustained. But all in all such "acts of God" are fatalistically accepted. Even when the harvest is good the yield is ridiculously low. If the farmer gets 10 units in return for every 1 planted it is considered an extremely good yield, but it is usually much less. A six- or eight-fold return, about the same as reported a century ago,[2] is still considered average or good. If, when harvest time rolls around, there is anything at all to reap, the season is a glorious one for all.

The grain is, of course, harvested by hand, an old-fashioned sickle being wielded in the right hand to cut the stalks, which are gathered together in the left hand, the fingers of which are protected against thistles and any careless blow of the sickle by ingeniously made individual fingerstalls. These protectors are similar to those of clay that have been used for thousands of years, excellent examples of which are to be seen in the museum in Baghdad. The cut stalks are piled up in tiny sheaves which are bound by the womenfolk. Children and old women usually act as gleaners, for every head, every grain of

[2] Churchill, Colonel, Mount Lebanon, p. 38, London, 1853.

wheat is precious. After the gleaning, goats are driven in to eat the stubble and to leave their manure as fertilizer. The sheaves are made into big bundles, which are then carried to the threshing floor on the backs of donkeys or camels or, if one is too poor to have a pack animal, on the backs of men. The sheaves are laid in piles around the threshing floor, a flat surface of tamped earth in the form of a rough circle 25 or 30 feet in diameter. The actual threshing-out of the grain is effected by having a team of donkeys or a yoke of oxen pull a threshing board (*mauraj*) round and round over the sheaves. The underside of the board is studded with irregular chunks of black volcanic rock.

When the question was asked how many times they had to go around with the threshing board before the grain was threshed out, the reply was that it was a question of days rather than the number of times—that they used a calendar, not a stopwatch. Various members of the family take turns in bringing the sheaves to the threshing floor and in riding around on the threshing sled. By the time the wheat is separated out the straw is ground up as fine as if it had gone through a modern hammer mill; this is piled up on one side of the threshing floor with a locally made fork costing about a dollar, which has both handle and tines made of wood, bound together with heavy rawhide thongs. The wheat is winnowed from the chaff by tossing it in the air when the wind comes up in the late afternoon. The chaff is blown several feet away from the pile of wheat upon which a few large straws fall, to be brushed away with a homemade brush broom. The pile of wheat is winnowed again after being poured into a sieve, locally made of wood and rawhide thongs and costing the same as the fork. The straw is brought to the house on donkey back in huge bags and poured down through a hole in the roof into the storeroom below. The chaff is frequently used to mix with fresh dung in making the cakes that are dried and used for fuel.

The wheat is brought from the threshing floor to the house, where it is placed on a low table around which members of the family squat as they carefully pick out the small pebbles that got mixed with the grain during the threshing process. The wheat that is destined to be kept is made into *bourghol*. It is placed in a giant kettle, boiled till thoroughly cooked, and dried on mats in the sun, making what looks like a kind of coarse cracked wheat. This process has killed all weevils and their eggs, and the resultant *bourghol* will keep for years and is a staple food; pounded into ground meat it makes *kibbeh*, a sort of national dish in this part of the world. The wheat for immediate consumption is carried to the nearest mill, usually on the back of the patient donkey. The huge millstones are driven by water, and the building in which the mill is housed has built-in mangers where the donkeys can be fed while their masters wait for the grain to be ground.

Going to the mill is a social occasion, eagerly looked forward to, and the more people waiting to grind their wheat the better, for then there is an opportunity to exchange gossip for hours, perhaps all night. When the grain is ground the miller takes a small fraction of the flour for his fee and the farmer returns home. This whole-wheat stone-ground flour is made into thin, unleavened loaves of bread, in the form of huge pancakes. The baking is done by the womenfolk who use a community oven. Baking day is anticipated as a kind of social meeting, in spite of the fact that every phase of the process of living is attended by a lavish expenditure of time and labor.

A certain amount of wheat brought in by the gleaners in small sheaves is beaten out by hand on the doorstep at home. A pleasant afternoon was passed in the company of a man and his wife so engaged. It was a period of interesting gossip for the onlookers, but Mrs. N. was working all the time as she talked. Besides doing chores of this kind, this well-preserved woman cares for her family of eight children, works in the field, helps thresh and winnow wheat, carries water from the spring and gathers firewood in the rocky hills, makes dung cakes for fuel, and so on. She does not belong to a bridge club, nor does she attend cocktail parties.

TREE CROPS

The annual crops are by no means sufficient to support the people of Dahr, who engage in a number of other activities to supplement their income. Perennial crops—figs, olives, and grapes—are produced, too, but not enough of them to make the village self-sufficient. One good sign is that the Government (in 1952) inaugurated the policy of distributing fig trees and grapevines to those farmers who would plant them. The quality of the olives could be improved if, instead of being beaten off the trees by sticks, they were picked by hand; but this "is not the custom." Mr. M., former *moukhtar* (mayor), of the village, when asked what would be the best thing for the village, replied that more terraces should be built and more tree crops planted, thus increasing the capital as well as the income of everyone. This suggestion was countered by Mr. N.: "It takes lots of capital to establish vineyards and orchards of olive and fig trees, and one must have enough to live on while waiting for the trees to mature. It's all very well to talk of long-term investments, but what do we eat meanwhile?" This is the problem that confronts most villages, for the demands of the population on resources is too great and too continuously applied to allow of capital accumulation. This pressure is so great, and so immediate, that in certain years fields are not planted, for the simple reason that all the grain has been eaten and at the time of planting the people are unable to buy seed. The question at once arises: Why does the Gov-

ernment not lend money to the small farmer for his seasonal needs? This it would seem is within the scope of an agricultural bank, and such a bank exists in the Lebanon. But there have been instances in which an individual with "background," as the local idiom has it, has borrowed a thousand or fifteen hundred dollars with which to improve a specified piece of rocky land, on which the bank takes a mortgage, but has squandered the money on something else or invested elsewhere, and when the bank has pressed for payment, the land, of no intrinsic worth and still unimproved, is turned over for the mortgage—a manipulation more profitable to the entrepreneur than to the taxpayer. At the same time a man who is "land poor" and who needs a little money to hire seasonal help, or repair terrace walls, or buy seed, or to tide him over a period of poor harvests, meets with endless red tape and ultimate refusal.

The farmer has not only poor soil to contend with, but he can never count on the weather. There is generally a cold, rainy season in winter followed by a hot, dry season in summer—a typically Mediterranean climate. But the rainfall will vary from a scant 27.18 inches one year (1950–51), to almost double that, 45.70 inches, the next (1951–52). The hot, dry wind from the desert will scorch a crop of wheat or lentils in a few days. Too much rain will tumble a substantially built retaining wall.

Another brake on agricultural activities—permanent, and man-made—is the immemorial tax collector. It seems incredible, but even farmland so poor as this pays taxes—ranging from 50 cents to a dollar an acre, depending on the appraised value. The value can be "lowered" if one knows the right people and procedure, but this proviso excludes the landowners of Dahr. Taxes are still farmed out as they were in Roman, Byzantine, and Turkish days. That is, the tax collector pays a large sum to the Government for the privilege of collecting taxes in a certain area, and then he collects whatever the traffic will bear, everything above what he has paid to the treasury representing his profit in the transaction. The people of Dahr are lucky that they do not have to pay a landlord into the bargain. The recently enacted tax on incomes of over a thousand dollars a year will not affect anyone at Dahr.

INDUSTRY

When the Dahr people were asked why they did not engage in spinning and weaving, they replied that theirs was a poor village. When they were told that people in the small village of Beino did engage in those household industries, the reply was, "O, but that is a rich village." Thus cause and effect are confused. Instead of realizing that industry brings wealth, they feel that the community must be wealthy in order to have industry. Of course, to establish

an industry a certain amount of capital and skill must be available, but the capital necessary to acquire a loom is very small. The skill, however, must be acquired. Two Dahr families do engage in silkworm culture, which is farmed out to them on halves by relatives in the neighboring village of Jibrail, whence come the worms and the mulberry leaves. The work of feeding and tending them is done in Dahr, and each family produces about 100 kilos of cocoons, which are sold for about 60 cents a kilo. Thus from this source each family nets $30 a year. The droppings of the worms are dried in the sun to be used later as cowfeed. It contains highly nutritious elements and is greatly relished by the cattle.

The big cash industry in the vicinity of Dahr is the burning of lime. Fifteen kilns, on the average, are burned each year. The industry is based on purely local material. The limestone exists in unlimited quantities, and the fuel consists of the thorny scrub bush that grows wild in the areas that have no soil. Each burning requires the brush from 25 to 30 acres of this wasteland. The privilege of gathering the brush costs the entrepreneur from 25 cents to a dollar an acre, depending on the thickness of the growth. The kiln site rents for $2.50 a burning. The chief lime burner is an old man whose father and grandfather before him were lime burners. His son is learning the business from him and will carry on after his death. He and his son do practically all the work themselves. They quarry the limestone, arrange it in the kiln, cut the fuel, fire the kiln, and market the product. Each burning means approximately $175 to $250 net, which, multiplied by 15, makes an income that is most welcome in this capital-starved community. In addition, they farm 5 acres of unirrigated land on which they grow wheat, barley, and lentils. They buy goat manure from their neighbors for fertilizer.

LIFE OF THE VILLAGERS

The village reaches out with long bony fingers, as it were, to exploit the area which is too rocky and infertile to be cultivated. Several families keep goats, which are grazed on the steep mountainsides in the spaces between the narrow strips under cultivation and even on the rocky knolls. The several flocks, which number about 200 in all, are each in the care of a goatherd, either a local Dahr boy or one from a neighboring village. These boys often break the monotony of their calling by playing on their bamboo pipes of Pan, which in the distance sound somewhat like Scottish bagpipes. They also occasionally have a little picnic by roasting a few heads of wheat, not yet quite ripe, over a small fire of thorny brush, and the grains thus roasted are very tasty. At night the goats are kept in pens in the village, and their manure finds a ready sale. They are clipped in June, and their hair is sold to city weavers who make the black goat-

hair cloth used by the Bedouins for their famous black tents. The horned cattle kept by the villagers are used primarily as draft animals, but the cows, when they have calved, are milked. From cow's milk, as well as from goat's milk, which is rarely drunk fresh, is made *leban*, the cream-cheeselike preparation made from fermented milk, known to the West by the Turkish name yogurt. This is a dish that is made practically every day and is relished by everyone. In the making of *leban* most of the pathogenic germs are destroyed by the heating process, a kind of mild pasteurization, while the harmless bacteria and those which might be beneficial when taken into the system are not destroyed. The bacteria that turn milk sour by forming lactic acid are preserved practically intact, so that they can multiply rapidly in the intestinal tract, put to rout undesirable and possibly deleterious organisms, and produce what the physician calls a "desirable bacterial flora."

A white cream cheese (*arish*) is made by putting the *leban* in a cloth bag and allowing the whey to drip out. Some of the residue is eaten when fresh, but the rest is rolled into balls about 2 inches in diameter, thoroughly dried in the sun, and then aged for 3 or 4 weeks in sealed containers. Afterward the mold is washed off, the balls are rolled in the dried leaves of a pungent herb, and the result is a delicious cheese (*shanklish*), somewhat similar in flavor to Roquefort.

The diet of the villagers is monotonous, especially in winter, but when ample it is fairly well balanced. One of the main dishes, along with bread and *bourghol*, is *mujaddara*, a mixture of lentils, onions, and olive oil. All winter long the women may be seen in the fields and on the grazing lands gathering various "greens." These are brought back to the house and carefully sorted. The edible ones—there are 23 varieties—are cooked up for family consumption, with lentils, or *bourghol*, and oil, and the others are fed to the cow or to the goats. Meat is expensive and therefore is eaten only occasionally. One villager complained that they do not eat meat day in and day out as foreigners do, but on occasions when meat is at hand they overeat. All meat is eaten the day it is killed, or the following day. Refrigeration is unknown except in the large cities, for the means are lacking. The preserving of meat for future use, by drying, salting, smoking, or canning, is likewise not practiced. Most of the villagers keep a few chickens, but both the eggs and the meat are delicacies. Unfortunately, many of the chickens died last year of Newcastle disease. *Bourghol* is a staple dish, either as a hot cereal, or pounded into meat to make the famous *kibbeh*, which could almost be considered the national dish. Good sets of teeth among the people of the village are the rule, which indicates that the diet in general is wholesome, nutritious, and well balanced.

The villagers are extremely hospitable. Even one so poor that, as the interpreter points out, "he has only two chairs" (and these were stools), will proffer you whatever he happens to have in the house, which is what is in season at the time—cucumbers, or apricots, or raw green broad beans, or grapes, or figs, and so on. The relatively well-to-do villager will probably serve the visitor a sample of most of the dishes eaten: first some fresh white cheese with unleavened bread and a nip of *arak*, the licorice-flavored "firewater" to wash it down, followed by cold soft-boiled eggs in a saucer, into which one is to dip his bread; then some ripe *shanklish* rolled in herbs, and a bowl of freshly cooked wheat or *bourghol* with a great deal of sugar in it. These snacks are topped off with Turkish coffee.

The Sunday morning on which I went to the village for the last time, to say my goodbys, everyone was as generous and as hospitable as ever and seemed genuinely sorry to bid me farewell. The old *moukhtar* seemed especially sad to say goodby, insisting that he would never see me again and that he wanted to wish me well on my journey. Once I entered his home, he quickly unlocked the chest in which the huge glass jar of *arak* was kept and filled two large glass tumblers. My host picked up his glass and drank hearty draughts while I sipped the fiery liquid slowly, cautiously. After half an hour or so, however, I began to realize that the *arak* was taking effect in no uncertain terms, and I intimated to my host that I had better ask some more questions before it was too late. His eyes danced as he replied, "Let's keep right on drinking. That way I'll find it easier to think up the answers."

Meals are not eaten regularly, and cases of undernourishment and malnutrition are not unknown, with the result that resistance to disease is low. Malaria is prevalent and the incidence was reported as being highest in October and November, when the rains begin. These are also the months when the young men who have been working in the malaria-infested coastal plain return to the village, and it could be that in some cases they return infected and the fever "comes out" at elevation. Influenza and colds are the bane of existence during the long winter months, with their short days and heavy rains, when people are closely confined to their poorly lighted and poorly ventilated houses, which are cold and damp. Cases of a persistent cough, or "asthma," are by no means rare, which lower the resistance of the victims to such lung afflictions as pneumonia and tuberculosis. The round of daily living becomes somewhat monotonous and the villagers eagerly await the more clement weather of spring, and particularly of summer when it is possible to sleep on the flat roofs of the houses or on the new straw on the threshing floor. The unfavorable features of the location of Dahr are somewhat compensated for by its elevation of 2,500 feet above the humid *akkar* coastal plain, and the presence nearby of a never-failing spring with excellent water.

On one occasion a villager, instead of answering a question that had been put to him, replied, "Just see all the questions a foreigner can ask! We are so busy trying to make a living that we don't have time to think up questions." The struggle for a living is keen indeed, and it is to be expected that one of the safety valves to population pressure would be leaving the village in search of work. Six young men from Dahr work during the summer months as day laborers on the large estates along the coast. They earn about a dollar a day, and save roughly two-thirds of this amount. With their savings they set up housekeeping in Dahr, improving their holdings, and perhaps buy some chickens or goats. The land base of the village is so poor that the mere fact that it is used at all is an index of the low level of living. It can be used only because it is worked by families, whose members do not receive wages; even without the necessity of paying wages the village achieves only a kind of precarious self-sufficiency. The members of families of Dahr scatter early in search of a livelihood. Of a representative family of eight children, between the ages of 3 and 22, two are in Tripoli—one in school, and the other serving as a carpenter's apprentice—two smaller boys are in school at a nearby village, and the two smallest children live at home, together with the two who work the family land.

How can people, using such primitive techniques on poor soil and on rugged terrain, compete with those who farm with the most modern machinery the broad fertile acres of the wheat belts of Argentina, Australia, or North America? The answer is that they are protected by a high tariff. It is difficult for the uninitiated to thread his way through the Lebanese labyrinth of tariff controls and Government decrees, but the result is seen in the market places. First-quality flour, made from wheat imported from Canada, Australia, or the United States, retails at about one-third more (65 piasters the kilo against 45) than flour made from wheat grown locally or in Syria. The removal of the high tariff on imported grains would make it no longer profitable to grow wheat on the narrow, rocky fields in the mountains, and many thousands of people, thus bereft of the possibility of making a living, would migrate from their villages.

The Lebanon has supplied a current of migrants to overseas countries. Thousands of Lebanese have emigrated to Africa and to the Americas during the past 60 or 70 years, and many of them have done well. Even a tiny village of the size of Dahr feels the influence of overseas migration and of returned emigrants. The present *moukhtar* (mayor), was in Africa for many years and the former *moukhtar* spent 12 years in Brazil. They both returned to their village with enough capital to buy small pieces of land and improve it by terracing and the planting of trees, and they were financially able to wait until an income would be realized on the investment. Of course, for every one

who comes back "rich" from America or Africa there are many who have not prospered markedly, but the villagers see and envy the one successful returned emigrant, not the ninety-and-nine who do not get rich enough to return or to send money home. The returned emigrant helps to inflate land values by buying and developing lands near his village which are for sale, not necessarily the most productive lands available in the country. But the returned emigrant usually does more for the country than those who merely send remittances home, which in many instances merely serve to support in relative idleness a number of able-bodied people at the bare subsistence level. It was a common experience during World War II, when remittances were cut off, to find that many families whose members had done no work for a long time, were forced to get out their tools and start working the land again.

Some of the villagers, as is to be expected, strike notes of pessimism. One of them said cynically, "Living is merely absence of death." But when asked why he did not live in Jibrail or even in Tripoli, he replied that there were a lot of places other than Dahr in which he might like to live, but where he would lack certain perquisites—a house on which he paid no rent, a living, such as it was, sympathetic friends and members of his family, and so on. When it was pointed out that he had a lovely view from his house over the valley and mountains beyond, he suggested that I try living there for 2 months without an income and see how beautiful I found it then. His final comment was, "The Devil must be very busy. He hasn't had time yet to come for us at Dahr."

On the other hand, the former *moukhtar*, twice a widower, and 85 years of age, is vigorous, cheerful, and hardworking, as are the other members of his family. His industry and sense of humor are contagious. The children by his second marriage, a girl of 7 and a boy of 10, are already performing their share of family duties; the little girl does chores around the house and brings water from the spring in the two big earthern jars on the donkey's back, and her brother makes a good "hand" at farm tasks. When asked what the striking differences were between today and yesteryear, the old man replied, "People now have more money, they travel more, but there is less happiness and satisfaction with one's lot because of jealousy of those better off. There is more display of wealth now than there was two generations ago, when there was less *visible* difference between the rich and the poor." He smiled at his recollections as he continued, "Fifty years ago rich and poor alike 'hobbled' into Tripoli on the old family donkey, taking a day to go and a day to come, but one went there only when it was strictly necessary. It was a place to go to on urgent business only, not a place to stay in long, for it was inhabited by 'savages'! We did not then consider it a center of civilization."

Much of the agricultural activity in the Near East is carried on without the aid of wheeled vehicles. Even the wheelbarrow is almost unknown. Almost all loads—sheaves of wheat, firewood and water for the house, manure for fertilizer, rocks for the walls of terraces—are carried on the backs of animals or of human beings. The donkey and the mule are used over short distances or in the mountains for loads up to about 200 pounds, and the camel is used for longer journeys for loads of 400 to 450 pounds. As long as a society makes little or no use of wheeled vehicles, roads are a luxury, for donkeys, mules, camels, oxen, and human beings on foot can negotiate the steep, muddy, and rocky trails to the tiny houses in the most remote villages. For Dahr this has all changed. The paved road for automobiles reached the village last year, and now Tripoli is only a pleasant hour's drive away.

So the village is not static; it is a going concern that lives on generation after generation. The meager base of raw materials and what seems to western eyes to be its precarious economic position would not seem conducive to the stability and continuity necessary for a going concern. Perhaps it will continue to have its raison d'etre in nonmaterial rather than in material factors. Although life is not easy it is savored as one goes along. All available satisfactions are drawn from living here and now and day by day. The villagers do not hustle and bustle through an 8-hour day; they work a much longer day during the summer, but not by the clock. There seems to be less wear and tear on the individual whose workday is 14 hours long instead of 8 if he feels the human warmth of working in a cooperative society and not in a social vacuum, and if he can take time out to gossip with neighbors and take his afternoon siesta. Stomach ulcers and nervous breakdowns are not yet known in Dahr.

One of the first things of which a Dahr child becomes aware is that he belongs to a family unit and to a kinship group which demands his unswerving loyalty. Members of a family must help each other at all times. "All for each and each for all" is the motto. Nepotism is consequently an established feature of the mores of the community. The family is the only social security organization that functions. Family life is closely joined up with the church and its rites, and one is expected to cling throughout life to the religious community into which he is born.[3] Family ties are, of course, the most important of all, but the feeling of community solidarity is also very strong. Villages tend to act as a unit in times of crisis, and bloody battles between villages are not uncommon. Even today in modern Lebanon the gendarmes must frequently be called in to settle disputes, and the result of an intervillage feud may be several killed and

[3] Tannous, Afif I., The Arab village community of the Middle East, Ann. Rep. Smithsonian Inst. for 1943, pp. 539–541, 1944.

wounded. One has but to glance at the daily newspapers to see, for example, the vivid account of an attack by the people living in the village of Kfarse'louan on those living in Jouar-el-Haouz, the upshot of which little differences was three killed and two gravely wounded.[4] If such events occur in the relatively highly developed towns bordering the shores of the Mediterranean, it can perhaps be imagined what fierce vendettas can be carried on between tribes of the desert interior.

Tiny mountain villages such as Dahr do more than merely maintain their numbers; they also create a surplus population for the cities, which grow by accretion from outside, and they send to distant shores migrants whose remittances enable the populations of many other small villages to continue to vegetate and to create a surplus which will in turn migrate, and so on in a continuous cycle. More people would leave Dahr if they could afford to do so, but they have neither the money with which to migrate, nor enough capital to improve their agriculture. Such a situation, while giving the more energetic and alert of the villagers a sense of frustration, is not, unfortunately, reflected in a declining birthrate. The birthrate remains the same as it was in former times when the infant mortality rate was so high that, in order to maintain the fighting and working strength of the family, and hence of the tribe or village, a large number of births was necessary in each family in order that a few might survive to adulthood. Thanks to the efficiency of modern public and household health measures, even in a community as primitive—by western standards—as Dahr, a far larger percentage of children than formerly live to grow up. There has been a huge increase of births over deaths. An adequate rate of population growth can now be assured without a high birthrate, but changes in folkways do not always keep pace with progress in techniques. The folkways still favor the old-fashioned high birthrate of other days, and so it remains.

Although much ink has been spilled in poetizing the joys and beauty of the farmer's life, the fact remains that if the returns of his toil—psychic and material—are not sufficient for proper living, the farmer will want to migrate. The people of the Near East have created a complicated cultural milieu within the framework of which they have shown a great deal of ingenuity in adjusting to a relatively harsh physical environment. Their lot can be improved by education—education, however, of a practical type, which will train farmers to keep on farming and to do so by improving their traditional practices. Elementary schools for teaching agricultural techniques as well as the three R's, are needed *in the villages*, to help the people to help themselves *within the framework of their own rural culture*. Since the difference between commercial success and failure depends

[4] L'Orient, Beirut, July 2, 1952.

upon the market and the prices obtained for crops, the problem of marketing should receive close attention if farm incomes are to be increased. In spite of publicity and propaganda the back-to-the-farm movement has succeeded nowhere, least of all in the United States, as long as the farm was still uninviting and unrewarding. What has *held* young people of the present generation on the farm in the United States is *not* publicity campaigns, but an income that makes it possible for them to afford automobiles, electric lights, running water, up-to-date plumbing, washing machines, milking machines, and so on. The careful selection of seeds, the use of fertilizers, the application of modern tools and methods, and the control of insects and plant diseases would result in a higher money income, which would in turn be reflected in a gradual but general rise in the level of living, and quite possibly in gradual cultural changes. Even the most apathetic of men want to better their condition. If at the end of each year of hard work he is as far as ever from being able to attain the most ordinary comforts of life, the farmer would be considered unnatural who would not want to change his lot. It seems axiomatic that as long as urban centers—even the slums of urban centers—hold more attraction for living than rural villages, just so long will the current of population be away from the country. Therefore it seems logical that any program, to achieve lasting results, should be built on the firm foundation of peasants who are reasonably well-fed, well-housed, well-clothed, and who are in consequence imbued with a certain amount of optimism as to their continued well-being, both physical and cultural.

The increased income derived from the improvement in agriculture should be used in raising the level of living. Its reinvestment in the agricultural enterprise or in better living is preferable to using it for the conspicuous consumption of goods. If labor-saving devices merely make it possible for the men to have more leisure time in which to squander in the cafes the money saved by the introduction of the new machines, the gain has been nullified.

