तदेकोऽवशिष्टः शिवः केवलोऽहम् ।
I alone persist : Blissful : Absolute.

ॐ

सोऽहम् ।

Yoga-Mimansa

EDITED BY

S'RĪMAT KUVALAYĀNANDA

(J. G. GUNE)

सर्वं खल्विदं ब्रह्म ।
All this is, indeed, Brahman.

नेह नानास्ति किंचन ।
There is nothing here apart from it.

July, 1930

Vol. IV No. 1

KAIVALYADHĀMA

Post—Lonavla

(BOMBAY-INDIA)

शरीरमाद्यं खलु धर्मसाधनम् ।
Surely Health is the primary requisite of spiritual life.

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तदेकोऽवशिष्टः शिवः केवलोऽहम् ।

सोऽहम् ।

YOGA-MĪMĀṄSĀ

VOL. IV JULY, 1930. NO. 1

Editorial Notes

MAY the Maker of all make this journal a success. Blessed is the name of the Lord. May He bless the workers of the Ās'rama with a happy and prosperous career as servants of the world which is only the Lord Himself objectified. May He, that has created us in His infinite wisdom, lead us to the light that is beyond all darkness.

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WITH this number begins the fourth volume. We offer our heart-felt thanks to all those who have helped us in the past and wish to help us in the future. May the Lord that has blessed us thus far, bless us hereafter.

⚜ ⚜ ⚜

THE principal theme of the fourth volume will continue to be Prānāyāma. We are anxious to take up some supplementary subject also, especially dyspepsia. Articles on this disease and its Yogic treatment may, therefore, appear in the current volume. Besides the technique of Kapālabhāti and Bhastrikā, the technique of some other Yogic practices will also be given.

⚜ ⚜ ⚜

THE treatment of the different subjects, will be as original, thorough and reliable as it has been in the last three volumes. In giving the technique of the Yogic exercises

even minutest detail will be attended to. The Yoga-Mīmāṅsā has already come to be recognized as an authoritative publication in matters Yogic. We shall try our level best to maintain in future the high standard that has once been established.

In reading this number, non-medical men will do well first to master our article on the pressure changes in Prāṇāyāma and then to read the experiments given in the Scientific Section. The article 'Ujjāyī Prāṇāyāma Explained' should be read last. Unless the physiological principles discussed in the Semi-Scientific and Scientific Sections are thoroughly understood, ordinary readers will find it difficult to follow the scientific explanation of Prāṇāyāma. This very circumstance is responsible for our not publishing in this issue a larger part of the article 'Ujjāyī Prāṇāyāma Explained.' We had first to make room for all the information that was needed for a clear understanding of that article. This took away so much of our space.

We beg to draw our readers' attention to the several appreciations published in the current number. Pandit Motilal Nehru's views published on the next page and Sir Shankaran Nair's note printed on page 4, are specially recommended to the attention of our readers. They tell their own tale.

The review of the activities of the Kaivalyadhāma appearing in the Miscellaneous matter is expected to give in brief a good idea about the work of the Ās'rama. May we request our readers to bring this matter to the notice of those promising youths that may be in search of opportunities such as are available at the Kaivalyadhāma.

May the Lord that enabled us to found the Ās'rama, give us strength enough to carry on its work! May He ever widen the circle of our sympathizers and thus allow us to serve Him and His children to the best of our ability!

PANDIT MOTILAL NEHRU'S NOTE

I have been very much impressed with the work of Swami Kuvalayananda (Dr. J. G. Gune). He has opened out an entirely new field of research and has already shown that the different aspects of Yogic culture and therapy can not only stand the fierce light of modern sciences but are well in advance of all that has so far been discovered in the West. His Ashrama has only been in existence for the last five years but has already built up a reputation in the successful application of Yogic principles and practices to modern conditions of life. The methods he has introduced in the field of physical culture have already found favour with many prominent individuals and institutions. Some of the Provincial Governments and Indian States have also approved of them. His journal "Yoga-Mimansa" has a fair circulation in India and abroad. With the help of this journal and the small band of self-sacrificing university men, he has gathered round him, he has rendered much valuable service. But it is evident that a small institution of this nature cannot satisfy the needs of a big country like ours. What is necessary is to make it a training ground for a sufficiently large number of teachers to be employed in schools and colleges all over India to instruct our young men and to give his journal "Yoga-Mimansa" a much wider circulation than it now has. The organization deserves to be developed into a National Institution for which considerable funds are necessary. It is in my opinion the duty of every Indian to help Swamiji's work and afford him a full and fair opportunity to realise his ideals for the physical and cultural uplift of India and of humanity at large.