CONCLUSION

The village of Dahr—as indeed almost the whole of Lebanon—is atypical in the Near Eastern panorama, for as one goes inland he sees that these hardy mountaineers whose strenuous toil is so meagerly requited are relatively well off. For the most part they own and farm their own small, fragmented parcels of land. Throughout the whole of the Near East peasant proprietors are found only under certain rare conditions and in certain limited areas—in mountainous regions difficult of access, in villages in which land is held and worked in common, and near some of the larger cities which are surrounded

by an effectively policed zone, where the resultant law and order invite the small peasant to take his chances in defending his rights. Everywhere else in the Near East, from the shores of the Mediterranean to the Persian Gulf, the land is held in great landed estates, some of which are very extensive, veritable principalities. Throughout the length of the Fertile Crescent, the great transition zone between the desert and the sown which extends from the Gulf of Aqaba northward to Aleppo and eastward to Basra, the more arid the climate is, the more extensive is the cultivation—two factors which coincide with the phenomena of great landed estates and of a miserable peasantry. These tremendous holdings are an outgrowth of the social climate, which in turn is conditioned by two principal factors, viz, the preeminent social and political role played in the Near East by the city vis-a-vis the country, and the economic and social prestige which accrues to the individual who has his entire fortune in land. The essential function of capital throughout the centuries has been and still remains the acquisition of land. We are not concerned here with the methods whereby the great landed estates have come into being. Suffice it to say that enormous agglomerations of broad and fertile acres are owned in fee simple by single families, the eldest member of which acts in each case as the manager. Thus the people who own land do not work it and those who work the soil own none of the land, although they are tied to it by the invisible bonds of immemorial custom and by the more tangible fetters of debts which they can never hope to pay.

These holdings comprise not merely tracts of land but entire villages as well, the sites of which are in reality, together with the inhabitants, "owned" by the manorial overlords. Only a few miles to the north of Dahr, in the eastern part of the Akkar Plain, the Dendachlis "own" more than 60 villages, and the Barazi of the town of Hama own 49 village in the Alawite Mountains.[5]

Olives, figs, grapes, apricots, and divers other fruits are consumed where tree crops are grown, but in the vast cereal-producing areas of the interior, bread, bourghol, and leban are the basis, year in and year out, of the diet of the inhabitants of the "owned" villages. It is only in the poorer districts and during periods of famine that actual want occurs, but the diet is, to say the least, very monotonous, and the peasants could in general consume much more food if it were available. But the general social insecurity, the extremely primitive housing and sanitary conditions, the deficient recreational facilities, and the widespread ignorance, make for a hunger which is not so much physical as cultural and spiritual. The fact that the good earth does not yield

[5] Weulersse, Jaques, Paysans de Syrie et du Proche-Orient, p. 119, Paris, 1946.

1. THE VILLAGE OF DAHR CLINGS TO A LIMESTONE CRAG MIDST NARROW, TERRACED FIELDS.

2. THE CHIEF MAN OF THE VILLAGE WITH SOME OF HIS RELATIVES.

1. FETCHING WATER FROM THE SPRING HAS BEEN WOMEN'S WORK FROM TIME IMMEMORIAL.

2. NEWLY BUILT TERRACES WHICH ACT AS SIEVES FOR WINTER STREAMS AND THUS COLLECT A THIN LAYER OF SOIL.

1. WOMEN CUTTING WHEAT BY HAND SICKLE.
Note the extremely rocky soil.

2. MEN HARVESTERS WEARING BAMBOO FINGER STALLS AS A PROTECTION AGAINST THISTLES.

1. A VIEW OF THE INTENSIVELY CULTIVATED MOUNTAINOUS INTERIOR OF THE LEBANON FROM ONE OF DAHR'S THRESHING FLOORS.

2. GLEANERS BRING THEIR SMALL SHEAVES OF WHEAT HOME WHERE THEY CAN THRESH THEM BY HAND, ONE HEAD AT A TIME.

1. THE THRESHING SLED IN OPERATION.
Unthreshed sheaves lie in the center of the threshing floor.

2. EVEN THE BABES IN ARMS GET A RIDE ON THE THRESHING SLED.

1. WOMEN MAKING UNLEAVENED BREAD.

They thoroughly knead the dough, pat it into extremely thin cakes from a foot to a foot and a half in diameter, and bake it on the hot iron disk under which a tiny fire is slowly fed eaves, grass, and twigs.

2. A MAN AND HIS WIFE WINNOWING THE WHEAT FROM THE CHAFF IN A BRISK WIND.

Note the hand-made forks with wooden tines used by the man.

1. COOKING WHEAT TO MAKE BOURGHOL, IN THE OPEN AIR IN A FAMILY-SIZED KETTLE.

2. CAMELS LADEN WITH SACKS OF WHEAT FOR GRINDING IN THE LOCAL STONE MILL.

1. WEIGHING SACKS OF LIME BROUGHT FROM THE KILN ON DONKEY BACK TO DAHR, WHERE THEY ARE TRANSFERRED TO A TRUCK.

2. A SHEPHERD BOY WHILES AWAY THE LONG HOURS PLAYING HIS PIPES OF PAN.

up a more abundant life to the peasant, results rather from the social organization than from any other cause. A keen and sympathetic student of the peoples of the Near East concludes: "Old, inefficient farming practices are pursued in the shadow of the new motor pumps, and poverty, ill health, and ignorance are still the lot of the majority. The new agriculture represents the uncoordinated efforts of individuals, when what is really needed is a radical comprehensive scheme of rehabilitation on a large regional scale, including soil and water conservation and major social changes. Unhappily, such a program is unlikely ever to be realized." [6]

Although the village of Dahr enjoys a climate without too great fluctuations and has been spared the economic and social burden of the worst features of landlordism, it is felt that from this short study it is possible to draw certain conclusions which have more than local application.

The countries of the Near East will in the foreseeable future inevitably remain primarily agricultural areas whose wealth will continue to be dependent upon the peasant, the *fellah*. Commercial activity will also depend upon the prosperity of the peasant whose produce mainly supplies the market and who is the consumer, by and large, of most of the goods of the merchant. Industrialization will certainly continue to be based to a large extent upon the processing of locally grown agricultural products. Hence the long-term capital accumulation necessary to the development of the Near Eastern countries is contingent upon increased agricultural production, upon which in turn will depend the more ample and richer diets, the improved conditions of public health, and the better educational facilities, which will in turn help further to increase agricultural production, and so on in an upward spiral.

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[6] Lewis, Norman N., Selemiya, Three Years After, Geographical Review, vol. 40, No. 3, p. 480, July 1950.

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The Problem of Dating the Dead Sea Scrolls[1]

By John C. Trever

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[With 8 plates]

The recent articles appearing in popular American magazines, describing the application of the radioactive carbon-14 process of age determination to the cloth found in the Dead Sea cave from which the famed Dead Sea Scrolls came, have once again fanned the flames of popular interest in these ancient documents. While popular interest and enthusiasm have waxed and waned, scholarly interest has continued unabated, as the analytical and critical literature on the subject has reached almost staggering proportions.

For the sake of those who may not be familiar with the subject, it would be well to review a little of the background of the discovery of the Dead Sea Scrolls. High up on the cliffs overlooking the northwest edge of the Dead Sea near 'Ain Fashkha, about 7½ miles south of Jericho in Palestine, some Bedouins happened upon a hole on the side of a rock projection early in the spring of 1947.[2] On entering, they found a large cave penetrating some 25 feet into the cliff, and about 6½ feet wide by 8 to 9 feet high (pl. 1, fig. 1).

On the floor of the cave, the Bedouins found some 40 jars, each with a specially prepared cover. Apparently they smashed many of those not already broken. Only two, now in the Hebrew University in Jerusalem, have been recovered intact. With patient labor some have been restored (pl. 1, fig. 2), and archeologists are able to determine

[1] A report based on a period of research in England made possible by grants from the American Philosophical Society and the American Schools of Oriental Research in 1950–51 and the generous assistance of the National Council of Churches. This paper was first presented as an illustrated address before the Annual Meeting of the American Philosophical Society on April 25, 1952. Reprinted, slightly revised to add later evidence as of August 1953, by permission from the Proceedings of the American Philosophical Society, vol. 97, No. 2, 1953. More detailed results of this research will appear in a volume of the series "The Dead Sea Scrolls of St. Mark's Monastery," being edited by Dr. Millar Burrows for the American Schools of Oriental Research.

[2] A more detailed account was published by the writer under the title "Scrolls from a Dead Sea Cave," in the Christian Century, July 12, 1950, pp. 840–842.

the approximate date of their manufacture. There seems to be little question about the fact that the jars were manufactured in the early first century A. D., during the early Roman period. Here, then, is one important means of determining the approximate age of the scrolls found in the cave, since the homogeneity of all the pottery gives a strong indication that the jars were made for the purpose of storing manuscripts.[3]

Also in the cave the Bedouins found a great deal of linen cloth, much of which was recovered by the excavators in February 1949. Analysis by textile experts revealed it to be native Palestinian cloth.[4] The radioactive carbon-14 test, developed by Dr. Willard F. Libby of the University of Chicago, resulted in a mean date of A. D. 33 for some of this cloth, but a 200-year plus or minus margin of error must be allowed.[5]

Hundred of fragments of manuscripts, trampled into the dust of the cave, were picked up by the archeologists. During a recent leave of absence for the study of the Dead Sea Scrolls the writer was able to examine photographs of about half of these fragments and the originals of the other half in the British Museum in London, through the courtesy of G. Lankester Harding, Director of Antiquities for Hashemite Jordan. Some 45 different hands or variations of script were counted, indicating that as many manuscripts were apparently at one time in the cave. Yet there is a definite homogeneity of script among all the materials from the cave. One group of unpublished fragments, matted together, was secured in November 1948 by the Syrian Orthodox Archbishop of Jerusalem from the vandals who rifled the cave, and these proved to contain parts of a scroll of Hebrew prayers and of two scrolls of Daniel.

The Bedouins sold the best-preserved of the documents to the St. Mark's Syrian Orthodox Monastery in Jerusalem in July 1947, through the help of some Syrian merchants in Bethlehem who were friends of the Bedouins. Five scrolls, making four different manuscripts, were in this collection. It was with this group of manuscripts that the writer first came in contact with the whole discovery, when on February 18, 1948, the Orthodox Syrians called the American School of Oriental Research in Jerusalem to obtain information

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[3] Since the original publication of this article the Palestine Exploration Quarterly for May–October 1952, and the Revue Biblique for January 1953, have arrived, telling of the excavations at Khirbet Qumran, the ruin of a site occupied in the first century A. D., apparently by the sect (Essenes?) who owned the scrolls. Pottery similar to that from the cave was found with coins dating from A. D. 10–67.

[4] Report upon a fragment of cloth from the Dead Sea Scroll Cave, Bull. Amer. School Orient. Res., vol. 119, pp. 9–11, April 1950. Crowfoot, G. M., Linen textiles from the cave of Ain Feshka in the Jordan Valley, Palestine Expl. Quart., January–April 1951, pp. 5–31.

[5] Collier, Donald, New radiocarbon method for dating the past, Chicago Nat. Hist. Mus. Bull., vol. 22, No. 1, January 1951, and Bibl. Archaeol., vol. 14, No. 1, pp. 25–28, February 1951. Sellers, O. R., Date of cloth from the 'Ain Fashkha cave, Bibl. Archaeol., vol. 14, No. 1, p. 29, February 1951.

about what they had purchased, having failed to get any information from others whom they had consulted. The writer invited the Syrians to the American School to examine their scrolls. Then began a long series of events which is far too involved to treat here.[6]

The largest of the scrolls is the Book of Isaiah, consisting of 17 sheets of leather sewn together to make a document 24 feet long by 10½ inches wide, with 54 columns of Hebrew writing, including the entire 66 chapters of the Book of Isaiah.[7] There are only a few breaks, such as those on the first three columns, in the entire manuscript (pl. 2).

The second scroll was identified by my colleague, Dr. William Brownlee, as a commentary or Midrash on Habakkuk. It is only about 6 feet long, composed of two sheets of dark brown leather, badly disintegrated by time and white ants. Only the first two chapters of the Book of Habakkuk are found in the scroll interspersed with the discussion, applying the Biblical prophecy to the period of the Roman conquest of Palestine.

The third document is called the "Manual of Discipline," since it includes rules and ceremonies of the sect which owned these documents as well as something of their theology. It is composed of a heavier leather, with five sheets sewn together, making the manuscript a little over 6 feet long by 9½ inches high, with 11 columns of Hebrew text.[8] Fragments of five or six additional columns of the beginning of this manuscript have since been secured by the Palestine Archaeological Museum in Jerusalem.

The fourth document in the possession of the Syrians has not yet been unrolled, and is in a badly disintegrated condition (pl. 3). The future of this document seems to hinge on the purchase of the documents by some museum or library which can carry through on the work of unrolling the document and publishing its contents. In April 1949 the writer succeeded in removing a fairly large fragment from the document and found that it is a narrative, purportedly written by Lamech, the father of Noah, telling, in this part at least, something of the birth of Noah. Though the name Noah does not actually appear on the fragment, comparison of the fragment with the Book of Enoch (ch. 106) makes it quite apparent that this is the general content. The most important fact about the scroll, however, is that it is written in Aramaic, a language in which we have almost no literary documents

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[6] A detailed account of the writer's experiences in Jerusalem has been published under the title "The Newly Discovered Jerusalem Scrolls," in Bibl. Archaeol., vol. 11, No. 3, pp. 45–57, September 1948.

[7] Burrows, Millar, ed., The Dead Sea Scrolls of St. Mark's Monastery, 1, Amer. Schools Orient. Res., 1950. This volume includes the complete facsimiles of both the Isaiah and the Habakkuk scrolls.

[8] Burrows, Millar, ed., The Dead Sea Scrolls of St. Mark's Monastery, 2, fasc. 2, Plates and transcriptions of the Manual of Discipline, Amer. Schools Orient. Res., 1951.

from an early period, and the current tongue in Palestine during the early Roman period.[9]

In addition to the four documents secured by St. Mark's Monastery, the Hebrew University in Jerusalem, through the late Dr. E. L. Sukenik, secured three additional documents in six separate sections in November of 1947. Four of these scrolls went together to make up the "Songs of Thanksgiving," written with a beautiful script similar to a number of the fragments found by the excavators. Another and less beautiful hand prepared part of the scroll.

Also among the Hebrew University documents is a scroll looking considerably like the Habakkuk commentary in structure, but which Dr. Sukenik called the "Battle between the Sons of Light and the Sons of Darkness," apparently an imaginary battle conceived as a part of the final days of the end of the age when righteousness will be victorious.[10]

The final scroll proved to be a very fragmentary section of another scroll of the Book of Isaiah, and to judge from its script, dates among the latest of the documents found in the cave, at least a hundred years later than the other Isaiah scroll.

But the question that is occupying the attention of many scholars is, how is it possible to date these documents? One phase of this question has been the area of the special research for which the American Philosophical Society has provided the writer its generous help. We have already seen how the pottery from the cave can be dated as a result of the scientific development in that field during the past 60 years. This method is not entirely satisfactory,[11] however, since it suggests only an approximate period for the deposit; and besides, a few scholars refuse to admit that the scrolls were ever in the cave, since they were discovered by ignorant Bedouins. Such a point of view is absurd, however, for the writer has found one fragment of the "Manual of Discipline" among those found by the excavators of the cave, and the script of all the fragments and the scrolls is amazingly homogeneous.

The radioactive carbon-14 tests applied to some of the cloth from the cave added to the archeological evidence for a general date between the second century B. C. and the second century A. D.

Some scholars believe that the only way the scrolls can be dated is by their contents—that is, their peculiarities of grammer, spelling,

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[9] Trever, John C., Identification of the Aramaic fourth scroll from 'Ain Feshkha, Bull. Amer. Schools Orient. Res., vol. 115, pp. 8–10, October 1949.

[10] Cross, Frank M., Jr., The newly discovered scrolls in the Hebrew University Museum in Jerusalem, Bibl. Archaeol., vol. 12, No. 2, pp. 36–46, May 1949.

[11] G. L. Harding (Palestine Expl. Quart., January–April 1951, p. 105) tells of the former uncertainty of dating first-centuries B. C. and A. D. pottery, but the excavations of this site and those of New Testament Jericho (Tulûl Abû el-'Alâyiq) have added significantly to this field of knowledge.

historical allusions, etc. But this method has led to such a wide disagreement about dating (from the second century B. C. to the period of the Crusades) that, without the help of other criteria, it would be almost impossible to resolve the problem. Furthermore, the contribution of the contents is largely to the date of the composition of the writings rather than the specific dates of the scrolls in hand. It is very probable that these scrolls are copies of earlier documents, not original compositions. Thus we come to the subject of paleography, or the study of the actual handwriting used on the documents, as a means of adding at least further evidence for the dating of the documents.

The paleographer must begin by setting up a general pattern of writing for a particular language on the basis of known dated materials, which for early Aramaic and Hebrew are admittedly not very plentiful. There are, however, the fifth century B. C. Aramaic papyri, many of which are dated to the year (pl. 4). Fortunately, many letters of this type have been found in Egypt from approximately the same time, giving considerable comparative material to illustrate the pattern of script at that time in Egypt. Knowing that the Jews adopted the Aramaic language and script sometime after the fifth century B. C., it is safe to start with these known dated Aramaic materials.[12]

Not all these letters were written on papyrus, however, for in the Bodleian Library at Oxford there is a group of 12 letters written on leather, which were found in Egypt. These can all be dated to approximately 408 B. C., with a margin of error of no more than 2 or 3 years.[13] The writer was able to examine some of these documents at the Bodleian Library, through the courtesy of the librarian and Dr. G. R. Driver, who is publishing them, and it is helpful to note that the script on these letters is almost identical with that of the papyri, indicating that these two media make very little difference in the process of writing. Furthermore, these letters were written in Persia, indicating that geographical location made little difference in script at that time.

On the other end of the scale, we can select a recent manuscript of approximately known date to see what happens to the script over a period of more than a thousand years; for example, the British museum codex of the Pentateuch in Hebrew (Or. 4445), long considered to be one of the oldest Hebrew manuscripts of the Bible in

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[12] The story of a new group of these papyri recently discovered has recently appeared: Kraeling, Emil G., New light on the Elephantine colony, Bibl. Archaeol., vol. 15, No. 3, pp. 49–67, September 1952; and now The Brooklyn Museum Aramaic papyri, by the same author, Yale Univ. Press, 1953.

[13] Driver, G. R., New Aramaic documents, Zeitschr. Alttestamentliche Wiss., vol. 62, pp. 220–224, 1949–50.

existence. This document dates very probably from the early tenth century of our era.

The problem now is to fill in the gaps between the two extremes of dates as far as possible with known dated materials, or materials that can be dated on other grounds, until a general pattern of the development of writing can be established. The collection of papyri in the Bodleian is here again an asset, for there are found the Edfū papyri, whose contents give a pretty clear dating from the third century B. C. They illustrate certain types of basic changes in the letter forms in the direction of the tenth century A. D. manuscripts.

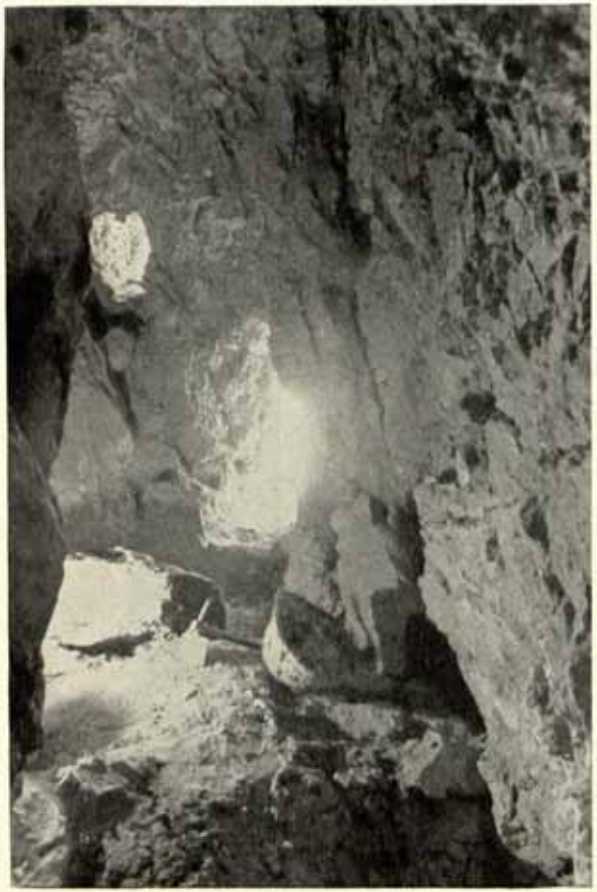
To narrow down the limits at the other end is more difficult for several reasons, the main one being that the greater amount of literary activity among the Jews in medieval times led to a much more complex pattern of writing for different purposes. Principles, therefore, which apply to the paleographic developments observable in early Aramaic-Hebrew scripts may not necessarily apply to medieval and later Hebrew manuscripts, and vice versa.

For this study the University of Cambridge Library is particularly valuable, since here is housed the tremendous collection of medieval manuscripts known as the Cairo Genizah. This large collection of documents was found in an abandoned storage room adjacent to an old synagogue in Old Cairo and much of it taken to Cambridge by Dr. Solomon Schechter in 1896.[14]

Almost 2,000 of the more important documents from this collection have been mounted in glass and are stored in a large case where they are easily accessible for study. The writer examined most of these to see whether any of them might be from an early date or might show similarities to the Dead Sea Scrolls. None of them show any paleographic evidence that would indicate a date as early as the newly discovered manuscripts.

In the basement of the library thousands of manuscripts from the same source have been organized in cardboard containers and merely cataloged according to subject matter. Altogether more than 27,000 Hebrew manuscripts and fragments in this collection have been cataloged. A perusal of these fragments is important to illustrate the problems involved in studying medieval paleography, for many different types of script are found among these manuscripts, but apparently were used for different purposes. In one marriage contract there is a literary quotation at the top, written in a formal type of script, while the rest of the document is written in a more cursive style, common to such documents. This would suggest, therefore, that in

[14] Kahle, Paul E., The Cairo Geniza. Schweich Lectures of the British Academy for 1941. Published for the Academy by the Oxford Univ. Press, 1947.

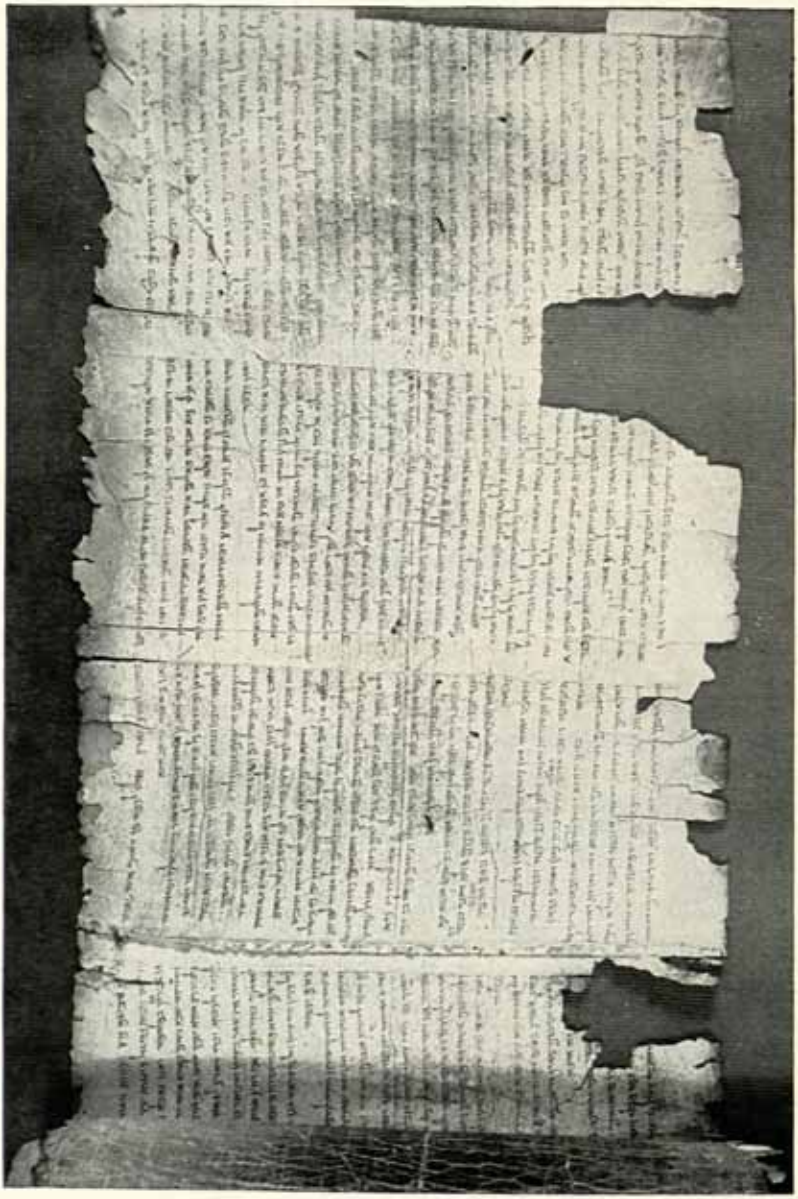


← 1. INTERIOR OF THE CAVE NEAR THE DEAD SEA IN WHICH THE DEAD SEA SCROLLS WERE FOUND.