March 14, 1930. (*Sd.*) **Motilal Nehru**

SIR SHANKARAN NAIR'S LETTER

DEAR SWAMIJI,

Your attempt to interpret the different aspects of Yogic culture in the light of up-to-date sciences and thus to co-ordinate the ancient and modern civilisation for drawing closer the East and the West, is simply unique. The work that your Ashrama has turned out during the five years of its existence in the field of physical culture and Yogic Therapy, has already attracted the attention not only of the general public, but even of some of the Provincial Governments and Indian States. Your journal, the Yoga-Mimansa, has found its way not only throughout India, but even abroad. You have gathered roundabout you a band of self-sacrificing university men anxious to serve humanity. If you get ample financial support, you are sure to develop an organisation that would competently and selflessly work for the progress of mankind. Under these circumstances it becomes the duty of every individual to render you substantial monetary help and thus to enable you to realise your noble ideals for the uplift of humanity.

New Delhi,
February 22, 1930.

(*Sd.*) **Sankaran Nair**

SYSTEM OF TRANSLITERATION

Letters, their sounds, and a description of these sounds :—

अ	A	Pronounce	'A'	like	'u'	in	'but'.
आ	Ā	„	'Ā'	„	'a'	„	'far'.
इ	I	„	'I'	„	'i'	„	'pin'.
ई	Ī	„	'Ī'	„	'ee'	„	'feel'.
उ	U	„	'U'	„	'U'	„	'fulsome'.
ऊ	Ū	„	'Ū'	„	'oo'	„	'wool'.
ऋ	ṚI	„	'ṚI'	„	'rö'	„	German.
ॠ	ṚĪ	„	'ṚĪ'	„	„	„	„ with a strong accent.
ऌ	ḶI	„	'ḶI'	„	'lö'	„	German.
ए	E	„	'E'	„	'a'	„	'fate'.
ऐ	AI	„	'AI'	„	'ai'	„	'aisle' but not drawled out.
ओ	O	„	'O'	„	'o'	„	'over'.
औ	AU	„	'AU'	„	'ou'	„	'ounce' but not drawled out.
क	KA	„	'K'	„	'k'	„	'kill'.
ख	KHA	„	'KH'	„	'kh'	„	'ink-horn' or like 'ch' in 'Loch' (Scottish).
ग	GA	„	'G'	„	'g'	„	'girl'.
घ	GHA	„	'GH'	„	'gh'	„	'log-house' or 'ghee'.
ङ	N̄A	„	'N̄'	„	'n'	„	'king' or 'link'.
च	CHA	„	'CH'	„	'ch'	„	'church'.
छ	CHHA	„	'CHH'	„	the second 'ch' in 'churchill'.		
ज	JA	„	'J'	„	'j'	in	'join'.
झ	JHA	„	'JH'	„	palatal 'z' as in 'azure'.		
ञ	N'A	„	'N''	„	'n'	in	'pinch'.
ट	ṬA	„	'Ṭ'	„	't'	„	'tub'.
ठ	ṬHA	„	'ṬH'	„	'th'	„	'pot-house'.

SYSTEM OF TRANSLITERATION

Letters, their sounds, and a description of these sounds :—

ड	ḌA	Pronounce	'Ḍ'	like	'd'	in	'dog'.
ढ	ḌHA	,,	'ḌH'	,,	'dh'	,,	'mad-house'.
ण	ṆA	,,	'Ṇ'	,,	'n'	,,	'splinter' or 'and'.
त	TA	,,	'T'	,,	dental 't' as in 'thin', or like the French 'T'.		
थ	THA	,,	'TH'	,,	'th'	in	'thunder'.
द	DA	,,	'D'	,,	'th'	,,	'then'.
ध	DHA	,,	'DH'	,,	'th'	,,	'this'.
न	NA	,,	'N'	,,	'n'	,,	'no'.
प	PA	,,	'P'	,,	'p'	,,	'paw'.
फ	PHA	,,	'PH'	,,	'ph'	,,	'top-heavy', or 'gh' in 'laugh'.
ब	BA	,,	'B'	,,	'b'	,,	'balm'.
भ	BHA	,,	'BH'	,,	'bh'	,,	'hob-house'.
म	MA	,,	'M'	,,	'm'	,,	'mat'.
य	YA	,,	'Y'	,,	'y'	,,	'yawn'.
र	RA	,,	'R'	,,	'r'	,,	'rub'.
ल	LA	,,	'L'	,,	'l'	,,	'lo'.
व	VA	,,	'V'	,,	'w'	,,	'wane'.
श	S'A	,,	'S''	,,	'sh'	,,	'ashes'.
ष	SHA	,,	'SH'	,,	a strong lingual with rounded lips.		
स	SA	,,	'S'	,,	's'	in	'sun'.
ह	HA	,,	'H'	,,	'h'	,,	'hum'.
ळ	ḶA	A dento-lingual pronounced with a little rounding of lips.					

Nasalized म् as in संयम—Ṃ ; Nasalized म् as in संलग्न—M̄ ;

,, ,, ,, ,, संवाद—M̱ ; ,, ,, ,, ,, संहिता—Ṁ ;

Nasalized न् as in मीमांसा—Ṅ ; Visarga—Ḥ.

THE SCIENTIFIC SECTION

N. B.—Those of our readers that claim no acquaintance with anatomy and physiology will do well to read The Semi-Scientific Section first.

PRESSURE EXPERIMENTS IN PRĀṆĀYĀMA

THEIR CULTURAL AND CURATIVE IMPORTANCE

It is an admitted physiological fact that the ordinary act of respiration involves appreciable changes in the pressure conditions obtainable in the lungs, in the thorax and in the abdomen. If the respiration is made deeper, the pressure changes become considerable; and under particular circumstances, these changes are observed to be remarkably great. Modern physiologists have very carefully studied the effects of ordinary respiration upon the circulation of the blood. It has been found that the pressure changes brought about by normal breathing greatly aid the circulation of the venous blood. These physiologists have also investigated the effects of forced respiration upon blood circulation. Some work has also been done in studying circumstances capable of producing very high pressures in the lungs and in the thorax.

Although the Western physical culturists have been anxious to take advantage of the advancing physiological knowledge of the world, their literature does not show much attention to have been paid to the pressure changes in 'Deep Breathing' and to the effects of these changes on blood circulation. They indeed speak of pressures and also of the improved circulation of the blood, in discussing their breathing exercises. But the whole treatment accorded to this subject is so superficial that it fails to satisfy the scientific mind.

Even if the physical culturists of the West had paid more attention to the study of 'Deep Breathing,' their observations would not have been of much use in understanding the physiology of Yogic Prāṇāyāma. Because so far as we know there is hardly any physical culturist worth the name in the West, who is teaching 'Deep Breathing' according to the exact technique of Prāṇāyāma. Under these circumstances it became absolutely imperative for us to undertake investi-

gating thoroughly the problem of Pranayamic physiology. Some of the X-Ray experiments done in this connection have already appeared in the third volume of this journal. The pressure experiments recorded in the following pages form another instalment of our research work in this subject. The field is vast. It will take years before we can claim to have studied the physiology of Prāṇāyāma with some thoroughness. In the meanwhile we shall be publishing through the Yoga-Mīmāṅsā whatever research work will be turned out in the Kaivalyadhāma in this connection.

The study of pressure changes involved in Prāṇāyāma in all its stages, is valuable from more points of view than one. Exercises in Yogic Physical Culture, Yogic Therapy and even Yogic Spiritual Culture can be intelligibly understood only if the pressure changes brought about by them are carefully studied. Serious mistakes are likely to be made in prescribing Pranayamic exercises for cultural or curative purposes, if these pressure changes are not sufficiently known. We shall explain how.

Physical culturists are often tempted to teach Prāṇāyāma to boys under thirteen. This is due to their ignorance about the pressure changes in Prāṇāyāma and is calculated to do considerable damage to the hearts of the juvenile athletes. The reason is this. The stock of the blood present in a child's body is held partly in the heart and partly in the other parts of the circulatory system. Now in children the volume of the heart is proportionately much smaller than the calibre of the rest of the circulatory system. Again it is a well known physiological fact that in deep inspiration, owing to the negative pressure in the thorax and the positive pressure in the abdomen, the blood from the large veins rushes to the heart. Under these circumstances, owing to its comparatively small calibre, the child's heart would find it difficult to receive into it the stock of venous blood pressing for admission, and would consequently suffer. If this exercise is repeated several times a day, the damage done to the juvenile heart is likely to be considerable. During adoles

cence, however, the volume of the heart is increased twelve-fold while the calibre of the arteries increases only three-fold. Owing to this circumstance, the proportion becomes favourable to the heart which afterwards can receive all the quantity of the venous blood that may be pumped up to it. Hence Prāṇāyāma can be practised only after adolescence, and if prescribed to boys of younger age through ignorance, is likely to do harm.