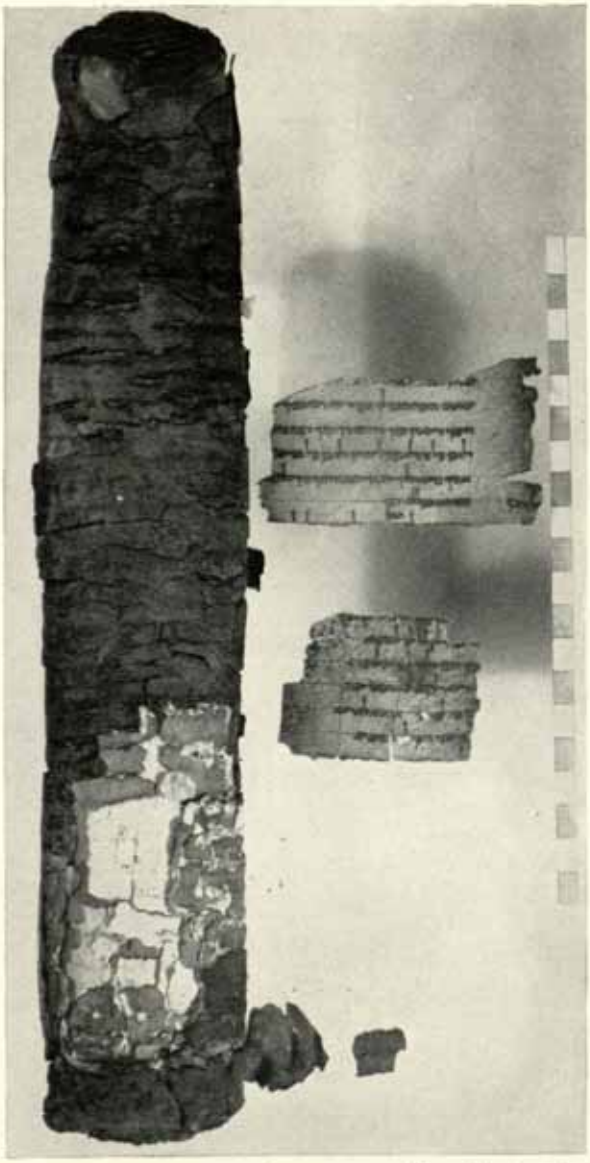
(Photograph courtesy of G. Lankester Harding.)

2. JARS RESTORED FROM FRAGMENTS FOUND IN DEAD SEA CAVE.

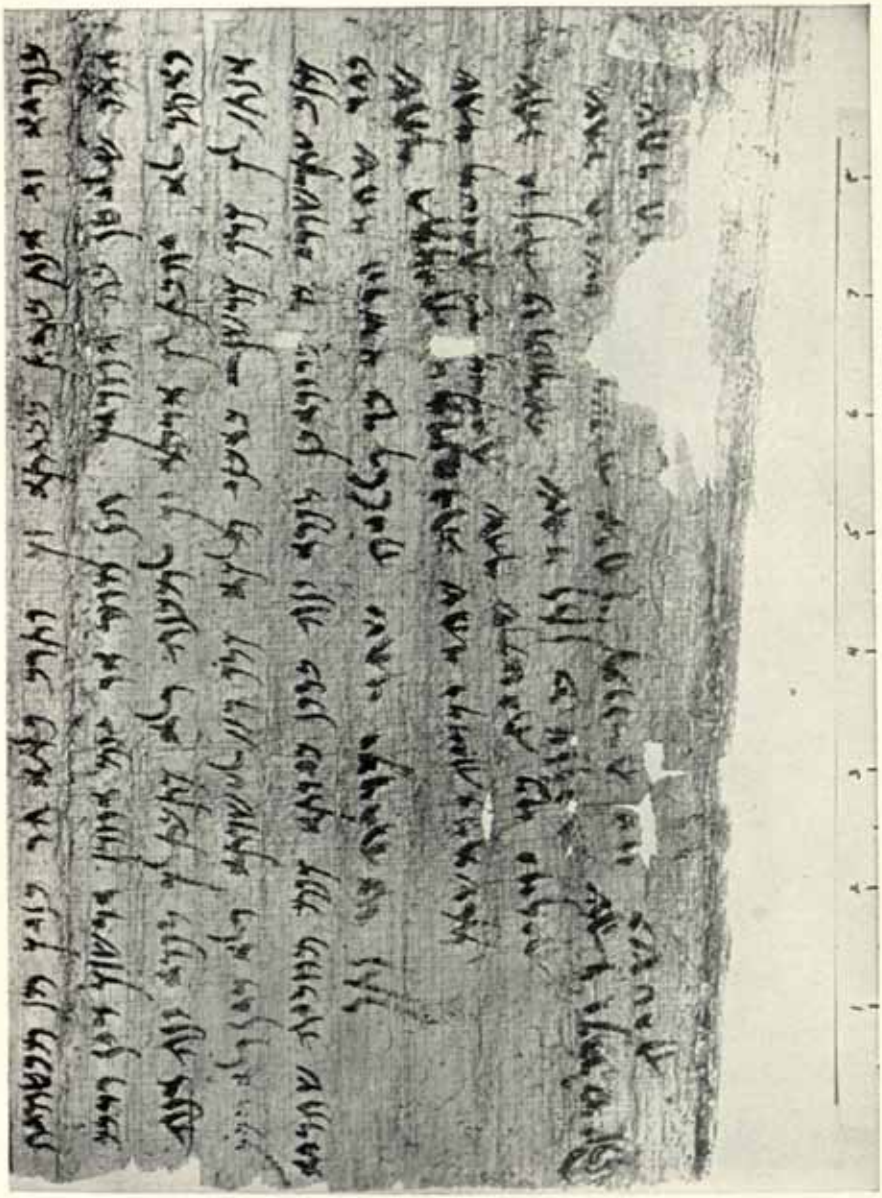
Each had a bowl cover like the one held here by Hassan Mamluk, an assistant in the Palestine Archeological Museum in Jerusalem. (Photograph courtesy of O. R. Sellers.)



THE DEAD SEA SCROLL OF ISAIAH, COLUMNS I–IV, CONTAINING ISAIAH 1:1–5:14, READING FROM RIGHT TO LEFT.
(Photograph by the author.)



THE ARAMAIC SCROLL OF LAMECH WITH TWO FRAGMENTS.
This scroll has not yet been unrolled. (Courtesy of Biblical Archaeologist.)



ARAMAIC PAPYRUS FROM ASSUAN, DATED 460 B. C.

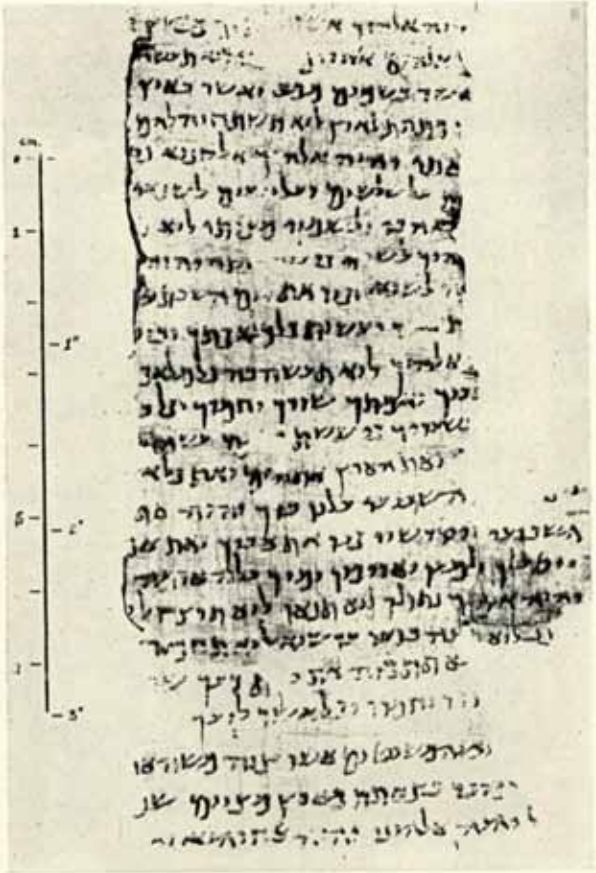
(From Sayce, A. H., and Cowley, A. E., Aramaic Papyri discovered at Assuan, London, 1906, Papyrus C., lines 12–22.)

FRAGMENT OF A MEDIEVAL SCROLL OF THE PSALMS CONTAINING PARTS OF PSALMS 113–115.

(Courtesy of the University of Cambridge Library.)

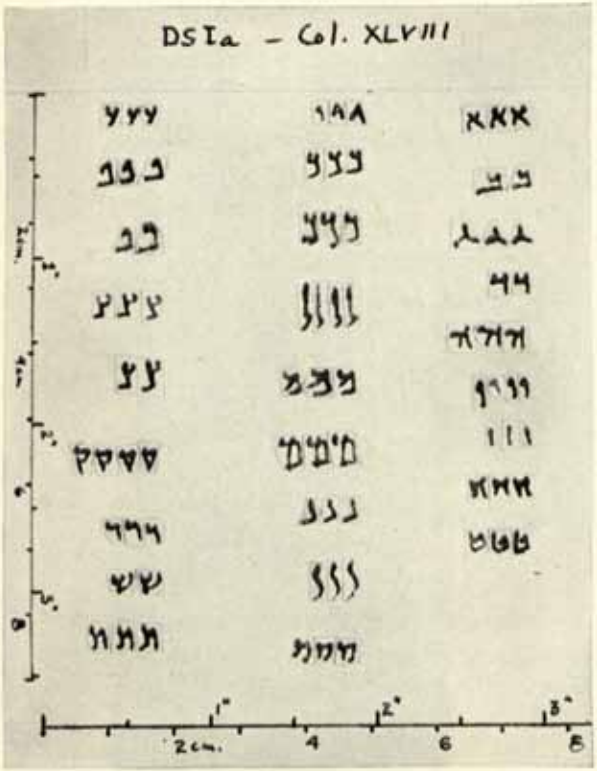
PSALMS SCROLL FRAGMENT. REVERSE, WITH HEBREW-ARABIC CURSIVE PALIMPSEST.
(Courtesy of the University of Cambridge Library.)

1. THE NASH PAPYRUS AS PHOTOGRAPHED WITH CONTRAST INFRARED FILM.

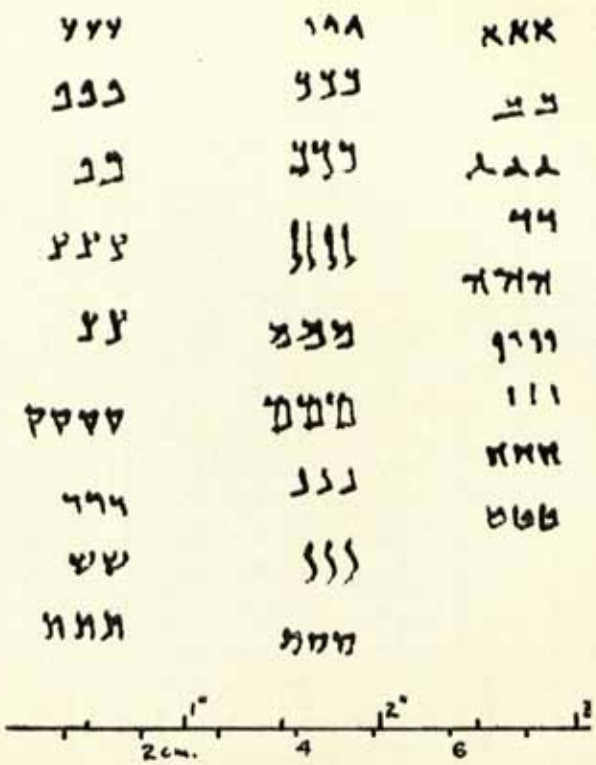


2. A HIGH-CONTRAST PRINT OF THE NASH PAPYRUS FROM THE SAME NEGATIVE AS FOR FIGURE 1.

(Courtesy of the University of Cambridge Library.)



1. Letter Chart Prepared from a High-Contrast Print of Column XLVIII of the Dead Sea Scroll of Isaiah.



2. Reproduction of Letter Chart, Figure 1, by High-Contrast Film and Zinc Etching.
(Photograph by the author.)

dealing with the problem of the relation of medieval manuscripts to the Dead Sea Scrolls, we should limit ourselves to literary documents and their styles of writing as far as possible.

Scholars have said for many years that the oldest Biblical Hebrew manuscripts date from the ninth and tenth centuries A. D. Dr. Paul Kahle, at whose home in Charlbury, near Oxford, the writer spent several valuable days, some years ago published a statement to the effect that he had found Biblical manuscripts in the Cambridge collection of the Cairo Genizah which had indications of being as old as the fifth to seventh centuries A. D. Among these were fragments of scrolls of Ezekiel and the Psalms. His basis of dating was largely on the presence of a type of vowel pointing seldom found on Hebrew manuscripts, but claimed by Kahle to be early Palestinian.[15]

After checking through the mounted fragments in the Cairo Genizah, the writer found another fragment of the same scroll of Psalms which Dr. Kahle had overlooked, the reason being that there were no vowel points on this part. The script is certainly the same, and comparing it with the ninth- and tenth-century manuscripts of the Bible, it would appear to be older (pl. 5). On the back of this manuscript fragment, however, there is other writing, a most unusual feature for Hebrew Biblical scrolls, which were considered sacred. The script is a semicursive form of Hebrew, though the language is Arabic, and it has been suggested that the contents indicate that it was probably done in the twelfth or thirteenth centuries A. D.

A closer examination reveals the fact, however, that this fragment is a palimpsest, for there is writing underneath the top writing that had been erased, probably at the time that the top writing was to be done (pl. 6). The fact that this Biblical fragment has been used in this way at all would probably indicate that the Biblical scroll was so old and fragmentary that it would be possible to reuse it in this way, though normally it would be considered a violation of the Jewish law to do so. It would seem, therefore, that we have here an additional argument in support of Dr. Kahle's suggestion that this manuscript dates from an early time. At least it would seem that we probably have here a manuscript from several centuries before the earliest dated Hebrew manuscripts. But the type of script on this old Biblical manuscript is still far removed from that of the early papyri and of the Dead Sea Scrolls.

While studying in the Cambridge University Library it was the writer's pleasure to participate in the opening of an early papyrus manuscript which has been for some 50 years in the Cambridge University Library, probably acquired from the Cairo Genizah. It is a

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[15] Kahle, Paul E., Masoreten des Westens, vol. 2, pp. 14*–15*, Stuttgart, 1930.

small Hebrew codex (originally about 7½ inches tall by about 6 inches wide) containing perhaps more Hebrew papyri than all the existing Hebrew papyri otherwise known. The original codex consisted of about 28 folio sheets, making a quire of about 56 leaves. At least 14 leaves were missing, except for their center margin strip. The extant codex is broken vertically about in half, and therefore the contents will be very difficult to decipher. Dr. J. L. Teicher, a reader in Talmudic for the University of Cambridge, is preparing the document for publication, and he says that its contents indicate an eighth century A. D. date, which therefore adds a little more to our knowledge of the form of literary Hebrew script in the early Middle Ages. The Bodleian Library at Oxford also possesses a large number of Hebrew papyri believed to date from the third to the seventh centuries A. D. They were all carefully studied by the writer, and are obviously later than the Dead Sea Scrolls.[16]

The most important piece of literary papyri in relation to the Dead Sea Scrolls is the little Nash papyrus containing fragments of Deuteronomy 6:4 and the Ten Commandments. Its date, to be sure, is not fixed; but it has a script that is similar to that of the Dead Sea Scrolls.[17] The writer spent almost 4 full days in the Cambridge University Library, analyzing every detail of the script and the structure of this document, and a number of points were discovered which should be published to complete its story.

The problem of publishing the Nash papyrus has been a difficult one, in view of the dark nature of its material and the very small script. Real progress in this, however, has been possible recently through processes of modern photography. After the writer discussed the problem with the Cambridge Library photographer, through the use of contrast infrared film, he produced a result which makes it possible now to publish it clearly and resolve some of the confusion about it. It is now even possible to include the letter forms from this document on a photographically produced chart without retouching (see below). Plate 7 is an unretouched direct photograph of the document in original size.

This leads to the mention of another aspect of the writer's research which should be reported here. Many Biblical scholars have been

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[16] O. H. Lehmann, of the Bodleian Library staff, has attempted to show (Materials concerning the dating of the Dead Sea Scrolls—1. Habakkuk, Palestine Expl. Quart., January–April 1951, pp. 41–47) that some of these papyri are earlier than the Dead Sea Scroll of Habakkuk (DSH), but his chart, plate 10, is misleading, and his evidence by no means conclusive. The writer will discuss this problem more fully elsewhere.

[17] W. F. Albright's splendid efforts to date this document are still basic to any analysis of Hebrew paleography: A Biblical fragment from the Maccabaean Age: The Nash papyrus, Journ. Bibl. Lit., vol. 56, pp. 145–176, September 1937.

skeptical of the whole matter of Hebrew paleography, and have criticized particularly the method of drawing letter forms in charts for comparison, on the grounds that the subjective element is too liable to appear.[18] It is true that, in drawing a certain form of a letter for a particular purpose, there is a tendency to exaggerate the feature which one is pointing out. Many published charts do show that this criticism is not entirely unfounded. The writer set about, therefore, to find a method of presenting paleographic charts to remove all possibility of subjectivity.

The process consists of producing a high-contrast photograph of the original document through the use of a fine-grain, contrast panchromatic film, or by use of infrared films, in the case of certain types of manuscripts (pl. 7, fig. 1).

From the high-contrast negative of the original, a print can be produced which removes the background, leaving the writing very clear (pl. 7, fig. 2). A chart can then be prepared by cutting out the individual letters and pasting them on a white card containing a scale showing the original size (pl. 8, fig. 1). This card is then rephotographed with "contrast-process ortho" film, which allows enlargement or reduction of the final chart on a photographic print which preserves the exact forms of the letters, without any possible violation of forms (pl. 8, fig. 2). Publication of the finished print therefore assures absolute accuracy.

This method, of course, has certain drawbacks, in view of the fact that not all types of materials can be treated in this way. Inscriptions on stone or clay must still be reproduced by tracings, and badly defaced letters, or those on disintegrated leather, cannot be selected for such a chart. Furthermore, the high contrast tends to obscure any elements which might show the method by which the form of the letter was achieved, but hand-drawn charts also have this latter handicap. Furthermore, the process is expensive, unless the paleographer does his own photographic work.[19]

To return to the problem of dating the Dead Sea Scrolls by means of paleography, however, we must admit that narrowing down the limits of the history of Hebrew writing to the point where the Dead Sea Scrolls could be fixed with considerable certainty, still leaves much to be desired, especially in view of the absence of literary materials of the second century A. D. It is easier to fix the upper limit of their age, since they could not possibly be as old as the third century

[18] Dr. Solomon Birnbaum, without doubt the leading authority in Hebrew paleography, effectively answers the critics in his The Qumran (Dead Sea) Scrolls and paleography, Bull. Amer. Schools Orient. Res., Suppl. Stud. Nos. 13–14.

[19] Birnbaum, ibid., p. 50, claims such a process is economically impossible.

B. C. papyri. But the lower limit is not so easy, in view of the paucity of our materials from the first and second centuries A. D.[20]

One of the most important contributions to this problem, it seems to the writer, comes from the ossuary inscriptions, although the often freehand scratching of the inscriptions into the limestone or chalk makes many of them worthless for comparison with the script of literary documents. These bone chests were a common form of disposal of the bones of deceased relatives in the first century B. C. and first century A. D., and many have been found with inscriptions in Aramaic and Hebrew, giving the names of the people whom they represent. The inability of the writer to secure a sufficient number of good photographs of this type of inscription is one of the reasons for the delay in publishing the results of the research, though it seems apparent that the script found on these ossuaries represents substantially the period in which the Dead Sea Scrolls must be placed.[21] Certain basic changes in the form of script of Hebrew seem to have been introduced in the late first century A. D. or early second century A. D., perhaps contemporaneous with the work of Rabbi Akiba, and if evidence can be established to fix the dates of these changes we may have the conclusive evidence for the placing of the Dead Sea Scrolls prior to the end of the first century A. D.

That the Dead Sea Scrolls cover a considerable period of time of themselves is evidenced by a comparison of the many different hands represented in the total discovery. Probably the earliest of the documents found in the cave (with the possible exception of a few fragments of Leviticus in archaic script) is the St. Mark's Isaiah scroll (DSIa) which has a script not too far removed from the third century B. C. Edfū papyri. It still seems certain that DSIa must have been written near the end of the second century B. C. The dating of the latest fragments found in the cave will need to await the publication of the new fragments recently found in the Muraba'at caves, considerably south and west of 'Ain Fashkha.[22]

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[20] Reports from Palestine received about the time this paper was first presented indicate that early second century A. D. Hebrew and Aramaic manuscript fragments have been found in some caves farther south and west of 'Ain Fashkha at Wadi Muraba'at and apparently not related to the Dead Sea Scroll deposits. Père Roland de Vaux, who is preparing them for publication, informs the writer that their script is later than that of the Dead Sea Scrolls. One of the documents can be accurately dated to A. D. 124. If the evidence is sufficient, it may supply the missing link that will settle the dating problem once and for all. See Bull. Amer. Schools Orient. Res., vol. 126, pp. 1–2, April 1952.

[21] Since presenting this paper orally, a complete set of photographs of the many ossuary inscriptions in the Palestine Archeological Museum in Jerusalem has been received by the writer.

[22] Some samples have now been published in the Palestine Exploration Quarterly for May–October 1952, plate 28 (including a fragment of another scroll of Isaiah) and in the Revue Biblique for April 1953, plates 12, 13, and 14 (including a fragment of Exodus and a phylactery with Deut. 6:4–9). There is no doubt now that the Dead Sea materials from the Qumran caves are earlier than these newer finds paleographically.

It is true that the study of Hebrew and Aramaic paleography has not developed to the point where we can assign such manuscripts with confidence within narrow limits in early periods of history on the basis of the form of the writing alone, but it certainly is an important tool to set beside the other means of dating documents. Certainly it has had an important bearing on the Dead Sea Scrolls, having led those who examined the scrolls in the first place to their initial conclusion—a conclusion which has not yet been seriously challenged—that they are about 2,000 years old.[23] It has also helped narrow down some of the very wide divergencies of dating derived from the study of the internal evidence only.

The writer is extremely grateful to the American Philosophical Society, the American Schools of Oriental Research, and the National Council of Churches for making a contribution to this research, and he hopes to publish the final results soon.

[23] The writer made a preliminary attempt to date the Dead Sea Scrolls by means of paleography in his A paleographic study of the Jerusalem Scrolls, Bull. Amer. Schools Orient. Res., vol. 113, pp. 6–23, February 1949.

Kinreizuka—The "Golden Bells Tomb" of Japan[1]

By Motosaburo Hirano and
Hiroshi Takiguchi

[With 4 plates]

THE ANCIENT TOMBS OF JAPAN

Among the most interesting man-made features found throughout Japan are the burial-mound tombs. They are found in many places, and are not only of general interest, but their scientific value to the archeologist who is reconstructing the past history of the people of Japan is tremendous. The Kinreizuka (Golden Bells Tomb) is of unusual significance, for it was erected when the custom of building elaborate burial tombs was beginning to decline, and it contained a quantity and quality of grave offerings never before found in a single tomb. Before going into the details of the excavation of this mound, the tomb's construction, and a description of some of the more significant objects discovered, a brief account of the burial-mound complex, its position and meaning in Japanese history, will be worthwhile.

Burial-mound tombs were first constructed in Japan at the end of the second century A. D. and continued to be a popular means of disposal of the dead until about the middle of the seventh century A. D. The introduction of Buddhism, with a shift in religious beliefs, was the main cause of their decline, and their construction stopped entirely in the ninth century A. D. Although burial-mound tombs are found over most of Japan, the main concentration of this burial custom was in Nara and its environs, in Kisarazu and its neighborhood in the Chiba Prefecture, in the northern districts of Kanto, and in the northern and eastern districts of Kyushu.