Prāṇāyāma has all along been a favourite curative measure in India. Although the Kaivalyadhāma may justly claim the credit of modernizing Yogic Therapy, even to-day there is a large number of students of Yoga outside the Ās'rama, who prescribe Yogic exercises for curative purposes. Now their prescriptions are likely to be dangerous, if they are given without understanding the pressure changes in Prāṇāyāma. We shall very briefly refer to the Pranayamic treatment of a weak heart and weak lungs.

Many people look to be under the impression that deep inspirations are likely to damage a weak heart. Others seem to think that Prāṇāyāma is capable of strengthening *any* weak heart. We are of opinion that both these views have their root in the ignorance of Pranayamic pressure changes. Properly speaking in every deep inspiration, the intra-thoracic pressure is remarkably lowered and hence the external pressure on the heart is equally decreased. Thus there is little chance of the heart being damaged owing to the pressure changes in deep inspiration. Of course the heart must have strength enough to stand the richer supply of venous blood drawn to it in deep inspiration. The other view that Prāṇāyāma is capable of strengthening *any* weak heart is equally untenable. Prāṇāyāma as it is generally taught outside the Kaivalyadhāma necessarily includes Kumbhaka of one type or another. Now there are particular varieties of Kumbhaka where the intra-thoracic pressure becomes considerably high. That means the external pressure on the heart is proportionately increased. Now this increase in the external pressure is very likely to damage a weak heart.

Thus we see that any Yogic treatment of a weak heart, if it is to be safe, must be based upon a knowledge of Pranayamic pressure changes; otherwise it may do more harm than good to the patient.

What holds good in the case of the heart equally holds good in the case of the lungs. In every deep inspiration the lungs are put on a stretch. And although at the end of every deep inspiration the intra-pulmonic pressure is only equal to one atmosphere, the fibres of the lung tissues are so much stretched that in the case of weak lungs they stand in the danger of being torn. But the matter does not end there. There are some varieties of Kumbhaka which increase very considerably the intra-pulmonic pressure. Some students of Yogic Therapy recommend the practice of this type of Kumbhaka even to persons with weak lungs. Under these circumstances damage to the lungs is sure and very serious consequences follow, simply for the ignorance of Pranayamic pressure changes.

Prāṇāyāma is one of the finest exercises for a weak heart and weak lungs. If its physiology is properly known and if it is judiciously administered, the exercise is capable of giving wonderful results.

This study of pressure changes in Prāṇāyāma has its own importance in understanding the physiology of Yogic exercises directly leading to spiritual development. Yogic processes practised for the awakening of Kuṇḍalinī are mainly characterized by two features. They either involve the stretching of the spine and its adjacent parts, or are capable of attracting a richer blood supply to the regions roundabout the spinal column, especially in the pelvic and lumbar regions. In Prāṇāyāma the stretching of the spine is effected by the manipulation of the contracted diaphragm, mainly through its crura. After deepest inspiration when the diaphragm stands most vigorously contracted and occupies the lowest position, it is pushed upward by means of the contracted abdominal recti pressing hard upon the abdominal

viscera. This upward push is counteracted by the contracted diaphragm and its two crura attached to the posterior part of the abdominal wall, and in doing this they exert a steady pull upon the spine and its adjacent parts.

Thus we see that the high abdominal pressure created in Prāṇāyāma by the action and counteraction of the different anatomical parts together with the upward pull of the crura, is responsible for the awakening of Kuṇḍalinī.

Pressure changes attract a richer blood supply to the lumbar region in the following way. When Uḍḍiyāna is practised after deep exhalation, negative pressure is developed in the abdomen. This decrease in the abdominal pressure naturally attracts a richer blood flow to the lumbar region. Similarly there are other pressures which can induce copious blood supply to the pelvis.

Thus we see that a knowledge of the pressure changes in Prāṇāyāma, is very important in understanding the cultural and curative values of this important branch of Yogic exercises.