The tombs were of different shapes, each characteristic of a certain period, thus helping to establish the historical development of the

[1] In 1951 a monographic study entitled "Kinreizuka, Old Tomb at Kisarazu in the Province of Kazusa (Chiba Prefecture)" was published in Japanese with English captions to the illustrations and a three-page English summary. In order that an English reading public might appreciate the significance of these finds, this longer summary was prepared, translated by Kazuo Hirano, and edited by Dr. Clifford Evans, Jr., division of archeology, U. S. National Museum.—Ed.

burial-mound tomb complex throughout Japan. The three types of tombs are: 1, the round or spherical tomb (Enfun); 2, the square-front, round-back tomb (Zenpokoenfun); and 3, the square tomb (Hofun). The round tomb is considered not only the earliest type constructed but also the simplest. Although it represents the earliest period, dating to the second century A. D., a few round, simple tombs were built until the end of the Kofun (Ancient Tomb) period of Japan in the eighth century A. D. The most complex type is the square-front, round-back, which represents the climax of perfection during the peak of this burial complex in the middle of the fourth century A. D. All the tombs of this type are much larger than the round variety and were supposed to have been constructed only for men of high social or political position. As a result the architecture and construction are not only good, but the grave offerings and objects inside are usually of greater number and finer quality. Perhaps one of the largest tombs ever built in this style, and an excellent example of the typical features of the square-front, round-back tomb is the famous Nintoku Ryō built for the Emperor Nintoku in the fifth century A. D. Kinreizuka (Golden Bells Tomb) belongs to this class. The last group, square tombs with a flight of stairs in front, is very rare and was constructed only occasionally during the middle and late part of the Hofun period of Japan.

Kinreizuka (Golden Bells Tomb), once a beautiful burial-mound tomb 6 meters high and 110 meters long with a water-filled moat surrounding it, today stands only as a rounded mound 5 meters high and 35 meters in diameter (pl. 1). Local people have constantly dug away the mound, taking the dirt for modern house or road construction, so that today only a small part of the square front still remains. The Golden Bells Tomb is on the outskirts of the city of Kisarazu, Chiba Prefecture, 70 kilometers south of Tokyo. It appears that thousands of years ago the coastline of this area had been about a kilometer inside the present line, as evidenced by several ranges of sand dunes in the region. Taking advantage of these dunes, the early inhabitants constructed their burial mounds here. Kinreizuka was constructed during the middle of the seventh century A. D. on one of these dunes closest to the coast, at which time the city of Kisarazu was only 300 meters from the water's edge. The geographical features of the coast must be considered in this discussion of the setting of the burial-mound tombs of the Kisarazu area. The River Obitsu drains the area, running not over 1 kilometer from the Golden Bells Tomb, and empties into the Bay of Tokyo at a point about 1½ kilometers from the mound. With good drainage, good agricultural lands, and the availability of a river, this area supported large populations in the past. Here once occurred one of the main concentrations of

the people who disposed of their dead with elaborate ceremonies in burial-mound tombs, for this small region around Kisarazu is dotted with over a hundred burial mounds of all varieties.

CONSTRUCTION OF THE GOLDEN BELLS TOMB

In 1932, during road building which was cutting off the square front of the tomb Kinreizuka, some gilded bronze shoes and horse trappings were found at the entrance of the tomb. Unfortunately, scientific excavation could not be undertaken at that time. In succeeding years sand drifted into the area and silted over the tomb. Finally, in May 1950, archeological excavation was begun by the Chiba Prefectural Board of Education and the Archeological Institute of Waseda University. The work continued until the end of July 1950, when the tomb was completely uncovered.

Careful preparatory work had preceded the construction of the tomb and the burial mound of earth over it. First the ground had been leveled and hardened by beating and then covered with a layer of brown soil, 27 centimeters thick. On top of this material was a 7-centimeter layer of clay paving, with the space for the stone chamber in the middle hardened again by beating. Upon this hardened foundation a room was built of sandstone blocks, quarried from the neighborhood. This chamber was 12 meters long and 3½ meters wide. The long side of the structure faces the east. The wall height at the entranceway measures 1.2 meters and in the interior 2.2 meters. It is divided into two sections, a front room and an inner room. The floor of the front room is paved with a large chlorite schist slab 82 centimeters long and 56 centimeters thick, while the inner room has a floor of clay 10 centimeters thick. These rooms were made by stacking chlorite schist stone slabs (20–30 centimeters wide, 50–100 centimeters long, and 50–70 centimeters thick) on top of one another, sloping inward slightly in what is known architecturally as a "false" or corbeled arch.

The ceiling to the chamber had been made of nine rock slabs laid across these rock-slab walls. One of the slabs had slipped off, since it had not been long enough, and had fallen slantwise into the room. Others had been taken away by looters, and the entranceway had been broken, and so the exact structural details of these features could not be determined. Loose sand filtering through the cracks had filled the entire room. However, it was evident that in the original construction everything possible had been done to prevent the infiltration of sand.

The spaces between the rock slabs were chinked with small pebbles. Upon the ceiling and wall surfaces, both interior and exterior, there were thick (50 centimeters) layers of clay. Upon the exterior of the clay-plastered rock structure of inner rooms, the dirt had been packed

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until a large earth burial mound had been built up which measured 6 meters high and 110 meters long. As mentioned, the entranceway to these rooms had been destroyed beyond recognition. However, based upon a study of other tombs of this type, it is believed that the entrance had been built originally facing south and was covered with a heavy pile of stone.

Inside the chamber, slightly to the left of center near the west wall, was the crude sarcophagus (pl. 2), made of 6 stone slabs, all grooved on the inside to add stability to the construction. Underneath the sarcophagus 10 small rock slabs had been wedged to make it sit level. The interesting thing about this stone coffin and the other chlorite schist stones in the tomb is that this particular variety of rock is not found locally but only at a certain quarry in Chichibu District of Saitama-ken Prefecture about 200 kilometers from Kinreizuka in Kasarazu District. The preference for this stone must indeed have been great when the size of some of these slabs and the distance they had to be transported are considered. The following table gives weight and dimensions of the chlorite schist slabs used to form the sarcophagus:

Measurement	Cover	East side	West side	South side	North side	Bottom
Width	78-88 cm	72 cm	78 cm	61 cm	62 cm	66 cm.
Length	233 cm	215 cm	232 cm	68 cm	68 cm	216 cm.
Thickness	12 cm	10 cm	10 cm	6 cm	7 cm	12 cm.
Weight	700 lbs	500 lbs	520 lbs	100 lbs	100 lbs	500 lbs.

CONTENTS OF THE STONE CHAMBER

When one of the roof slabs fell into the inner chamber, it would be supposed that it disturbed the original position of the offerings. The looting of some of the stone from the entranceway could have further disarranged the contents of the tomb. But careful examination seems to indicate that neither of these occurrences disturbed the original position of any of the materials or bodies placed inside the chamber. The main destruction had resulted from decay and corrosion. Although all traces of wood had been destroyed, there had apparently been several wooden structures inside the chamber; patterns of iron nails suggested wooden shelves and coffins. From the accumulation of pottery in the rear of the chamber and the intermixture of nails and decayed matter it is highly probable that wooden shelves had been built inside the chamber to hold some of the vessels buried with food offerings. Further evidence of another wooden structure is connected with the remains of one body. Decay had destroyed all evidence of the coffin, but the accumulation of iron nails, seven swords, amber and crystal beads, a bronze mirror, horse trappings, gold bells, a bronze

vessel and numerous pottery vessels in direct association with a few bone fragments and five teeth suggests that this person had at one time been placed in a wooden coffin.

Near the entranceway another person had been buried on a chlorite schist slab, perhaps in a wooden coffin which had long since disintegrated. The bones of the body were decomposed, but the skull was in a rather good state of preservation. In association were gilt-bronze earrings and a crystal, amber, and glass bead necklace. From the location of this burial, it would appear that the stone chamber had been reopened, after the sarcophagus had been buried and the entranceway closed, and this burial placed just inside the entrance.

Before examining the remains of the sarcophagus itself, the materials lying around the coffin should be mentioned. In front and by the side of the sarcophagus lay a necklace consisting of over 500 glass beads, a bronze mirror, two pairs of earrings, five gold bells, seven silver tips of a bow, one iron spearhead, numerous iron arrowheads, four gilt-bronze saddles, three bronze horse bells, three bronze vessels, two gilt-bronze ornaments, a chatelaine, a wide variety of harness and trappings for horses, and over 200 pottery vessels (pl. 3). Inside some of the pottery vessels, which had been used for food offerings, were the remains of several types of shellfish. Sand and silt filtering into the chamber had packed the pottery and other remains so tightly together that excavation was extremely difficult. The fact that the hundreds of pottery vessels were buried in three layers suggests further that some of them originally had been on wooden shelves and gradually as the chamber silted up and the shelves rotted, another group of vessels fell to the chamber floor soon to be covered with more sand as it filtered in through the cracks in the ceiling and wall.

CONTENTS OF THE SARCOPHAGUS

The large stone coffin had been placed in the chamber parallel to the long side of the wall with its head toward the south, feet to the north. When the stone lid was raised, disclosing the golden articles, the iron swords, bronze bells, knives, and beads, it was evident we had discovered the tomb of a very important high official who had lived over 1,300 years ago. Sand, which had filtered through some of the cracks in the stone walls of the coffin, and the dust of decomposed bones, garments, and other perishable objects filled the interior to a depth of 15 centimeters. Apparently only one body had been buried inside. The bones had completely disintegrated; only the teeth remained. From eruption and wear of the teeth, we can conclude that they were from a young male, probably in his mid-twenties. In positions in the coffin which would suggest their original placement on the body of the deceased man, were a pair of earrings, a mirror wrapped in hemp cloth

on the chest, and a necklace of 24 beads; 8 iron swords with elaborate handles lined the sides of the body next to the coffin walls. Above the head on the east side were two large bronze vessels. Near the feet a set of iron body armor and a helmet had been placed along with 36 iron arrowheads. In addition, 54 gilt-bronze bells, 3 bronze horse bells, 18 gilt-bronze ornaments, 11 knives, a gilt-bronze shoe, and a large quantity of gold braid were scattered throughout the coffin. From the arrangement of the small gilt-bronze bells and gold braid, apparently the body had been dressed in ornate clothes and a large cloth decorated with gilt-bronze bells and gilt-bronze ornaments sewed on with gold thread, had been spread over the entire contents of the coffin. From the array of objects there is little doubt that this man was an important ruler who carried to the afterworld all his accoutrements of war and symbols of office.

DESCRIPTION OF SOME OF THE GRAVE OBJECTS

Mirrors.—The mirrors unearthed in the ancient burial-mound tombs of Japan are of two kinds: those made in ancient China and imported to Japan and those made in Japan imitating the imported product. Although the Chinese mirrors are usually far superior to any of those imitated in Japan, the style of design is so unique on the Japanese copies that there is never any doubt of the place of manufacture even if the actual mirror is of a good quality resembling the Chinese variety. The two mirrors found in Kinreizuka, one in the sarcophagus and one in the chamber, are of Japanese manufacture. Both are round and made of nickel. The one found in the coffin is an exceptionally well-made copy of the Chinese-style mirrors with a diameter of 15.8 centimeters, a thickness of 6 millimeters, and the face slightly bulged like a convex lens. The design on the back consists of three men and five animals intertwined (pl. 4, A, left). The other mirror is smaller, only 10.4 centimeters in diameter, and 3 millimeters thick, with an arabesque design.

Jewels and beads.—The necklace around the young man's neck in the coffin consisted of one pale agate bead 3.3 centimeters long, amber beads ranging from 2.3 to 3.0 centimeters in diameter, and dark blue, slightly flat glass beads, 1 centimeter in diameter. Since amber has been found in the Choshi District of the Chiba Prefecture, it is highly possible that these beads were manufactured in the area and brought from that district.

The other glass beads from outside the chamber range in size from 3 to 5 millimeters in diameter and are divided according to their colors as follows: 420 blue, 112 yellow, 38 green, 8 dark blue, 1 white. In addition to the complete specimens many broken fragments suggest that a larger number might have been in the original necklace.

Earrings.—The earrings are of two types: a large variety of copper tubing bent into a loop, and a small variety of copper wire. Both styles are gold plated. The pair of earrings from the coffin, of the larger variety, measure 3.5 centimeters in outside diameter with the tubing 8 millimeters in diameter. The smaller pair measured only 2.7 centimeters in outside diameter with the tubing 6 millimeters.

Gilt-bronze shoes.—In the front part of the chamber a pair of gilt-bronze shoes were found. Although shoes were generally made of leather or wood, metal ones were used for formal occasions.

Gold bells, threads, and chatelaines.—The tomb was named Kinreizuka for the beautiful small gold bells found inside the burial chamber. These bells are 8 millimeters in diameter and weigh 1.5 grams each, and still ring clearly. Other gold goods included a variety of gold thread which had been woven into a kind of Gobelin tapestry in which the warp threads were presumably silk and the weft made of finely thinned gold coiled around the threads. This gold tapestry, combined with the gold bells and silver ornaments, probably constituted some sort of waistband. The gold thread from Kinreizuka is thought to have been a trade item introduced from China or Korea and not developed locally in this part of Japan.

Swords.—Over 20 different sword specimens were found in the tomb, counting fragments too badly corroded to be restored. They can be classified as to type according to the shape of the pommel, for the iron blades of ancient Japanese swords are all straight. Although swords are found in even the poorest of the burial-mound tombs, no other single burial-mound tomb in Japan has produced the quantity of elegant swords found in Kinreizuka. All the sword blades were so corroded that it was impossible to reconstruct the exact length, the fragments of the longest specimens measured 133 centimeters. Of particular interest are the elaborately modeled birds, dragons, and lions in the ring of the pommel. The pommels are covered with a thin gold plate. The sheaths were usually made of a thin gilt-bronze plate with a design of beads and arabesque with a metal ornament of open arabesque work affixed to the central portion of the sheath. It should be mentioned that although most of the metalwork of the swords and sheaths was in gold, some had silver wire coiled around the hilt or, in a few cases, the pommel might be made entirely of silver.

Two ornamental swords for formal use came from the tomb. These are called Kabutsuchi-tachi, meaning "hammer-shaped." This style of sword, originating in Japan, has a peculiar type of pommel formed like a flattened ball into which a cudgel is inserted and fastened by packing it with hemp cloth and then riveting. The rivet passes through the cudgel and ring and carries a string or cord. The ball

is made of gilt-bronze. The hilt is extremely short and made of thin gilt-bronze so that it would never have been strong enough for use as a fighting sword.

Iron helmet and body armor.—The tomb contained many objects related to warfare, such as silver tips of wooden bows, arrowheads, swords, knives, and armor. Perhaps the best preserved was the armor. The iron helmet (pl. 4, A, right) is 19 centimeters high, 26 centimeters in depth, and 20 centimeters from side to side. It is made of seven iron plates; the saucer-shaped top plate and the long and narrow side plates are all held in place with rivets. The neck pieces had rusted so badly that they had broken and their shape could not be be reconstructed. The body armor consisted of 1,574 small iron plates which must have been joined together somehow on a perishable material to form a covering for the chest and back.

Horse trappings.—The harness, saddles, stirrups, and ornaments worn by horses included over 130 pieces, most of which came from outside the coffin. Three sets came from the excavations conducted in 1950, but fragments found in the road construction which damaged the tomb in 1932 suggest that four sets of harness and trappings existed originally. Three saddles made of iron (pl. 4, B, top) and covered with gilt-bronze plates came from inside the chamber. All the wood, leather, and cloth had decayed except for a few pieces of lacquered cloth. Around the saddles some decorations could be seen which had been made of bronze plate and with a gold hem design in cloth in the form of a dragon. There is little doubt that when new these saddles must have been highly ornamented and beautiful objects. The bridles were decorated with heart-shaped plates of bronze. Two pieces of iron stirrups covered with bronze plates were found in association with the harness. Bronze horse bells, such as were tied around the horse's neck and hung in front of his chest, came from both inside the coffin and outside of it in the chamber. The six bells are of two sizes, 22.5 centimeters long and 19.5 centimeters long. These specimens are unusually large, for most horse bells average only 15 centimeters long. The larger ones are decorated with a sort of pendant with raised bumps and diagonal and parallel lines (pl. 4, B, bottom, right) while the smaller one is decorated with cross stripes with eight sections demarked by vertical and horizontal lines with small raised bumps all over the surface (pl. 4, B, bottom, left).

Gilt-bronze bells and ornaments.—Fifty-four gilt-bronze bells and 18 gilt-bronze ornaments were taken out of the coffin. Although the small bells usually decorate the the trappings of horses, in Kinreizuka the bells and ornaments were undoubtedly sewn on a large cloth which was draped over the body and objects inside the coffin. The bells range in size from 3.5 to 27.0 centimeters; some of them contain

small pebbles and still tinkle sweetly. The plates of gilt-bronze are of two types: 1, round plates 6.8 centimeters in diameter with a hemispheric projection in the center and five arms from the base of the projection; and 2, small hemispheres 2.5 centimeters in diameter with six petals attached.

Bronze vessels.—Some of the bronze vessels were so badly corroded and broken that restoration was impossible; but two specimens (pl. 4, C) were in excellent condition and proved to be unique objects from Japanese burial tombs. These vessels are sitting on a flat plate-like stand with a pedestal base. Each vessel is goblet-shaped, with a stem, flaring base, and round cup, and covered with a hemispherical lid with a small knob on the top. The total height of the plate, goblet, and lid is 17 centimeters.

Pottery vessels.—The pottery vessels of the burial-mound tomb periods of Japan can be classified into two distinct types: thin, red-brown ware without much design (Hajiki), and a hard dark-gray pottery made in mass production on the potters wheel and fired in unusually hot furnaces (Sueki). Of the pottery from Kinreizuka 26 vessels are of the first type, Hajiki, and 243 of the second type, Sueki. These numerous vessels have been further subdivided into various categories meaningful to the specialist in ancient Japanese pottery but too technical for a discussion of this nature. The various pottery vessel shapes from this tomb include stemmed bowls, plates, bowls of a wide variety with covers, deep round-bodied jars with long or short necks. Some of the plates had been painted on both surfaces with cinnabar but one plate had a black interior and a red painted exterior. Several platterlike vessels showed oil smudges along the edge suggesting use as oil lamps. Without any doubt all the vessels at the time of their placement in the tomb were intact and contained offerings of food and drink to the deceased. When the wooden shelves fell and the pottery vessels crashed to the floor of the chamber, many vessels were broken, but the majority were restorable. The photograph (pl. 3) of some of the vessels in the chamber before complete excavation will give an idea of the range of shapes.

CONCLUSIONS

The burial-mound tombs of Japan are indicative of the high rank and opulence of the families who built them. Only persons of great wealth and power could amass the material and employ the labor necessary to construct these tombs and furnish the quantity of lavish articles buried in them.

From the numerous and elaborate objects found in Kinreizuka, this was evidently the tomb of a person of exalted station—undoubtedly a very important young ruler. The other two bodies in

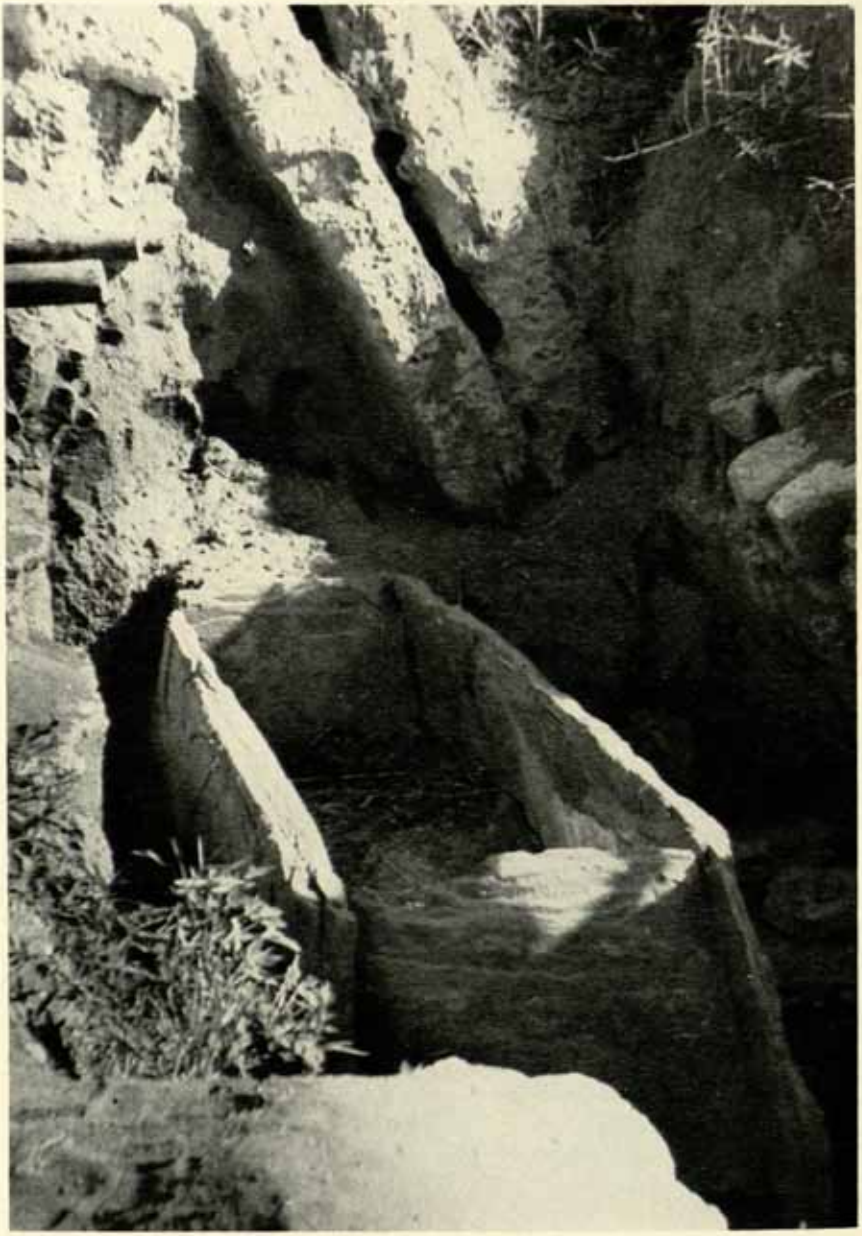
the tomb, probably buried at slightly later times, must have been members of his family. Certain features of the tomb indicate that it was built near the end of the Hofun (burial-mound tomb) Period, sometime in the middle of the seventh century A. D., when the burial customs were being changed by law. (For example, most of the elaborate burial-mound tombs have paved floors in the inner chamber, but this one did not.) This change was brought about by the adoption of Buddhism as the official religion of Japan, and the consequent passage of laws prohibiting the construction of elaborate tombs with extravagant furnishings and establishing simple burial ceremonies.

In spite of these laws, burial-mound building continued until the eighth century A. D. in the Kanto district and until about the beginning of the ninth in the Tohoku district. However, it apparently came to an end in the Kazusa district in the late seventh century, and Kinreizuka can be considered to be one of the last large burial mounds with a moat, a large chamber, and elaborate burial goods.

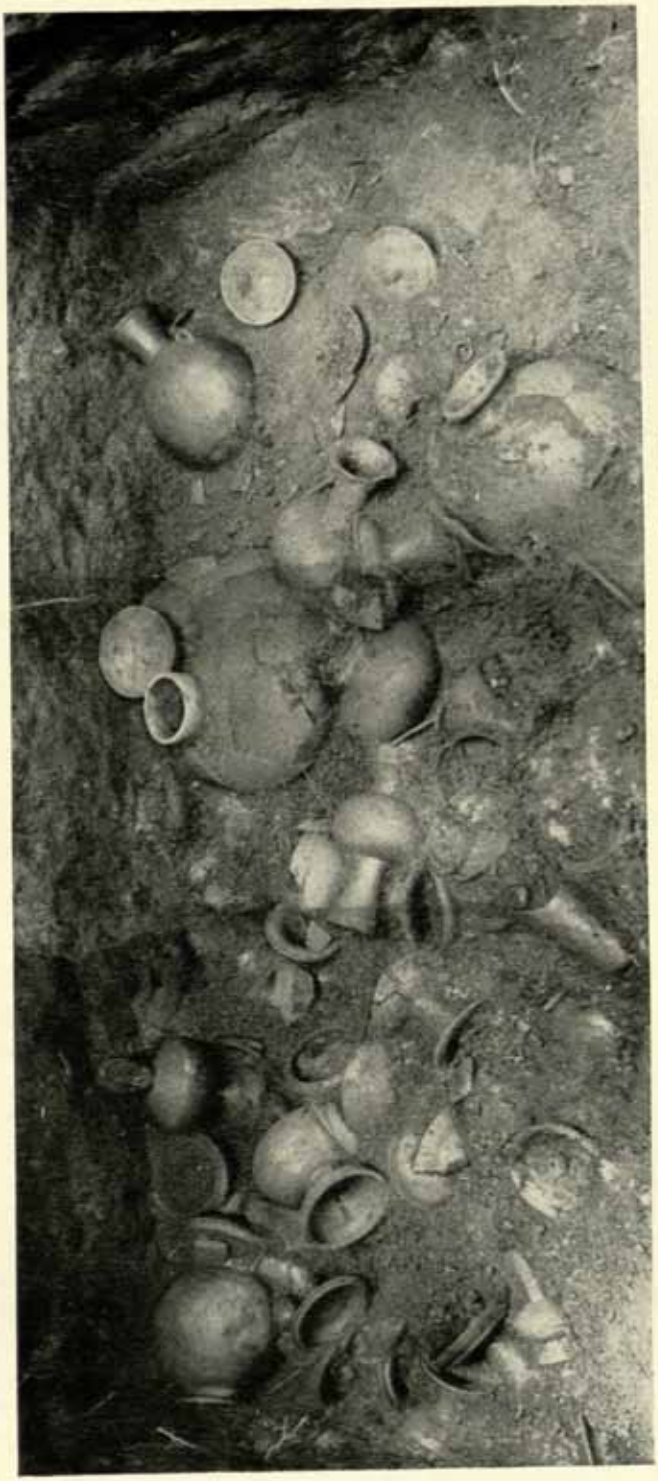
Since the close of World War II there has been an increased interest in the archeological remains of Japan. The scientific excavation of Kinreizuka is an important contribution to an understanding of the prehistory of Japan because no previously discovered tomb has contained so many valuable artifacts.

1. VIEW OF THE KINREIZUKA BURIAL-MOUND TOMB.

2. PRESENT CONDITION OF KINREIZUKA.

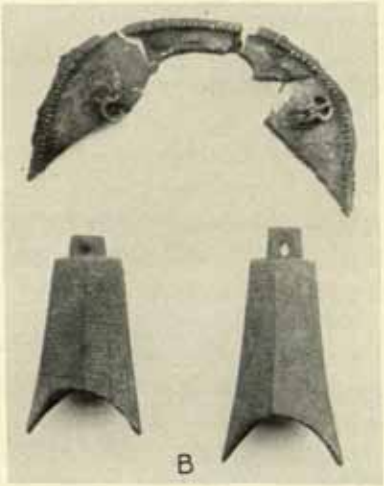


CRUDE STONE SARCOPHAGUS (WITH THE LID REMOVED) FROM INSIDE THE CHAMBER OF THE TOMB.



POTTERY VESSELS AMASSED ON THE FLOOR OF THE CHAMBER.

A



B

C

A, *left*, rear view of the large mirror; *right*, fragmentary iron helmet. B, *top*, iron and bronze horse saddle with the leather, cloth, and wood rotted away; *bottom*, small and large types of bronze horse bells. C, bronze vessels resting on a platelike stand.

The Archeology of Colonial Williamsburg[1]

By Thomas J. Wertenbaker

Edwards Professor Emeritus of American History
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[With 4 plates]

In America archeology formerly was employed almost entirely to throw light upon the life and customs of the Indians. Scholars, digging into Indian mounds, or at the sites of villages and forts, have found much of interest—knives, arrowheads, spearheads, scrapers, pottery, skeletons—and they have been able, by examining the earth and noting where it was discolored, to determine the exact position of prehistoric palisades. Americans have also taken a leading part in European, Egyptian, and Asiatic excavations. But until recently it had not occurred to anyone that beneath the soil at Jamestown, or Plymouth, or Williamsburg there might be historic treasures whose discovery would be as important for American history as the opening of an Egyptian tomb, or the uncovering of the market place of a Greek city for ancient history.

The pioneers in the field of colonial archeology were the staff of the National Park Service. At Jamestown they unearthed so many foundations and so many fragments of hardware that this historic village, where Nathaniel Bacon, that heroic young defender of American liberty, defied the fury of Gov. William Berkeley, could be restored with a large degree of accuracy. In fact the first brick church, which the foundation showed to be in the Gothic style like charming old St. Luke's at Smithfield, has been rebuilt. Also the many artifacts discovered—farm implements, household utensils, china—throw a flood of light on the habits and everyday lives of those first Americans.

It is unfortunate that we have been so blind to the importance of archeology and so careless in digging on historic sites. In London recent work made necessary by the German bombings has disclosed evidences of walls and pavings dating to the Roman period. But in New York, when excavations have been made for the skyscrapers, there has been little, if any, regard for history. For all we know the great

[1] Reprinted by permission from Proceedings of the American Philosophical Society, vol. 97, No. 1, February 1953.

steam shovels may have tossed aside fragments of a tumbler from which Peter Stuyvesant once drank his wine, or a rusty hinge from the house of John Jay, or a bayonet from old Fort George. Since we cannot level places like Boston, Plymouth, Charleston, Salem, or Philadelphia to search for buried historical treasure, would it not be wise for us to take advantage of the excavations for new buildings to rescue such artifacts as are dug up?

At Williamsburg, it was an exciting moment when, on June 30, 1930, the first shovelful of earth was brought up at the site of the Governor's Palace, in what proved to be the most interesting of all the excavations there. Guided by several old maps, the archeologists began by making exploratory trenches just north of the public school. Finding that in some places they were working in undisturbed ground and in others in brick and mortar debris, they concentrated their attention on the latter. After two days of work they were rewarded by touching several walls. They now warned the workmen to proceed with extreme care in undercutting the debris, so that it would fall away from the brickwork and leave it unscarred by the picks.

Elated at their success, the archeologists dug deeper until, when they had uncovered a small area of floor paved with flagstones, they realized that they had found a large basement. Their next task was to remove four large locust trees, which were growing in the debris, and whose roots reached down to the floor. Then, one after another, parts of all four exterior walls, several partition walls, several chimney foundations, the brick basement steps, the foundations of the main entrance steps, the stone steps of the side entrance were laid bare.

It was not only with care, but with reverence, that members of the restoration staff handled the multitude of objects which were now unearthed, for they spoke eloquently of men and scenes intimately connected with the early history of our nation—of Governor Spotswood and his Knights of the Golden Horseshoe, of Dinwiddie in earnest conference with the youthful Washington, of Jefferson, when a student at the College of William and Mary, joining Governor Fauquier in a concert in the beautiful ball room, of the flight of Lord Dunmore to British warships in the York River to escape the wrath of the American patriots.

Since it was assumed that when the palace burned, heavy objects such as locks or tiles fell straight downward and so would be directly beneath their original location, the entire site was divided into small numbered sections, each having its own box into which all objects within its bounds were put. Thus a record of the location in which each article was found was kept for future reference.

How valuable to the architects this proved is shown by the discovery of fragments of marble beneath the fireplace of the middle room of

the main floor, which made it possible to restore the mantel exactly as it had been in the days of Governor Botetourt and Lord Dunmore. Especially interesting was the lovely floreated slab in the center, of which almost all the pieces were unearthed. Some of the Delft tiles of the mantels in other rooms were found in such perfect condition that they could be replaced in their original positions. The architects were grateful, also, for fragments of water-table bricks, of marble floor tiles, rubbed corner bricks, stone-step scrolls, lead joints for the stone steps, bricks from the window arches, keys, hinges, shutter hooks, and locks.

In like manner as the archeologists who excavated the agora at Athens or the site of ancient Antioch found evidences of civilizations earlier than those for which they were searching, so the restoration staff, in looking for the foundations of colonial Williamsburg occasionally uncovered those of some Middle Plantation house built perhaps nearly three centuries ago. One of these was discovered not far from the College of William and Mary. About 48 feet in length and 19 feet in depth, with chimneys at each end, and a basement partly paved with brick, the building must have corresponded closely with those of Jamestown in the days of Sir William Berkeley.

The objects dug up from the debris confirmed the ancient origin of the house, for the fragments of ale bottles, the bits of broken rectangular or diamond-shaped panes and the lead cames into which they had fitted, all were typical of the seventeenth century. In the paved area of the basement was found, almost complete, the lead frame of a casement, lying flat just where it seems to have fallen when the building was demolished.

The objects dug up on the site of an old building proved invaluable in determining its functions and the period of construction. If the workmen found numerous fragments of the little earthen bowls used for mixing drugs in colonial days, one could be sure that formerly an apothecary shop had stood on the spot; if in another place they found rusty harness buckles or stirrups or bits, it was certain that a stable had once been there; if their picks turned up handsaws, gouges, augurs, chisels, adzes, or axes, it was clear that they were digging on the site of a carpenter's shop. And since styles in glassware, pewter, earthenware, bricks, mortar, ironwork, and stonework changed from decade to decade, the fragments found in or near the foundations of old houses were of great assistance in fixing not only the dates of construction but those in which they were burned or torn down.

The very absence of certain objects among the artifacts proved helpful. When no broken roof tiles were found it became clear that tiles were seldom, if ever, used to cover the houses; the absence of lead casement frames on the sites of eighteenth-century buildings makes

it almost certain that sashes were in common use almost from the date of the founding of Williamsburg. Nor does the discovery, on the site of the William Parks printing office, of innumerable fragments of lead cames in any way alter this conclusion, for it is probable that Parks, when the owners of houses dating back to the days of Middle Plantation substituted sashes for casements, bought up the lead with the purpose of sending it to England to be converted into type.

Valuable was the light which articles found in or near a foundation threw on the parts of the structure which were no longer standing. Not only did fragments of mantels, or of stone steps or of windowpanes, or of flagstones yield welcome evidence, but every bit of rusty hardware was helpful. The architects were left in no doubt that the builders of two centuries ago made frequent use of H hinges, H L hinges, and butterfly hinges on the doors of residences, and long strap hinges on stables, coachhouses, smokehouses, dairies; that the houses were fitted with large brass or iron locks; they got exact information as to the form of nails, shutter fasteners, gutter supports, cramps used for binding stone or brickwork, foot scrapers, latches, iron railings, metal gates, etc. The fullest use was made of bits of wall copings, water-table bricks, butter bricks, well bricks, firebacks, hearth stones, fireplace facings, entrance steps.

The archeologists, with all the persistence and insight of a Sherlock Holmes, even secured information from wood which had rotted away perhaps a century ago. They would have liked to find fragments of wooden cornices, balusters, and pediments, but this was not to be expected, since earth is very destructive of wood. But they did locate certain fence lines by identifying the post holes by the discoloration of the soil, and so determined the boundaries of some of the lots.

In the restoration of Williamsburg the archeologist proved as valuable an ally to the landscape gardener as to the architect. In fact, since histories, letters, and reports gave few details as to the layout of garden walks, steps, walls, and garden houses, without the data gleaned with the pick and shovel the landscape gardener would often have been working in the dark.

We do not know who designed the palace gardens. The work was done under the supervision of Governor Spotswood, but for the plans themselves, with the main layout and the details, he must have employed an expert landscape gardener. Now, little by little, fragments of the work of this long-forgotten "artist" were unearthed, which, together with maps, inventories, and descriptions, made is possible to restore it in all its unity and beauty.

In what had been the North Garden the excavation revealed parts of the foundation of the west, the north, and the east walls, showing not only their positions, but the width, the distance between posts,

and the fact that the posts were set diagonally to the wall. The ornate form of these posts was determined by the finding of fragments of stone caps and balls. The foundations of the garden houses at the northwest and northeast corners of the garden showed that these little structures, like the wall posts, were not parallel with the walls, but diagonal to them. The location and width of the central path were fixed by the discovery of the remains of its underdrainage bed of broken bricks, of the foundations of the north gate, and of the wide central limestone steps. As for the steps themselves, enough was left to determine their length, rise, tread, nosing, and material. Remains of the two flanking steps were also found, one near the east wall and one near the west wall, and the three, in turn, made it possible to estimate the elevations of the south terrace of the adjoining Ballroom Garden.

But the architects and landscape gardeners were not alone in profiting from the findings of the archeologists, for the thousands of fragments of china, glassware, household utensils, and tools which were dug up threw a welcome light upon the tastes, fashions, habits, domestic life, trades of the people. In fact, what the earth was made to yield was of vital importance, not only in restoring the buildings of colonial Williamsburg, but the people who lived in them. As a piece of broken china was brought to light the archeologist could reflect that from it Thomas Jefferson may have enjoyed a luncheon of turnip salad and jowl; a bit of discolored glass might be part of a bottle from which a waiter at the Raleigh Tavern had filled a glass with wine for George Washington; on this iron step, now a mass of rust, Lady Dunmore may have mounted to her seat in the Governor's coach; with these tools the cabinetmaker may have fashioned a table or a desk for Chancellor Wythe.

In a province where a majority of the people, rich and poor alike, were engaged in cultivating tobacco, it was to be expected that smoking would be, among the men, almost universal. But were there no other evidence available, the unearthing at Williamsburg of thousands of pieces of broken clay pipes would establish the fact. It seems to have been the custom in every household to place in the hallway near the front door a rack full of pipes. A guest, as he entered, was expected to take one, and before filling it with tobacco and lighting up, to break off an inch or more from the long, slender stem. In this way the same pipe could be used by different persons, each of whom could be certain of a clean end to place in his mouth.

In refurnishing the houses, the staff were left in no doubt as to what varieties and patterns of china had been in use in Williamsburg in colonial days, for innumerable fragments were dug up in all parts of the city. Here was a bit of a cup from which a blacksmith or a tailor

had drunk his tea, here a piece of creamware from the Raleigh Tavern, here a fragment of the costly Lowestoft which once had adorned the palace diningroom. Of especial interest were several pieces of Lowestoft bearing Lord Dunmore's coat-of-arms. The Governor, when he fled from the wrath of the patriots at the beginning of the Revolution, had been forced to leave most of his personal belongings behind, and his china, together with other things, seems to have been destroyed by the fire of 1781.

Unlike iron and glass, china is not seriously affected by a long stay under earth, so that it was an easy matter to clean the recovered fragments. When this had been done, the archeologists attempted the more difficult task of piecing them together as though they had been bits of a jigsaw puzzle. Often this proved impossible, but in some cases a vase, or a bowl, or a saucer was almost entirely restored.

The people of Williamsburg were especially fond of a yellow or cream-colored English earthernware first perfected by Josiah Wedgwood and subsequently made by other potters in various colors, degrees of hardness, and quality. When attempts to find sets of an especially popular pattern of this ware proved unsuccessful, a representative of colonial Williamsburg went to the Wedgwood works to ask whether it would be possible to make an accurate reproduction. To his surprise, the management, after a brief search, reported that they still had most of the molds from which the original sets were made, the patterns for others, and Josiah Wedgwood's formulae for the clay mixtures. So today, Anthony Hay, if he could visit the Raleigh Tavern of which he formerly was proprietor, would be astonished to find that of his set of creamware, with its 139 plates, 5 sauce boats and dishes, 2 fruit baskets, to all appearances many pieces had survived the vicissitudes of 175 years.

But had he passed on to the Old Court House to view the archeological exhibit, he would not have believed that some of the bits of glass there had once belonged to wine bottles from his cellar or goblets from his diningroom, for glass which in his day had been clear had now become scaly and iridescent under the action of time and earth. Yet glass, too, yielded evidence that was invaluable to the work of restoration. This bit came from a baglike bottle in common use in the seventeenth century, this from a round bottle with fairly straight sides characteristic of the eighteen century, this from a square bottle which had contained Dutch gin. Especially interesting are the many bottle buttons, or circular stamps on the glass bearing the owner's name or initials. Two buttons marked F. N., one unearthed from an early foundation near the Capitol and another in the vicinity of the Wren Building, undoubtedly came from bottles belonging to Sir Francis Nicholson.

That the people of Williamsburg often quaffed their wine or ale from glass goblets rather than mugs or tankards may be inferred from the finding of many fragments of wineglasses. In the eighteenth century the British glassblowers delighted in ornamenting the stems of the goblets according to certain well-recognized patterns, so that when one grasped the stem to lift the glass to his lips he could recognize at a glance that it was a baluster stem, or an opaque-twisted stem, or a ribbed stem, or a tear and beaded stem, or an air-twisted stem, or a cut-glass stem. That the Virginians, who depended entirely upon imports for their glassware, filled their diningroom cupboards with goblets in all these styles, the discoveries of the archeologists amply testify.

For the important information yielded by objects made of iron the archeologists had to pay by the trouble it took to clean and preserve them. Often, when a hinge, or a shovel, or a knife was discovered, they found that under the action of the earth, it had almost rusted away. So in the laboratory every bit of iron was subjected to a thorough process of cleaning. First, as much of the rust as possible was scraped off with a knife. Then the object was treated with granulated zinc in a caustic bath, after which it went through repeated washings, followed by drying in an oven to remove every bit of moisture from the pores. The process was completed by giving the iron a coat of paraffin.

We can follow the colonial carpenters in the work of constructing the Williamsburg houses by the implements they used and then cast aside—saws, gouges, augers, chisels, axes, lathing hatchets, wedges, frows for splitting shingles, compasses, hammers, draw knives. These implements, though the same as those used by their ancestors in England, in some cases underwent a development in the hands of the Virginians. In the axes with which the settlers at Jamestown had made their first assault upon the great oaks and chestnut trees of the primeval forests, almost the entire weight was on the cutting side of the head. But in time, when experience had shown that more drive was needed behind each stroke, the colonists gradually weighted the blunt side. Thus the eighteenth-century Virginia axes were unlike those of seventeenth-century Virginia and unlike those of England.

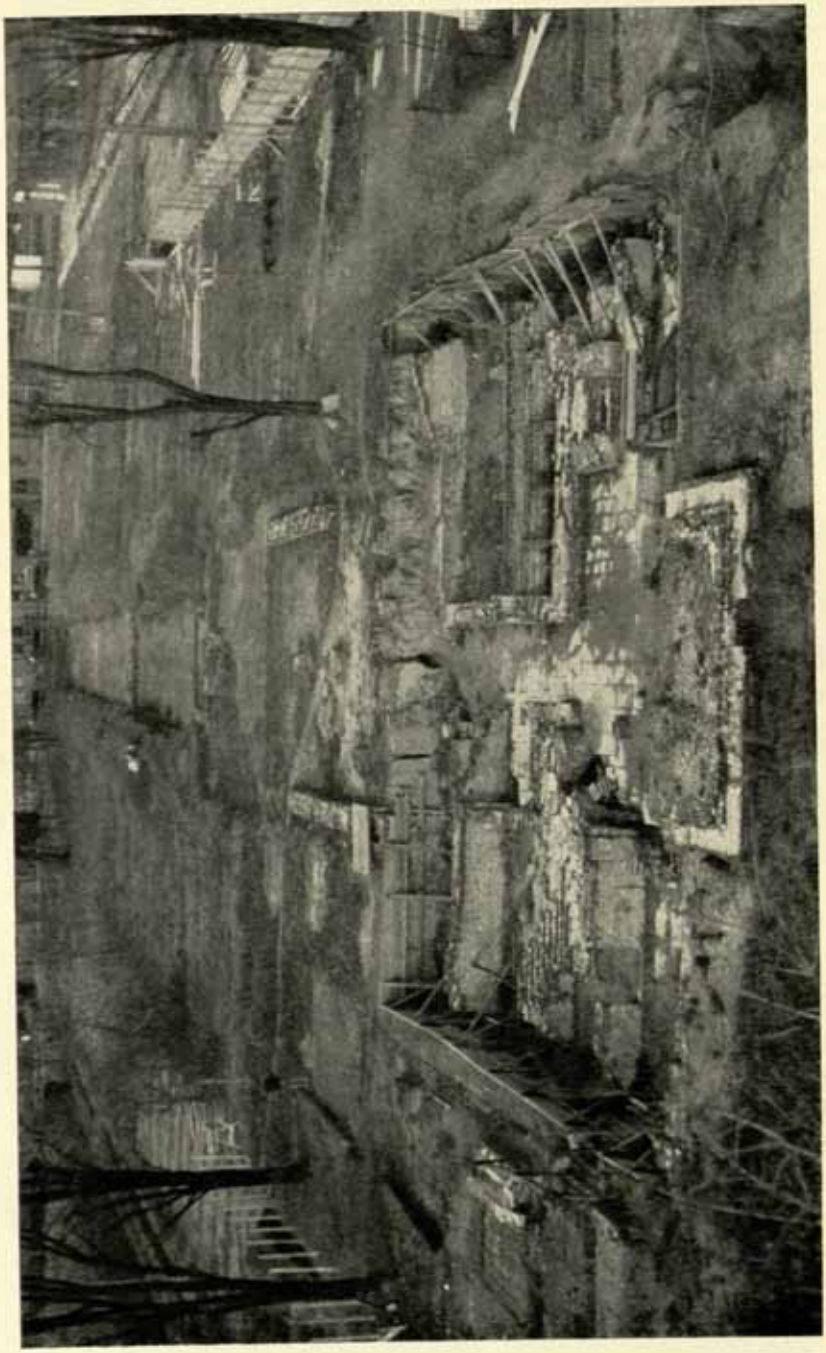
If one wishes to accompany the planter in his various tasks in cultivating the soil, one has only to examine the farm implements found at Williamsburg—tobacco knives, hoes, scythes, rakes. A sight of the cobbler's knives, pliers, pincers, hammers, rasps, and other tools, makes it easy to visualize Robert Gilbert in his shop near the Capitol, his leather apron spread over his knees, busily at work on a pair of shoes. The pickup tongs, the grip tongs, the bending forks, the sledge

hammers, the punches, the drills, enlighten us as to the blacksmith's tools used in the Deane Shop and Forge. In like manner an assortment of tools—routers, compass saws, gouges, chisels, ogees—reveal some of the "mysteries" of the cabinetmaker's trade.

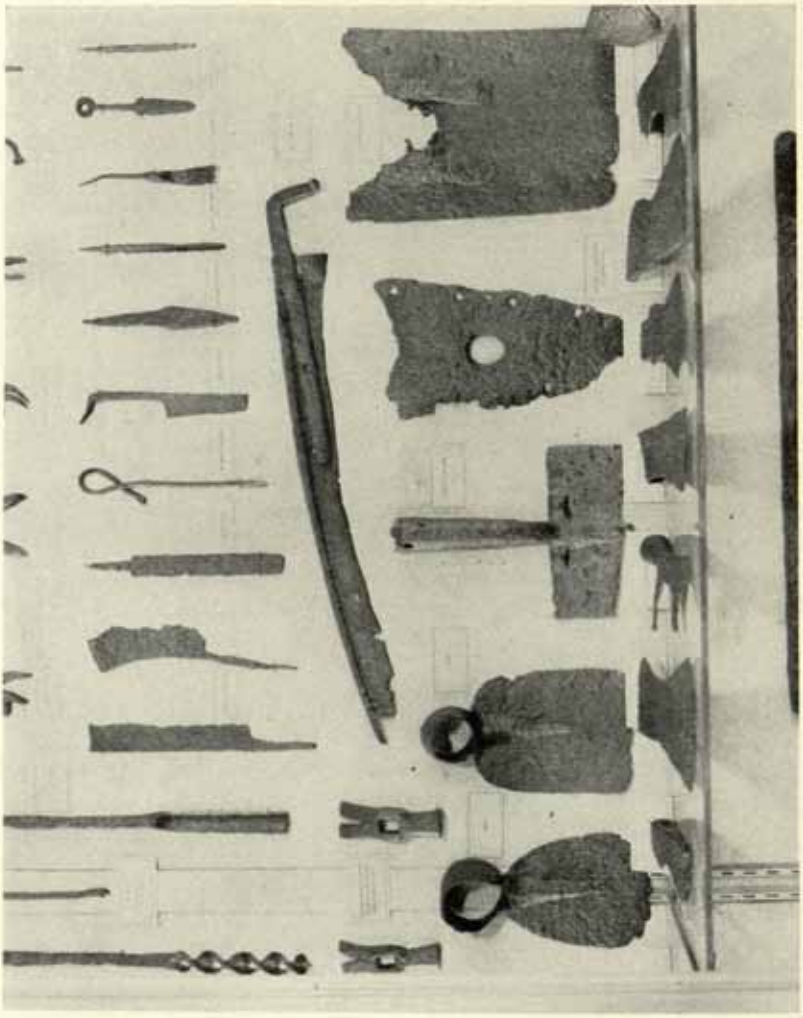
Although colonial Williamsburg is especially concerned with the eighteenth century, the discoveries of the archeologists cover the long period from the first settlement of Middle Plantation to comparatively recent times. Thus they have made it possible to follow the changes and developments in a restricted area through three centuries, changes in architecture, in fashions, in farming, in cooking, in sanitation, in heating, in transportation, in manufacture. In short, the objects taken out of the ground, when arranged in chronological order, present a panorama of life as fascinating as any which comes from the written word.

At the beginning of the archeological work, as its value became more and more apparent, the greatest care was taken to see that nothing was overlooked. All fragments of stone, marble, china, glass, earthenware, together with locks, nails, keys, tools, everything save brickbats, were placed in boxes and removed for examination. Then the remaining debris was taken out in wheelbarrows and later screened. After the artifacts, large and small, had been cleaned, they were classified, cataloged, and stored where they would be accessible to the restoration staff and the general historian. If certain objects were especially interesting, they might be selected for the museum to give visitors a view of a cross section of the entire collection and through it a better understanding of the methods used in securing the fidelity upon which Mr. Rockefeller insisted.

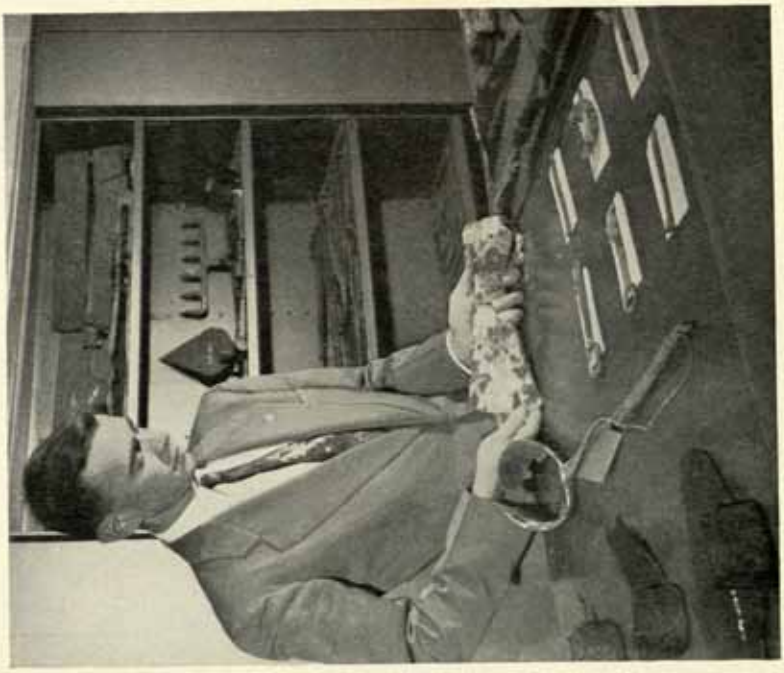
There can be no doubt that colonial Williamsburg has emphasized a field of research which offers great opportunities for American historians. Hitherto they have depended too much upon manuscript evidences. It would be rash to say that in historical investigation the pickax and the trowel are as mighty as the pen, yet it has been demonstrated at Williamsburg that the one can be a most helpful ally of the other. Perhaps the day is not distant when the social historian, whether he is writing about the New England Puritans, or the Pennsylvania Germans, or the rice planters of Southern Carolina, will look underground, as well as in the archives, for his evidence.



EXCAVATIONS AT GOVERNOR'S PALACE AND GARDENS.

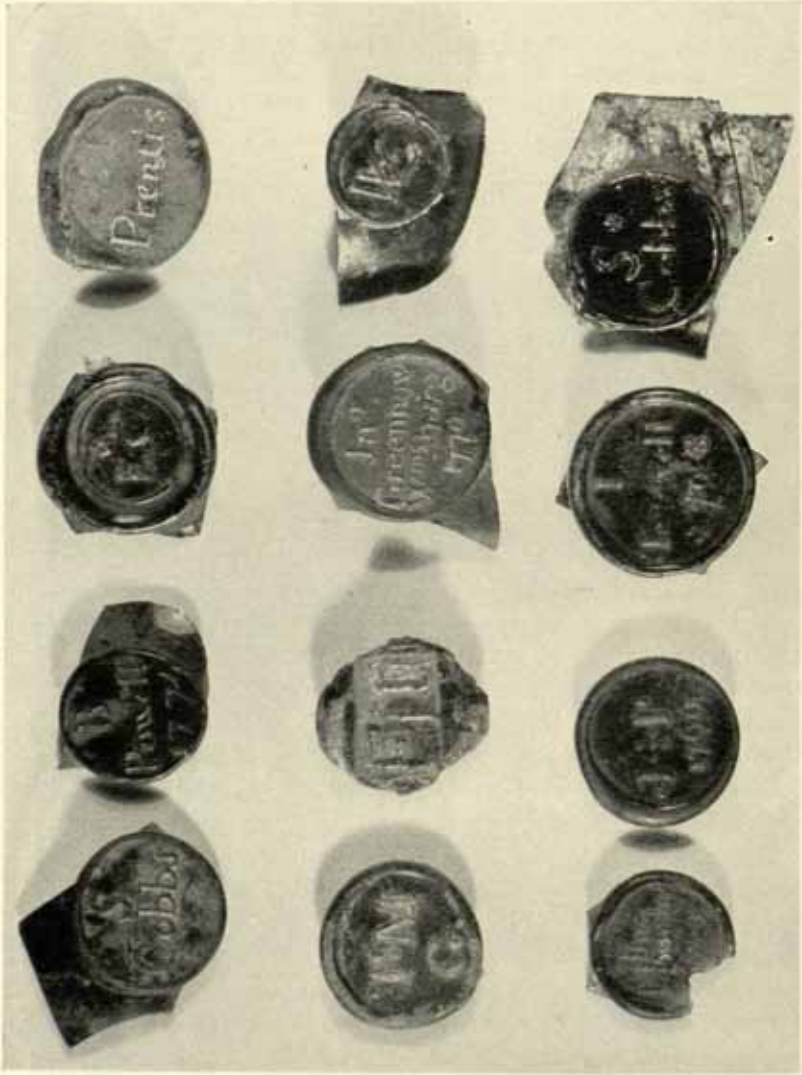


COLONIAL IMPLEMENTS EXCAVATED AT WILLIAMSBURG.



2. AN ANCIENT AX COMES TO LIGHT.

1. PIECING TOGETHER FRAGMENTS OF CHINA.



BOTTLE BUTTONS

The Story of the Declaration of Independence Desk and How It Came to the National Museum

By Margaret W. Brown

Associate Curator, Division of Civil History
U. S. National Museum

[With 5 plates]

In the halls of the United States National Museum, surrounded by such significant relics of American history as the sword of George Washington, the original Star-Spangled Banner flag of Fort McHenry, and the life mask of Abraham Lincoln, is another historical relic—perhaps the most important of them all. It is the desk on which Thomas Jefferson drafted the Declaration of Independence. Because it is the great charter of our freedom, the document itself, the man who wrote it, and any object associated with its composition have acquired a historical interest that has increased through the years.

The story of this desk, of its claim to a place in history, and of how it came to the National Museum is a fascinating sidelight on the history of the Declaration of Independence and its author.

Thomas Jefferson was identified with the aggressive, anti-British element in the Virginia Assembly from the beginning of his public service as a member of the House of Burgesses in 1769. He was a member of the committee that drew up the resolution creating the Virginia Committee of Correspondence, and he served also as member of that committee. In 1774 he was also a champion of the resolution to make the day on which the Boston Port Act was to go into effect, one of fasting and mourning. Jefferson was unable to attend the Virginia Convention of 1774, but he sent a paper, later published as "A Summary View of the Rights of British America," which outlined his point of view of the coming struggle, presenting the right of the Colonies as being derived from the laws of nature; it asserted that such allegiance as the colonists showed to the King was a matter of natural right of choice, and denied the British Government any parliamentary authority over the Colonies. The views embodied in the

paper were not adopted by the Convention, as its sentiments were regarded as too radical by many of the delegates.

Jefferson was next selected as an alternate delegate to the Continental Congress meeting in Philadelphia, and when a vacancy occurred in the Virginia delegation he took his seat in that body for the first time in June 1775. He quickly became a prominent member of the Convention by reason of his earnestness, his capacity for hard work, and his facility for expressing in writing his own ideas and the ideas of others. Here, too, Jefferson became identified with the more radical element of the Congress, and during that first year, some of the papers he submitted were rejected by the Congress as being too anti-British in tone to be acceptable while there was still a chance of reconciliation with Great Britain.

Following the resolution for independence, which was introduced in Congress in June 1776 by Richard Henry Lee of Virginia, Thomas Jefferson was appointed one of the committee of five to draw up a declaration of independence. It was felt by the Congress that the bare resolution of independence was not sufficient. The reasons for the resolution must be set forth explicitly and must be presented in a manner that would not only convince Americans but also would inspire them to fight for that independence and maintain it. Moreover, the facts must be explained to the other nations of the world, as the good opinion of other countries might prove essential to the success of the cause of American independence.

Thomas Jefferson, already well known for the forcefulness of his pen, was selected by the committee of five to draft the declaration. The document that he wrote, though changed and corrected first by members of the committee and later by the Congress as a whole, remains essentially Jefferson's own. It eloquently expresses his ideas of the rights and grievances of the American Colonies, and his passionate sincerity rings convincingly today.

In 1775, when Thomas Jefferson first went to Philadelphia to attend the Continental Congress, he lived for a short time at the home of Benjamin Randolph, one of the most famous of the Philadelphia cabinetmakers.

Mr. Randolph had been an active supporter of the patriots in Philadelphia for several years; and undoubtedly his interest in the cause of independence and in the Congress then meeting in Philadelphia persuaded him to open his home to Thomas Jefferson for temporary lodging. Also, he might have been influenced by a possible relationship between himself and Jefferson, whose mother was Jane Randolph.

Again, in May 1776, when Jefferson arrived for the Second Continental Congress, he stayed at Randolph's home for several weeks. The account book of Thomas Jefferson for the year 1776 shows a pay-

ment of 40/ to Benjamin Randolph on May 27 for 8 days' lodging.[1] Sometime during this period of association between Randolph and Jefferson, either in 1775 or 1776, Benjamin Randolph made for Thomas Jefferson a small, portable writing desk of mahogany inlaid with a narrow band of satinwood around the drawer and the keyhole.

It was on this writing desk that Thomas Jefferson, according to his own statement, wrote the draft of the Declaration of Independence, working in his second-floor parlor room in the boardinghouse in Philadelphia in which he was living at that time.

Convenient in size and weight for carrying, the desk was made according to Jefferson's own design. It is approximately 9¾ inches long by 14⅜ inches wide by 3¼ inches deep, with a folding writing board hinged to the top which opens to give a surface 19¾ inches long. This writing board is lined with green baize. The desk contains a drawer 1¾ inches deep, which is divided into sections for holding paper and pens, and a compartment containing a small hand-blown glass inkwell.

From 1776 on, the desk must have been an indispensable part of Thomas Jefferson's writing equipment. Its convenient size would have made it an ideal traveling companion while he was abroad in the service of his country and also during his terms of public office with the Federal Government in New York, Philadelphia, and Washington. It is probably true that much of the extensive correspondence that Jefferson carried on during his long and active life was written on this desk.

In 1825, when Ellen Randolph, oldest child of Jefferson's beloved daughter and companion, Martha Jefferson Randolph, and a grandchild to whom Jefferson was most devoted, married Joseph Coolidge, Jr., of Boston, she was given for her new home in Boston a handsome inlaid desk made by John Hemmings, skillful Negro carpenter at Monticello. The desk was shipped to Boston in a packet sailing from Richmond and was lost at sea.[2] As a consolation Thomas Jefferson determined to send for a substitute the writing desk on which he had drafted the Declaration of Independence. He wrote to Ellen Coolidge from Monticello on November 14, 1825:[3]

> We condole with you on the loss of your baggage, (especially) that beautiful writing desk . . . it has occurred to me, however, that I can replace it, not indeed to you, but to Mr. Coolidge, by a substitute not claiming the same value from its decorations, but from the part it has borne in our history and the events with which it is associated.
>
> I received a letter from a friend in Philadelphia lately, asking for information of the house, and room of the house there, in which the Declaration of Independence was written, with a view to future celebrations of the 4th of July

[1] In the Manuscripts Division of the Library of Congress.
[2] Kimball, Marie, The furnishings of Monticello, pt. I. Antiques Mag., November 1927.
[3] Massachusetts Hist. Soc., Proc., vol. 12, ser. 2, pp. 271, 272, 1899, Boston.

in it; another enquiring whether a paper given to the Philosophical Society there, as a rough draught of that Declaration was genuinely so. A society is formed there lately for an annual celebration of the advent of Penn to that place. It was held in his ancient mansion, and the chair in which he actually sate when at his writing table was presented by the lady owning it, and it was occupied by the president of the celebration. Two other chairs were given them made of the elm under the shade of which Penn had made his first treaty with the Indians. If these things acquire a superstitious value because of their connection with particular persons, surely a connection with the greater Charter of our Independence may give a value to what has been associated with that; and such was the idea of the enquirers after the room in which it was written. Now I happen still to possess the writing box on which it was written. It was made from a drawing of my own by Ben Randall, a cabinet-maker in whose house I took my first lodgings on my arrival in Philadelphia in May, 1777,[4] and I have used it ever since. It claims no merit of particular beauty. It is plain, neat, convenient, and, asking no more room on the writing table than a moderate 4to volume, it yet displays itself sufficiently for any writing. Mr. Coolidge must do me the favor of accepting this. Its imaginary value will increase with years, and if he lives to my age, or another half-century, he may see it carried in the procession of our nation's birthday, as the relics of the Saints are in those of the Church. I will send it thro' Col. Peyton, and hope with better fortune than that for which it is to be the substitute. . . .

And on the desk itself, under the writing board, Jefferson affixed the following affidavit in his own handwriting:

Th. Jefferson gives this Writing Desk to Joseph Coolidge, junr. as a memorial of affection. It was made from a drawing of his own, by Ben Randall, cabinet maker of Philadelphia, with whom he first lodged on his arrival in that city in May, 1776 and is the identical one on which he wrote the Declaration of Independence. Politics as well as Religion has its superstitions, these, gaining strength with time, may, one day, give imaginary value to this relic, for its association with the birth of the Great Charter of our Independence, Monticello. Nov. 18, 1825.

The desk arrived in Boston safely, and Joseph Coolidge, Jr., acknowledged its receipt as follows on February 27, 1826:

I have deferred too long to mention the valued Memorial which you sent me: several times, however, have I written to thank you for "the Desk," and as often destroyed my letter least that, which was but the sincere expression of gratified feeling, should seem to you like exaggeration: but I was truly sensible of the kindness of the gift, and the compliment it conveyed: the desk arrived safely, furnished with a precious document which adds very greatly to its value; for the same hand which, half a century ago, traced upon it the words which have gone abroad upon the earth, now attests its authenticity, and consignes it to myself. When I think of this desk, "in connection with the great charter of our independence," I feel a sentiment almost of awe, and approach it with respect; but when I remember that it has served you fifty years, been the faithful depository of your cherished thoughts; that upon it have been written your letters to illustrious and excellent men, your plans for the advancement of civil and religious liberty, and of Art and Science; that it has, in fact, been the companion,

[4] Note the mistake Jefferson made in the date here. He gives the correct date in the manuscript note attached to the desk. Also, after a lapse of some years, Jefferson here refers to the cabinetmaker as Randall instead of Randolph.

of your studies, and the instrument of diffusing their results; that it has been the witness of a philosophy which calumny could not subdue, and of an enthusiasm which eighty winters have not chilled, I would fain consider it as no longer inanimate, and mute, but as something to be interrogated, and caressed.[5]

The desk remained in the Coolidge family for the next 50 years, and, true to Jefferson's prophecy that the relic would become valuable for its association, it was held in veneration not only by the Coolidge family but by the whole city of Boston. The desk was exhibited at a meeting of the Massachusetts Historical Society in 1857. It received even greater honor and veneration in 1876 when it was exhibited at the Centennial Exhibition being held in Boston in that year.

The Coolidge family realized that an object of such historical importance should not remain in private hands, and on April 14, 1880, Robert C. Winthrop of Boston, prominent statesman and orator and president of the Massachusetts Historical Society, wrote to President Rutherford B. Hayes about the desk:[6]

I have been privileged to bring with me from Boston, as a present to the United States, a very pretty historical relic. It is the little desk on which Mr. Jefferson wrote the original draught of the Declaration of Independence.

This desk was given by Mr. Jefferson himself to my friend, the late Joseph Coolidge, of Boston, at the time of his marriage to Jefferson's granddaughter, Miss Randolph; and it bears an autograph inscription of singular interest, written by the illustrious author of the Declaration in the very last year of his life.

On the recent death of Mr. Coolidge, whose wife had died a year or two previously, the desk became the property of their children, Mr. J. Randolph Coolidge, Dr. Algernon Coolidge, Mr. Thomas Jefferson Coolidge, and Mrs. Ellen Dwight—who now desire to offer it to the United States. . . .

They have done me the honor to make me the medium of this distinguished gift, and I ask permission to place it in the hands of the Chief Magistrate of the nation in their name and at their request.

President Hayes informed Congress of this gift to the Nation in a letter written on April 22, 1880, giving the history of the desk and advising them of the offer made by the Coolidge heirs.

The desk was thereupon accepted by joint resolution of both Houses of Congress,[7] approved on April 28, 1880, and by order of the Congress a copy of the Resolution of Thanks signed by the President of the Senate and the Speaker of the House of Representatives was transmitted to the donors.[8]

The desk was first placed in the custody of the Department of State, and for a number of years it was exhibited there with the original document of the Declaration of Independence.

In the meantime the United States National Museum, under the administration of the Smithsonian Institution, had grown from a

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[5] Extract from letter in Massachusetts Historical Society.
[6] Journal of the House of Representatives, 46th Cong., 2d sess., vol. 1879–90, p. 1086.
[7] Ibid., p. 1085.
[8] Ibid., p. 1088.

"cabinet of curiosities" to become the storehouse of the Nation's treasures. Cognizant of the fact that the National Museum had been officially designated as the Government repository for objects of historical importance, many Government agencies deposited in the Museum specimens which they did not have the facilities to preserve or exhibit.

In 1921 the Department of State, on Executive order, turned the original document of the Declaration of Independence over to the Library of Congress, and a few months later the Declaration of Independence Desk was sent to the National Museum.

During the years in which this desk has been on display at the National Museum, a number of replicas have come to light. All these reproductions seem to date from the centennial year, and it is assumed that they were made at that time with the consent of the owners of the desk. In construction they are exact copies of the original desk. Each replica also bears under the writing surface a facsimile of Jefferson's note to Joseph Coolidge, Jr., so perfectly done that it seems identical with the note attached to the original desk. Endless confusion has resulted from these replicas as they are inherited by descendants of the persons who first acquired the desks, or as they pass into the hands of others who have no knowledge of the fact that such reproductions had been made.

The most famous of these replicas received a great deal of publicity in 1925 when newspapers in America carried a front-page story stating that the desk on which Thomas Jefferson wrote the Declaration of Independence was then in the Bismarck Museum in Berlin, Germany. The story continued that the desk had been given to Prince Otto von Bismarck, on the occasion of his eighty-first birthday, by Thomas Jefferson Coolidge, great-grandson of Thomas Jefferson and son of Joseph Coolidge, Jr., who was the United States Minister to France from 1892 to 1896. Public sentiment demanded the return of the desk to the United States, and it was reported that the Bismarck family could at last be persuaded to part with the desk for a price. Fortunately, when this stage of the transaction was reached, a Jefferson expert advised the authorities that the original desk had been given to the United States Government by the Coolidge heirs in 1880.[9]

It is interesting to note, in view of this newspaper story, that in 1899, when Thomas Jefferson Coolidge presented the Jefferson papers to the Massachusetts Historical Society, he stated:[10]

> Several copies were made of it [the desk], and I was amused in reading an essay by Smalley, that on visiting Bismarck he found a desk there which the statesman thought was the original. Undoubtedly one of the copies had been presented or sold to the great German.

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[9] Kimball, Marie, op. cit.

[10] Massachusetts Historical Society, op. cit.

It does not seem from this statement that Thomas Jefferson Coolidge could possibly have given Bismarck the desk in 1896, only 3 years before, and not have remembered it at this time.

The publicity accorded the Bismarck desk brought to light another replica owned by a doctor in Berryville, Va., who had also assumed that he had the original desk. He said it had been presented to him by a patient in Alexandria, Va., and that the desk had been in the possession of the patient's family for a great many years. Comparison of this desk with the desk in the National Museum revealed that the drawer of the Berryville desk opened on the opposite side from the drawer in the original desk. The writing surface of the replica was covered with red felt rather than green baize.

A third replica is today at Monticello, Thomas Jefferson's home at Charlottesville, Va. Fiske Kimball, chairman of the Restoration Committee of the Thomas Jefferson Memorial Foundation, says that the desk at Monticello came many years ago, at the time Stuart Gibboney was president of the foundation. They do not have any record today of the source of the replica.

The Smithsonian Institution recently had an opportunity to examine one of these replicas closely when it was brought to the National Museum for comparison with the original desk. At first glance the replica seemed to be identical with the Museum desk. Closer inspection revealed that the wood of the original was slightly darker in appearance. The metal fittings of the replica, such as the hinges, the screws in the hinges, and the lock did not match exactly the handmade fittings of the Museum desk. To all appearances the manuscript notes on the two desks were identical. The Library of Congress Division of Manuscripts was not able to explain the process by which these notes had been made without removing the note from one of the replicas. This last desk had been obtained from an old New England family, and, again, it had been assumed by the family that the desk was the original Declaration of Independence desk.

Making souvenir relics of the founders of our country was a well-established practice throughout the nineteenth century. It was especially popular about the time of the centennial celebration of the signing of the Declaration of Independence in 1876, when millions of souvenirs were copied from all types of articles that had historical associations. In view of the accuracy with which the original desk is copied, it is reasonable to believe that the Coolidge family had reproductions of the desk made before it was turned over to the President of the United States in 1880. It is even possible that each of the four donors had copies of the desk made and that more of these replicas are in existence than we suppose. It is hoped that the continuing research by the staff of the National Museum will eventually uncover

the exact facts of the circumstances under which the replicas were made.

The original desk was part of a special exhibition set up at the Jefferson Memorial in Washington, D. C., in 1943, in honor of the bicentennial anniversary of Jefferson's birth. It was exhibited with Jefferson's own draft of the Declaration of Independence at the foot of the heroic Statue of Jefferson which stands in the rotunda of the Memorial.

During World War II the desk was evacuated from Washington to protected storage with other irreplaceable specimens from the collections of the Smithsonian Institution.

On its return to the Museum, the desk was given a place of honor in the North Hall of the Arts and Industries Building of the United States National Museum. There it is exhibited in a special case in the main aisle of the hall where it serves as an inspiration to the many thousands of persons who visit the Smithsonian Institution annually.

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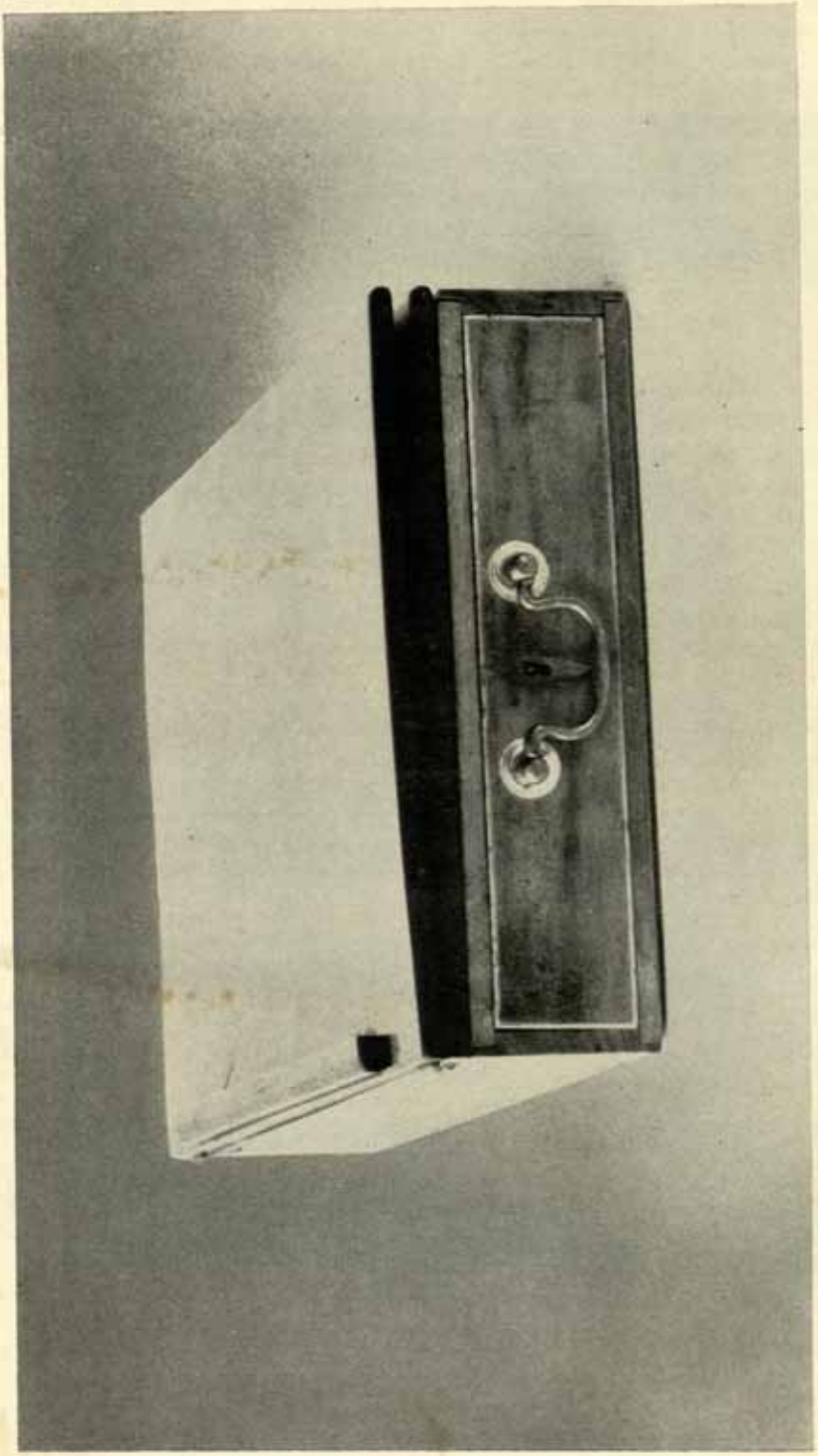
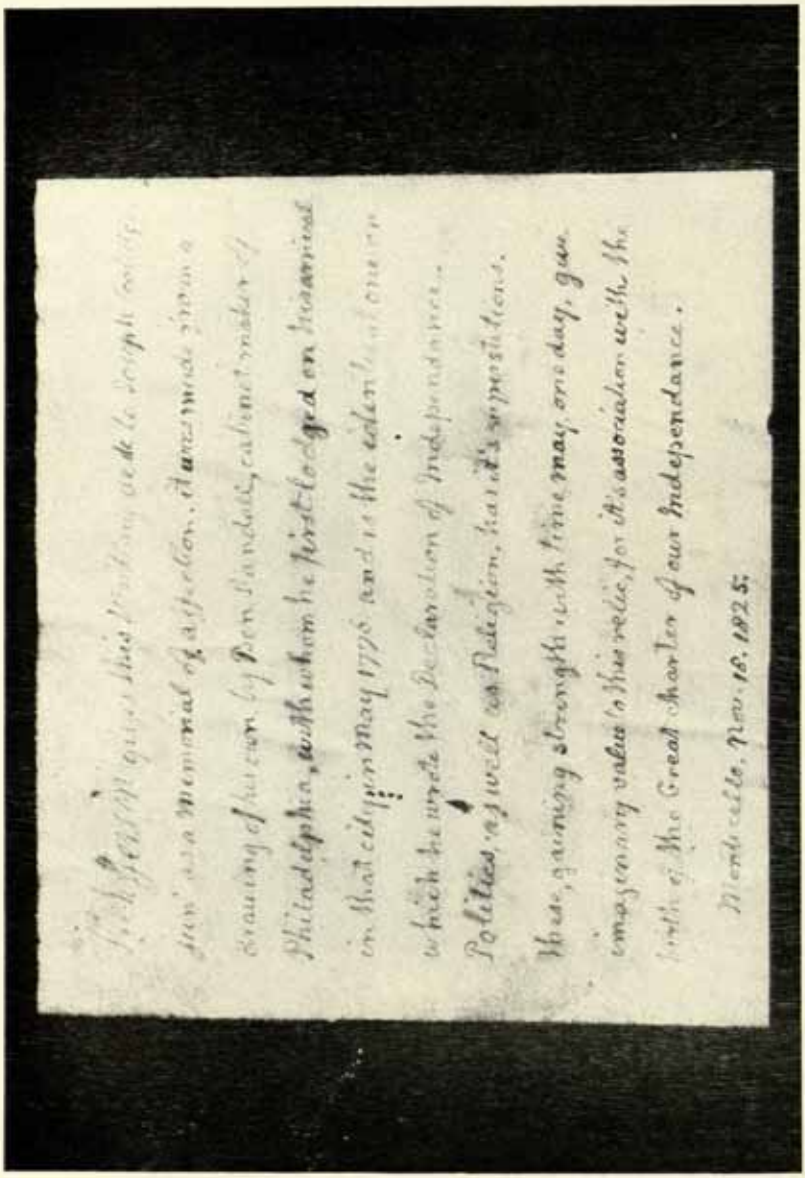
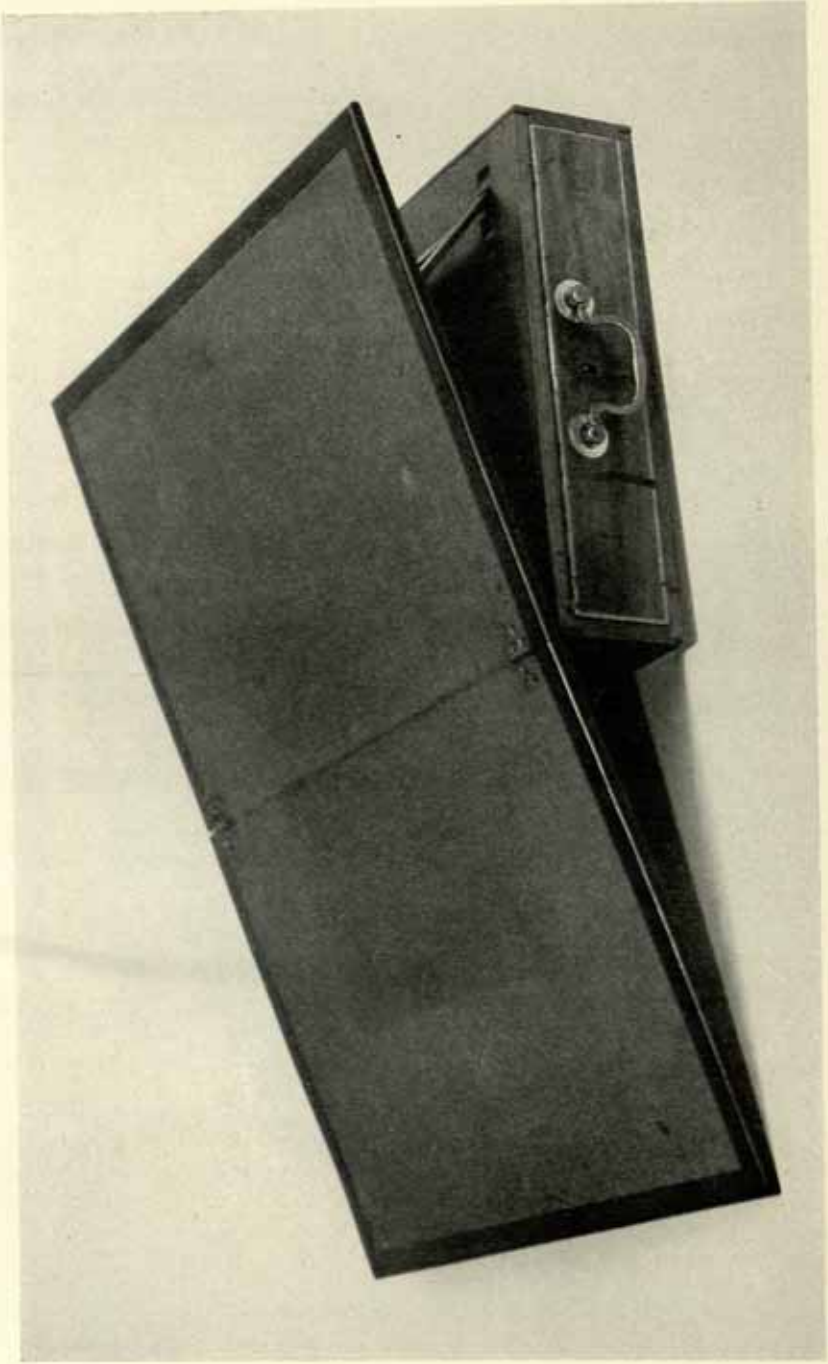


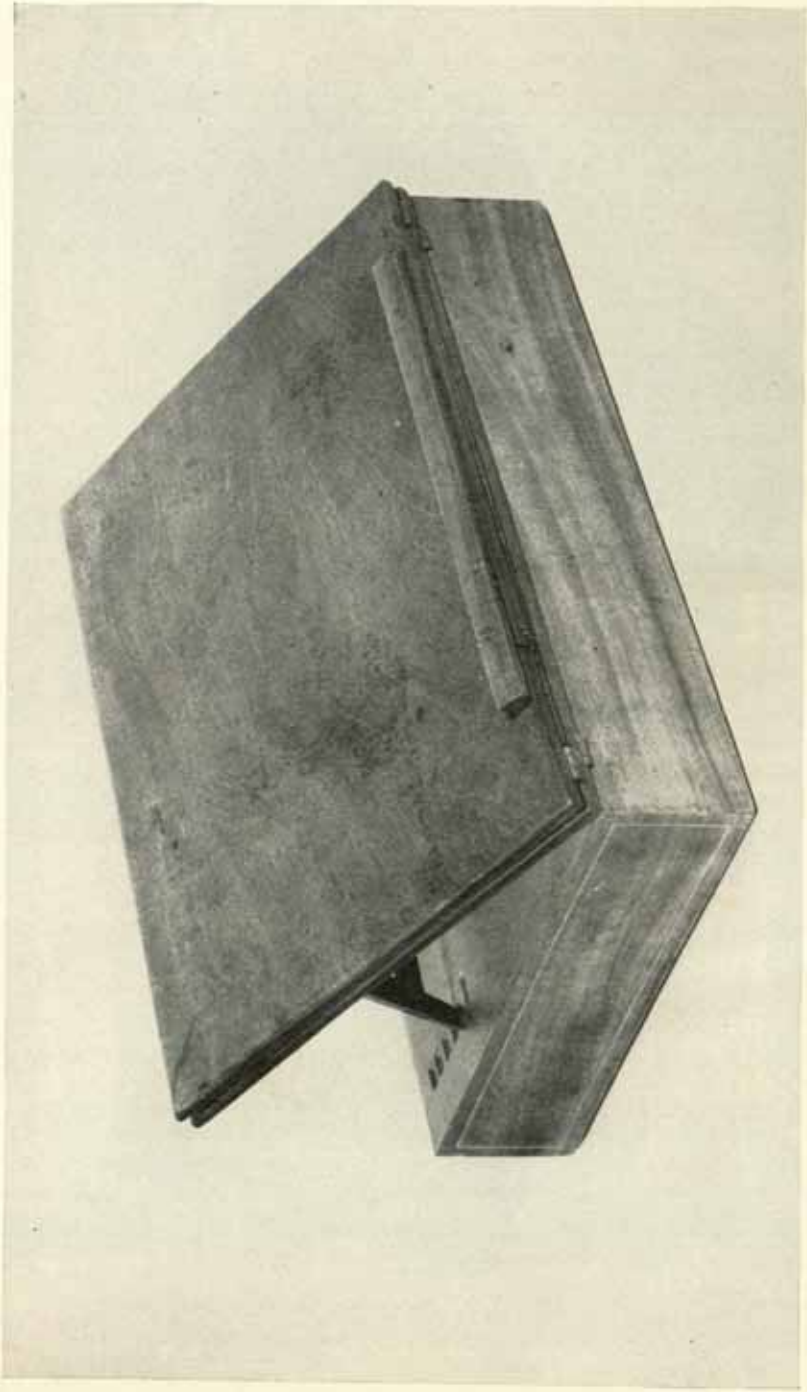
JEFFERSON'S PORTABLE WRITING DESK FOLDED FOR CARRYING.



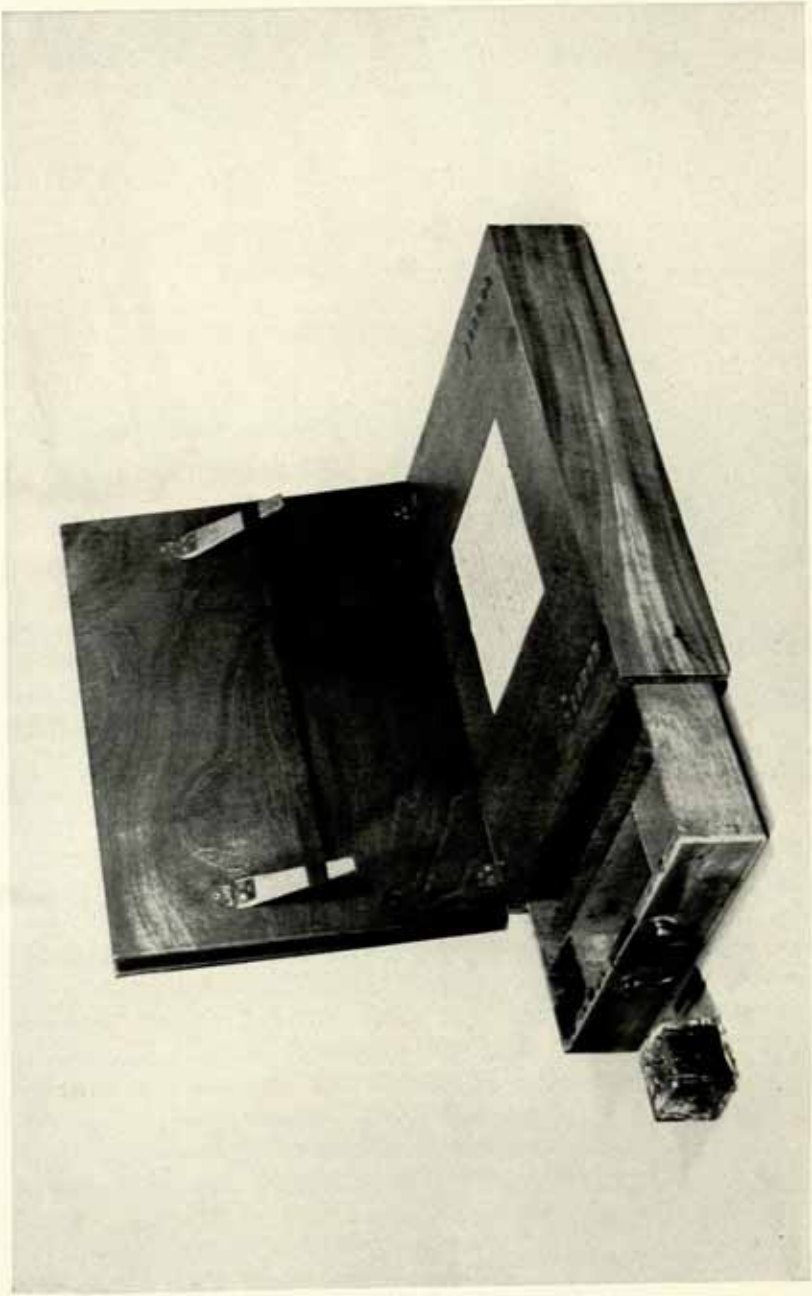
NOTE IN HANDWRITING OF THOMAS JEFFERSON, ATTACHED TO THE DESK AND ATTESTING ITS AUTHENTICITY.



DESK OPENED TO FORM WRITING BOARD.



DESK IN POSITION AS A SUPPORT FOR READING.



DESK WITH DRAWER OPEN AND WITH TOP UP SHOWING THE POSITION OF THE NOTE ATTACHED.

Charles Bird King, Painter of Indian Visitors to the Nation's Capital

By John C. Ewers

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U. S. National Museum

[With 8 plates]

Among the many artists who depicted the North American Indians in the days before the development of photography, Charles Bird King enjoyed a unique and rather paradoxical distinction. King never set foot on American soil west of the Mississippi River. Nevertheless, he was the first white man known to record in oils the physical appearances and picturesque dress costumes of many Indian leaders of the Great Plains tribes. It is doubtful if King ever saw an Indian village. Yet he painted from life portraits of Indian leaders from more than a score of tribes. Except for those intrepid paintbrush pioneers, George Catlin and John Mix Stanley, who traveled extensively amid the dangers and inconveniences of the Indian country, no other artist of the precamera period painted a larger or more varied series of Indian portraits.

Charles Bird King was born in Newport, R. I., in 1785. He showed an early interest in painting that was encouraged by some of the best artists of his day. Samuel King of Newport, instructor of Allston and Malbone, was his first teacher. Later (probably from 1800 to 1805) he studied under Edward Savage in New York. Thereafter, he spent 7 years in London, where he roomed with Thomas Sully and had the advantage of Benjamin West's instruction. In 1812 he returned to this country. For 4 years he worked at his easel in Philadelphia with little success. In 1816 he moved to Washington, D. C. Here he remained until his death on March 18, 1862.

Here, at the seat of government, King achieved a reputation as a painter of portraits of socially and politically prominent persons of his time. Among his sitters were John C. Calhoun, Henry Clay, and John Howard Payne, famed writer of "Home Sweet Home." King built a studio and gallery on the east side of Twelfth Street between

E and F Streets NW. Probably, many, if not all, of his Indian portraits were executed there.

The first Indians known to have been painted by King were members of a delegation of 16 leaders from the Pawnee, Omaha, Kansa, Oto, and Missouri Tribes of the Great Plains who arrived in Washington on November 29, 1821, in care of Maj. Benjamin O'Fallon, United States Indian agent. *The National Intelligencer* of November 30, 1821, heralded their arrival: "Their object is to visit their Great Father, and learn something of that civilization of which they have hitherto remained in total ignorance. They are from the most remote tribes with which we have intercourse, and they are believed to be the first of those tribes that have ever been in the midst of the settlements . . . These red men of the forest who now visit us are completely in a state of nature." President Monroe entertained these red-skinned visitors at the White House. Everywhere they went in the Nation's Capital they aroused the curiosity and interest of onlookers. It was probably Thomas L. McKenney, United States Superintendent of Indian Trade, who encouraged King to paint portraits of several members of this delegation. He is known to have made individual portraits of at least six of them: the Oto chiefs Choncape and Shaumonekusse; the latter's pretty 18-year-old wife, the Eagle of Delight; and three Pawnee leaders, Sharitarish (Wicked Chief), Peskelechaco (pl. 2, left), and Petalesharro (Generous Chief). King's portrait of Petalesharro is the earliest known representation of a Plains Indian wearing the picturesque feathered bonnet (pl. 2, right). His painting of The Eagle of Delight may be the earliest oil portrait of a Plains Indian woman (pl. 3). Probably these were among the Indian portraits that hung on the walls of McKenney's office in Georgetown.

King also undertook a group portrait of five unnamed members of this delegation simply titled "Young Omawhaw, War Eagle, Little Missouri, and Pawnees," reproduced as plate 4. This original oil painting was presented to the Smithsonian Institution in 1946 by Miss Helen Barlow of London, England. It is noteworthy that these paintings were executed a full decade before George Catlin traveled west to paint these and other "wild tribes" in their home territories.

When Thomas L. McKenney was placed in charge of the Bureau of Indian Affairs under the War Department in March 1824, he took vigorous steps to enlarge the Government collection of Indian portraits. Secretary of War James Barbour in 1832 credited McKenney with conceiving "the expediency of preserving the likenesses of some of the most distinguished among this most extraordinary race of people. Believing, as I did, that this race was about to become extinct, and that a faithful resemblance of the most remarkable among them would be full of interest in aftertimes, I cordially approved of the

measure. This duty was assigned to Mr. King, of Washington, an artist of acknowledged reputation; he executed it with fidelity and success, by producing the most exact resemblances, including the costume of each." Thomas L. McKenney stated (1828) that King was paid for his Indian portraits at the rate of $20 for "each head and about half the body." (Hodge, 1916, pp. 190–191.)

There was no dearth of Indian delegations trekking to Washington during the decades of the 1820's and 1830's. Some groups of Indians from beyond the Mississippi were brought to Washington primarily to impress tribal leaders with the numbers of Whites, with the power and good intentions of the United States Government and to encourage Indian loyalty and good behavior. Others came to do business with the Government in matters involving cessions of Indian lands. In 1825, President Monroe recommended to the Congress a plan for the resettlement of Indian tribes then living east of the Mississippi on lands west of that great river, in order to permit the expansion of white settlement in the South and Midwest. In those days the United States recognized the Indian tribes as independent nations. To effect their removal from their traditional agricultural lands and hunting grounds, legal treaties had to be negotiated. Other treaties had to be made with tribes of Plains Indians to secure portions of their hunting grounds upon which the eastern Indians could be resettled. These treaties required prolonged and complicated negotiations between representatives of the Government and leaders of the Indian tribes involved. During the years 1824–38 no fewer than 18 Indian treaties were signed in the city of Washington. Each ceremony was attended by a delegation of chiefs and headmen of the tribe or tribes concerned. Other tribes sent delegations to Washington to discuss land cessions which were later formally negotiated by treaties signed in the field.

King painted portraits of many members of these delegations when they came to Washington during the periods 1821–22 and 1824–37. During the years 1826–27, when Indian visitors to the capital were few, King copied for the Government collection at least 26 portraits of Indians of the western Great Lakes (most of them Ojibwa), executed in the field by the less able artist, James Otto Lewis. In 1837, when the number of Indian visitors to Washington was unusually large, George Cooke, friend and pupil of King, was called in to paint some of their portraits. In the 16-year period 1821–37 King painted from life Cherokee, Choctaw, Creek, Seminole, and Uchi Indian leaders from the South; Ojibwa, Potawatomi, Menomini, Sac, Fox, and Seneca from the Great Lakes region; Iowa, Kansa, Omaha, Oto, and Pawnee from the central Great Plains; Eastern, Yankton, and Yanktonai Dakota, and a lone Assiniboin from the far Northwest.

Many of those Indians were chiefs of prominence in the regional history of our country. Others, such as Keokuk, Black-Hawk, and Red Jacket, gained national prominence and were painted by white artists other than King during their lives. Of outstanding historical significance is King's portrait of Pushmatha, the great Choctaw leader and consistent friend of the Whites. (See pl. 5, left.) Pushmataha sat for King on his visit to Washington in 1824. He died in Washington on December 24 in that year, and was buried in the Congressional Cemetery.

Nor were King's Indian paintings limited to likenesses of official delegations. He also portrayed lone Indians who appeared in Washington for other and varied reasons. There was Tshusick, clever and beautiful Ojibwa adventuress, who reached Washington (1826) in rags with a sad story on her lips, remained to capture the sympathies and admiration of official and social Washington through her wit and charm, and left town loaded with presents before stories of her previous successes in other white communities reached the capital. There was also Mohongo, attractive widow of an Osage chief. She had been a member of a party of Osage Indians taken to Europe by an enterprising white man in 1827 to be exhibited as representatives of the wild tribes of America. Mohongo's husband died at sea on the return journey in 1830. Disillusioned and without funds she appealed to the Government to return her to her own people.

The great majority of King's original Indian portraits were executed for the Government collection. Frances Trollope, that indefatigable recorder of American customs, saw this collection in Washington in 1832, and wrote: "The bureau for Indian affairs contains a room of great interest; the walls are entirely covered with original portraits of all the chiefs who from time to time, have come to negotiate with the great father, as they call the President. These portraits are by Mr. King, and it cannot be doubted, are excellent likenesses, as are all the portraits I have ever seen from the hands of that gentleman." (Trollope, 1832, vol. 1, pp. 314–315.)

This collection was transferred to the National Institute in 1841 and exhibited in the old Patent Office building. Curator John Varden counted "One Hundred and Thirty Indian Portraits Taken by Charles King and Others" in this collection September 1, 1852. In 1858 the collection was transferred to the Smithsonian Institution. *A Catalogue of Indian Paintings belonging to the Government Collection* in 1859 lists 147 items. Of this number 82 are attributed to Charles Bird King, 15 are attributed to other artists, while the names of the painters of the remaining portraits are not given. Some, possibly many, of the paintings in the last group should be attributed to King. (Rhees, 1859, pp. 55–58.) The collection remained on

exhibition in the art gallery of the Smithsonian building until most of the art collection was destroyed by fire, January 15, 1865.

It is fortunate that Charles Bird King painted replicas of a number of the Indian portraits he had created for the Government collection. Some subjects he copied more than once. Two replicas of The Eagle of Delight, for example, have been preserved. Careful study of these portraits (pl. 3) indicates that the two paintings differ somewhat in detail. This suggests that King's replicas may not be meticulous duplicates of the originals.

King's originals also were copied by other artists. In the early 1830's Henry Inman copied in oil a majority of the Indian paintings in the Government collection. These copies are now preserved in the Peabody Museum of Harvard University. From Inman's copies colored lithographs were prepared for McKenney and Hall's "History of the Indian Tribes of North America," published by Key and Biddle of Philadelphia, 1836–44. These large, handsome, 19¼- by 13¼-inch plates are now collector's items. In the form of these lithographic reproductions many of King's Indian portraits have survived.

Contemporaries of Charles Bird King made no rash claims for his artistic genius. Nevertheless, they had respect for his technical skill. Thomas Sully, who roomed with King in London, termed him "the most industrious person I ever met" and the possessor of "much mechanical skill." Dunlap decried King's use of a mechanical gadget to measure the proportions of his sitter's features and appendages. Tuckerman thought King's paintings were "not remarkable for artistic superiority, but often curious and valuable likenesses, especially the Indian portraits." (Dunlap, 1834, vol. 2, pp. 261–262; Tuckerman, 1867, p. 68.)

Since many of Charles Bird King's portraits of prominent Indians are the only known representations of the physical appearance of those individuals, it is important that we try to appraise his ability to execute true likenesses of his Indian sitters. Perhaps we should not give too much weight to the opinions of his contemporaries regarding this matter, for it is unlikely that the most competent critics of his time had opportunities to compare King's portraits with the features of the living Indians who posed for him. Certainly some of King's Indians appear to display rather marked Caucasian features. In some cases this characteristic may properly be attributed to the fact that the Indians themselves were mixed-bloods. In other cases that possibility appears remote. For example, King's portrait titled "Assiniboin Indian, from the Most Remote Tribe That Had ever Visited Washington previous to 1938," is almost certainly intended to be a likeness of The Light, the Assiniboin who came to Washington in 1831–32, whose tragic experiences resulting from that visit were entertainingly described by George Catlin and other contemporaries.

(Catlin, 1841, vol. 2, pp. 194–200.) Catlin executed a portrait of this man in St. Louis in the fall of 1831 that bears little resemblance to King's portrait of the same man painted only a few months later. In King's front view (pl. 7, left) this putative full-blood Indian looks like a white man, while in Catlin's three-quarter view The Light's Mongoloid characters are pronounced (pl. 7, right).

On the other hand, King's three-quarter-view portrait of the Iowa Chief, No Heart, painted in 1837 when the subject was about 40 years of age, compares very favorably with the photographic likeness of that Indian taken some years later, and probably not long before No Heart's death in 1862. When we make allowances for changes in No Heart's features due to aging, we certainly can observe a strong resemblance between the Indian in King's portrait and the one in the photograph. (See pl. 8.)

These comparisons suggest that King achieved varying degrees of success in portraying the likenesses of his sitters. Perhaps he was most successful in profile and three-quarter-view portraits. He was not uniformly successful in the more difficult front-view poses.

A single extant example of King's attempt at an Indian subject other than a portrait is his "Indian Girl at Her Toilet" in the collection of the Redwood Library and Athenaeum, Newport, R. I. (pl. 5, right). In this sentimental, imaginary canvas is exhibited the work of an artist who had seen and painted many individual Indians in his Washington studio, but who remained ignorant of the cultural background of these people.

A CHECKLIST OF INDIAN PORTRAITS ATTRIBUTED TO CHARLES BIRD KING

Listed below are 105 Indian portraits and 1 romantic Indian scene attributed to Charles Bird King. The originals of 89 portraits were in the National Collection in 1859. (Rhees, 1859.) With the possible exception of three portraits now in the U. S. National Museum, these originals were destroyed in the Smithsonian Institution fire of 1865. We may assume that other extant versions of subjects in the old National Collection are replicas.

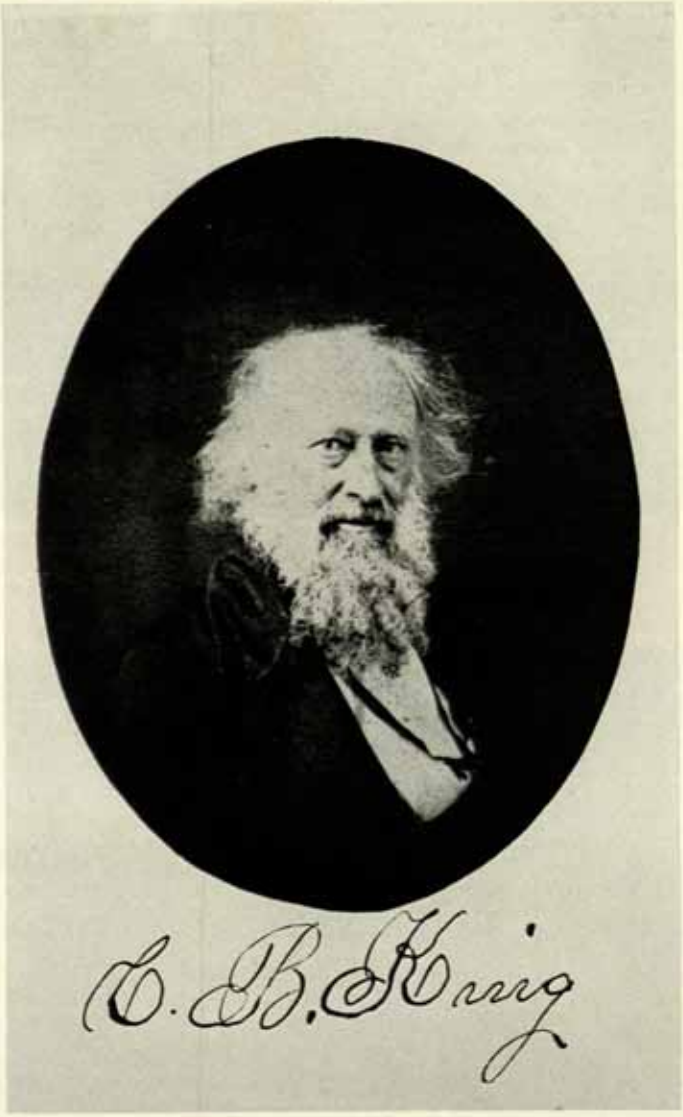
Of the extant collections, the largest is the series of 21 paintings given or bequeathed by King to the Redwood Library and Athenaeum in his home town of Newport, R. I. Nine oil portraits (seven of them replicas) now in the Nationalmuseet, Copenhagen, Denmark, are illustrated (three in color) in Birket-Smith (1942). These paintings were presented to Maj. Gen. Peter von Scholten, Governor General of the Danish West Indies, probably by President Jackson in 1831. Six King portraits belonging to the Thomas Gilcrease Foundation of Tulsa, Okla., were exhibited there in 1949. In addition, there are 4 portraits in the United States National Museum, 2 in the University

of Pennsylvania Museum, Philadelphia, and 2 (1 a miniature) in the Fine Arts Gallery of Yale University, New Haven, Conn. It is very possible that there are other Indian portraits by Charles Bird King in public or private collections not known to the writer.

Tribe	Name	Date	Reference
Assiniboin	The Light	1832	Oil: Redwood Library.
Cherokee	John Ridge	1826?	Oil: No. 69 in S. I., 1859. Lith: McK. and H.,[1] vol. 2, p. 181.
Do	Tugoniscoteyeh (Black Fox)	1828	Oil: No. 9 in S. I., 1859.
Choctaw	Pushmataha	1824	Oils: No. 42 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 1, p. 31.
Creek	Apauly Tustennuggee	1825	Oil: No. 80 in S. I., 1859. Lith: McK. and H., vol. 3, p. 184.
Do	Coosa Tustennuggee	1825	Oil: No. 51 in S. I., 1859.
Do	Ledagie	1835	Oil: No. 138 in S. I., 1859. Lith: McK. and H., vol. 3, p. 72.
Do	Menawa	1826	Oil: No. 23 in S. I., 1859. Lith: McK. and H., vol. 2, p. 97.
Do	Mistippee, son of Yoholo Micco.	1826	Oils: No. 24 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 2, p. 19.
Do	Nahetluchopie (Little Doctor)	1825	Oil: No. 50 in S. I., 1859. Lith: McK. and H., vol. 3, p. 88.
Do	Oche Finceco (Charles Connelo).	1825	Oil: No. 124 in S. I., 1859. Lith: McK. and H., vol. 3, p. 56.
Do	Opothle Yoholo	1825	Oil: No. 53 in S. I., 1859. Lith: McK. and H., vol. 2, p. 7.
Do	Selocta	1825	Oil: No. 70 in S. I., 1859. Lith: McK. and H., vol. 2, p. 193.
Do	Tuskiehu Tustennuggee (Little Prince).	1825	Oil: No. 71 in S. I., 1859.
Do	Yoholo Micco	1826	Oil: No. 27 in S. I., 1859. Lith: McK. and H., vol. 2, p. 17.
Iowa	Mahaskah (White Cloud)	1824	Oil: Gilcrease Foundation. Lith: McK. and H., vol. 1, p. 141.
Do	Mauchcoomaim	1826	Oil: King after Lewis—No. 136 in S. I., 1859.
Do	Moanahonga (Great Walker)	1824	Oils: No. 88 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 1, p. 157.
Do	Nacheninga or Notchimine (No Heart).	1837	Oils: No. 103 in S. I., 1859. U. S. National Museum. Lith: McK. and H., vol. 2, p. 59.
Do	Neomonni (Walking Rain)	1837	Oil: No. 101 in S. I., 1859. Lith: McK. and H., vol. 2, p. 81.
Do	Rantchewaime (Female Flying Pigeon).	1824	Oils: No. 97 in S. I., 1859. Redwood Library. Gilcrease Foundation. Lith: McK. and H., vol. 1, p. 147.
Do	Tahrohon (Plenty of Meat)	1837	Oil: No. 38 in S. I., 1859. Lith: McK. and H., vol. 2, p. 85.
Do	Watchemonne (The Orator)	1837	Oil: No. 46 in S. I., 1859. Lith: McK. and H., vol. 2, p. 89.
Do	Young Mahaskah	1837	Lith: McK. and H., vol. 1, p. 153.
Kansa	Monchousia (White Plume)	1821?	Oils: No. 91 in S. I., 1859. Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 3, p. 24.
Menomini	Amisquew (The Spoon)	1831	Oils: No. 82 in S. I., in 1859. Redwood Library. Lith: McK. and H., vol. 3, p. 96.
Do	Chanannoquot	1835	Oil: Redwood Library.

[1] McKenney and Hall.

Tribe	Name	Date	Reference
Missouri	Hawchekeongga (Kills the Osages).	1837	Oil: No. 15 in S. I., 1859.
Ojibwa	Ahacamegishca	1827	Oil: King after Lewis—No. 56 in S. I., 1859. Lith: McK. and H., vol. 1, p. 169.
Do	Attecure (Young Reindeer)	1827	Oil: King after Lewis—No. 54 in S. I., 1859.
Do	Caatousee (Creeping Out of the Water).	1827	Oil: King after Lewis—No. 115 in S. I., 1859. Lith: McK. and H., vol. 1, p. 97.
Do	Chippewa Chief	1827	Oil: King after Lewis—No. 18 in S. I., 1859.
Do	do	1827	Oil: King after Lewis—No. 29 in S. I., 1859.
Do	do	1827	Oil: King after Lewis—No. 83 in S. I., 1859.
Do	Chippewa Squaw and Child	1827	Oil: King after Lewis—No. 146 in S. I., 1859. Lith: McK. and H., vol. 1, p. 99.
Do	Corbamappa (Wet Mouth)	1827	Oil: King after Lewis—No. 109 in S. I., 1859.
Do	Esmeboin or Cosniboin	1827	Oils: King after Lewis—No. 112 in S. I., 1859. U. S. National Museum.
Do	Gadegewe (Spotted)	1835	Oil: No. 19 in S. I., 1859.
Do	Ianbeanu	1826	Oil: King after Lewis—No. 30 in S. I., 1859.
Do	Jackopa (The Six)	1827	Oils: King after Lewis— No. 72 in S. I., 1859. U. S. National Museum. Lith: McK. and H., vol. 3, p. 128.
Do	Kewadin (The North Wind)	1827	Oil: King after Lewis—No. 45 in S. I., 1859.
Do	Keemeone (Rain)	1827	Oil: No. 52 in S. I., 1859.
Do	Kitcheewabeshas (Good Martin).	1827	Oil: King after Lewis—U. of Penna. Museum.
Do	Mishshaquat (Clear Sky)	1827	Oil: King after Lewis—No. 3 in S. I., 1859.
Do	Naagarnep (Sits at the Head)	1827	Oil: King after Lewis—No. 21 in S. I., 1859.
Do	Notin (Wind)	------	Oil: No. 129 in S. I., 1859. Lith: McK. and H., vol. 3, p. 16.
Do	Ocangeewack	1827	Oil: King after Lewis—No. 122 in S. I., 1859.
Do	Ohyawamincekee (Yellow Thunder).	1827	Oil: King after Lewis—No. 55 in S. I., 1859. Lith: McK. and H., vol. 3, p. 166.
Do	Pashenine	1827	Oil: King after Lewis—No. 60 in S. I., 1859. Lith: McK. and H., vol. 3, p. 48.
Do	Peajuk	1827	Oil: King after Lewis—No. 4 in S. I., 1859.
Do	Tahusick	1827	Oil: No. 147 in S. I., 1859. Lith: McK. and H., vol. 1, p. 173.
Do	Weshcubb (The Sweet)	1827	Oil: King after Lewis—No. 47 in S. I., 1859. Lith: McK. and H., vol. 1, p. 59.
Omaha	Kihegamawsheshe (Brave Chief).	1837	Oil: No. 137 in S. I., 1859.
Osage	Mohongo	1830	Oil: No. 110 in S. I., 1859. Lith: McK. and H., vol. 1, p. 21.
Oto	Choncape	1821?	Oils: No. 94 in S. I., 1859. Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 1, p. 107.



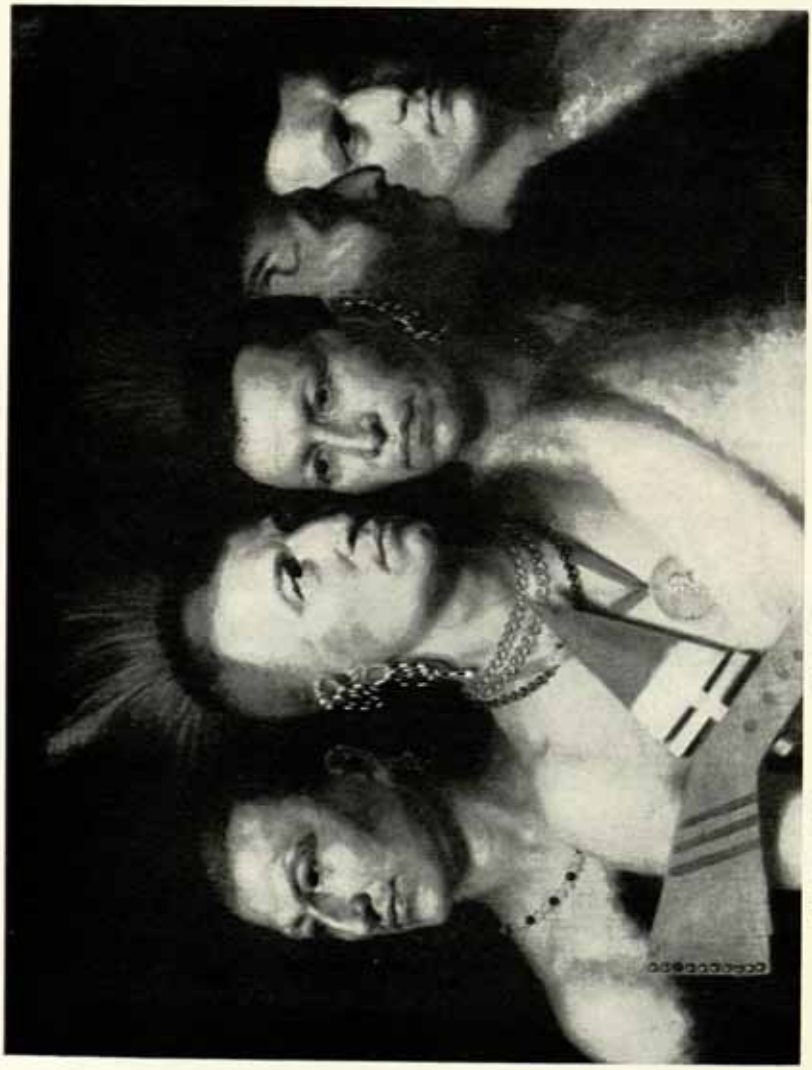
CHARLES BIRD KING, PAINTER OF INDIAN VISITORS TO THE NATION'S CAPITAL.
(Courtesy of Mrs. Walter Harvey.)

2. PETALESHARRO, GENEROUS CHIEF, LOUP PAWNEE.
(Courtesy of Nationalmuseet, Copenhagen.)

1. PESKELECHACO, REPUBLICAN PAWNEE.
(Courtesy of Redwood Library.)

TWO VERSIONS OF KING'S PORTRAIT OF THE EAGLE OF DELIGHT, OTO WOMAN.

1. Replica in the Redwood Library.
2. Replica in Nationalmuseet, Copenhagen.



"YOUNG OMAWHAW, WAR EAGLE, LITTLE MISSOURI, AND PAWNEES."
Painted by Charles Bird King, 1821. (U. S. National Museum.)

TWO KING PAINTINGS IN THE REDWOOD LIBRARY.

1. Pushmataha, Choctaw Chief. 2. "Indian Girl at Her Toilet."

TWO PORTRAITS COPIED BY KING FROM ORIGINALS BY JAMES OTTO LEWIS.

1. Eameboin, or Cosniboin, Ojibwa. 2. Jackopa, The Six, Ojibwa.

(U. S. National Museum.)

PORTRAITS OF THE LIGHT, AN ASSINIBOIN INDIAN WHO VISITED WASHINGTON IN 1832.

1. Portrait by King in Redwood Library. 2. Portrait by George Catlin in the U. S. National Museum.

PORTRAITS OF NACHENINGA, NO HEART, IOWA.

1. Portrait by King, 1837. (U. S. National Museum.) 2. Photograph taken prior to 1862. (Bureau of American Ethnology.)

Tribe	Name	Date	Reference
Oto	Shaumonekusse	1821	Oils: No. 130 in S. I., 1859. Redwood Library. Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 1, p. 75.
Do	Hayne Hudjihini (The Eagle of Delight).	1821	Oils: No. 131 in S. I., 1859. Redwood Library. Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 3, p. 8.
Do	Nowaykesugga (Strikes Two at Once).	1837	Oil: No. 64 in S. I., 1859. Lith: McK. and H., vol. 3, p. 8.
Do	Wahronesah (Surrounder)	1837	Oil: No. 13 in S. I., 1859.
Do	Wekrootaw (He Who Exchanges).	1837	Oil: No. 139 in S. I., 1859.
Pawnee (Republican)	Peskelechaco	1821?	Oils: No. 89 in S. I., 1859. Redwood Library. Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 2, p. 169.
Pawnee (Loup)	Petalesharro (Generous Chief)	1821	Oil: Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 1, p. 101.
Pawnee (Grand)	Sharitarish (Wicked Chief)	1821	Oil: Nationalmuseet, Copenhagen. Lith: McK. and H., vol. 2, p. 163.
Pawnee	Lakeetoomerasha (Little Chief)	1837	Oil: No. 12 in S. I., 1859.
Pawnee (Loup)	Leshawloolalehoo (Big Chief)	1837	Oil: No. 74 in S. I., 1859.
Penobscot	Joseph Porus	1842	Oil: Gilcrease Foundation.
Potawatomi (Prairie)	Wabaunsee (Causer of Paleness)	1835	Oils: No. 105 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 2, p. 107.
Sac and Fox (Sac)	Asheaukou (Sunfish)	1837	Oil: No. 95 in S. I., 1859.
Sac and Fox (Fox)	A Fox Chief	1826	Oil: King after Lewis—No. 121 in S. I., 1859.
Sac and Fox (Sac)	Kaikeekaimaih (All Fish)	.....	Oil: No. 123 in S. I., 1859.
Sac and Fox (Fox)	Keesheswa (The Sun)	.....	Oil: No. 37 in S. I., 1859. Lith: McK. and H., vol. 2, p. 83.
Sac and Fox (Sac)	Keokuk (Watchful Fox)	1829	Oils: No. 77 in S. I., 1859. Redwood Library. Nationalmuseet, Copenhagen. Gilcrease Foundation.
Do	Keokuk and Son	1837	Oil: No. 144 in S. I., 1859. Lith: McK. and H., vol. 2, p. 63.
Do	Makataimeshekiakiah (Black Hawk).	1837	Oil: No. 133 in S. I., 1859. Lith: Redwood Library. Lith: McK. and H., vol. 2, p. 29.
Do	Naasheoshuck (Son of Black Hawk).	1837	Oil: No. 25 in S. I., 1859.
Sac and Fox (Fox)	Nesousquoit (Bear in the Forks of a Tree).	1837	Oil: Redwood Library. Lith: McK. and H., vol. 1, p. 155.
Do	Peamuska (Fox Winding in his Course).	.....	Oil: Redwood Library. Lith: McK. and H., vol. 1, p. 113.
Sac and Fox (Sac)	Panansee (Shedding Elk)	1827	Oil: No. 114 in S. I., 1859.
Do	Pashepahaw (The Stabber)		Oil: No. 41 in S. I., 1859. Lith: McK. and H., vol. 1, p. 95.
Sac and Fox (Fox)	Powasheek (To Dash the Water off).	1837	Oils: No. 34 in S. I., 1859 (credited to George Cooke), Redwood Library. Lith: McK. and H., vol. 2, p. 161.
Do	Waatopenot (Eagle's Bill)	1826	Oil: King after Lewis—No. 49 in S. I., 1859. Lith: McK. and H., vol. 3, p. 150.
Do	Wakechal (Crouching Eagle)	1824	Oils: No. 65 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 2, p. 229.
Do	Wapella (The Prince)	1837	Oil: No. 106 in S. I., 1859. Lith: McK. and H., vol. 2, p. 51.

Tribe	Name	Date	Reference
Seminole	Foke Luste Hajo (Craggy Black Clay).	1826	Oil: No. 68 in S. I., 1859. Lith: McK. and H., vol. 2, p. 179.
Do	Hoho Tustennuggee (Deer Warrior).	1826	Oil: No. 111 in S. I., 1859.
Do	Governor Hicks (Head Chief)	1826	Oil: No. 107 in S. I., 1859.
Do	Holato Micco (Blue King)	1826	Oil: No. 107 in S. I., 1859.
Do	Tulcee Mathla	1826	Oil: U. of Penna. Museum. Lith: McK. and H., vol. 3, p. 120.
Do	Micanopy		Oil: No. 63 in S. I., 1859. Lith: McK. and H., vol. 2, p. 187.
Do	Neamathla	1826	Oil: No. 36 in S. I., 1859. Lith: McK. and H., vol. 2, p. 143.
Do	Yaha Hajo (Mad Wolf)	1825	Oil: No. 67 in S. I., 1859. Lith: McK. and H., vol. 2, p. 217.
Seneca	Red Jacket	1828	Oils: No. 98 in S. I., 1859. Redwood Library. Yale University. Lith: McK. and H., vol. 1, p. 1.
Do	Young Cornplanter	1827	Oil: Nationalmuseet, Copenhagen.
Sioux (Yankton)	Ammoi (Comes for Something)	1837	Oil: No. 87 in S. I., 1859.
Sioux (Mdwekanton)	Little Crow	1824	Oil: No. 125 in S. I., 1859. Lith: McK. and H., vol. 1, p. 61.
Do	Wahkeontawkah (Big Thunder)	1837	Oil: No. 14 in S. I., 1859.
Sioux (Yanktonai)	Wanata (The Charger)	1826	Oils: King after Lewis—No. 119 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 1, p. 109.
Stockbridge	John W. Quinney	1842	Oil: Gilcrease Foundation.
Winnebago	Amisquam (Wooden Ladle)	1826	Oil: King after Lewis—No. 6 in S. I., 1859. Lith: McK. and H., vol. 2, p. 151.
Do	Wakaun Haka (Snake Skin)	1826	Oil: King after Lewis—No. 61 in S. I., 1859. Lith: McK. and H., vol. 2, p. 165.
Yuchi	Timpoochee Barnard	1825	Oils: No. 135 in S. I., 1859. Redwood Library. Lith: McK. and H., vol. 2, p. 25.
	"Young Omahaw, War Eagle, Little Missouri and Pawnees".	1821	Oil: U. S. National Museum.
(?)	Makwehawmak (Great Walker)		Oil: Gilcrease Foundation.
(?)	Col. John Stedman (or Stidham)	1825	Oil: No. 35 in S. I., 1859.
(?)	Chief No Cush		Miniature: Yale University.
(?)	"Indian Girl at Her Toilet" (Not a portrait).		Oil: Redwood Library.

Since this list was compiled five additional Indian portraits by Charles Bird King, formerly owned by a private collector in England, have been offered for sale by James Graham & Sons, Inc., of New York. These paintings were illustrated in an advertisement in Antiques magazine for June 1953, p. 487. Four of the paintings appear to be replicas of his portraits of the Pawnee, Petalesharro; the Oto chief, Shaumonekusse and his wife, The Eagle of Delight; and the Sac chief, Wakechai. The fifth painting, a portrait of The Prophet, brother of the famous Shawnee chief, Tecumseh, does not appear in my check list.

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