THE TWELVE EXPERIMENTS

We may now proceed to note a few general features of the twelve experiments that are recorded in this issue. The first two experiments were done to ascertain the pressure conditions at the nares in ordinary respiration. The remaining ten experiments were undertaken to know the pressure conditions in the œsophagus as it is affected in the different processes of Prāṇāyāma. Here the question arises as to why we have tried to study the intra-œsophageal pressure changes, when in the discussion that we have just finished, we pointed out the physiological importance of knowing the intra-pulmonary and intra-thoracic pressures. The following is our answer.

So far as the thorax is concerned, the pressure changes that really count in the study of Prāṇāyāma are the intra-thoracic and the intra-pulmonic. But situated as we are, it is

impossible for us, not only at present but even in the near future, to undertake any experiments on the intra-thoracic or intra-pulmonic pressures, because even in the best equipped laboratories the opportunities for this kind of research are so rare. So we thought of trying to see whether the intra-thoracic and intra-pulmonic pressure changes could be roughly understood by studying intra-œsophageal pressures during the different stages of Prāṇāyāma. It suggested itself to us to try these experiments because of the following physiological fact. The intra-thoracic pressure is known to affect the pressure conditions existing in the different organs situated in the mediastinal cavity. So we thought that the pressures available inside the thoracic part of the œsophagus would in a rough proportion represent the pressures existing in the mediastinal cavity. In the 250 readings that we took during the ten experiments on the intra-œsophageal pressures, we found that every time we expected a change in the intra-thoracic pressure, there was a corresponding change in the intra-œsophageal pressure also. Thus we concluded that a study of the intra-œsophageal pressures can, though somewhat roughly, give a clear idea of the intra-thoracic pressures brought about in the various developments of Prāṇāyāma. It remains for the scientific world to see how far we are justified in coming to this conclusion.

Physiological research has shown that the intra-pulmonic pressure is equal to the intra-thoracic pressure plus the pressure due to the elastic recoil of the lungs. And as the elastic recoil of the lungs always varies within particular limits, intra-pulmonary pressure can always be ascertained, though somewhat roughly, from the intra-thoracic pressure. We have already indicated in the preceding paragraph that intra-œsophageal pressure roughly varies in proportion to the intra-thoracic pressure. Hence it is possible to know clearly the pressure changes both in the lungs and in the mediastinal cavity, if we can know the pressure changes in the œsophagus, although the exact degree of different pressures existing in the lungs and the mediastinal cavity, may remain unknown.

So a study of intra-œsophageal pressures was undertaken simply with a view to determine, though somewhat roughly, the intra-pulmonic and intra-thoracic pressures in Prāṇāyāma.

For conducting experiments on the intra-œsophageal pressures, an india-rubber tube was introduced into the œsophagus as far as the middle of its thoracic portion, the other end of the tube being connected with a water manometer in Experiments III and IV, and with a mercury manometer in the remaining experiments. In Experiments III and IV, a water manometer was preferred because the pressure changes were comparatively small.

Pressure changes in Uḍḍiyāna have been experimented upon here, because at times Uḍḍiyāna is included in the technique of Prāṇāyāma.

For every experiment five subjects were tried, each subject being required to make five attempts to produce the necessary condition in respiration. Thus for every experiment twenty-five readings were taken and averages were worked out, the final average being made to represent the ultimate result.

The conclusions to be drawn from each experiment are discussed at the end of that experiment.

PRESSURE EXPERIMENTS IN PRĀṆĀYĀMA

EXPERIMENT I

OBJECT OF THE EXPERIMENT :—

It is well known to the students of physiology that the act of inhalation starts with the lowering down of the intra-pulmonic pressure which is equal to one atmosphere at the end of the previous exhalation. This decrease of pressure is to be felt not only in the lungs, but throughout the air tubes, although the degree of decrease varies at different places. It is supposed that in the air passage the negative pressure below the glottis is greater than the negative pressure above the glottis. Again the degree of pressure change depends upon the rapidity of the respiratory act. The object of this experiment was to measure the negative pressure developed at the nares during the process of *a quiet and normal inhalation.*

PREPARATION OF THE SUBJECTS :—

Five subjects were tried in this experiment. They were young adults of sound constitution, with ages ranging from 20 to 29. The experiment was done in the morning and the subjects were taken up with an empty stomach. No special preparation was deemed necessary.

THE APPARATUS :—

An ordinary water manometer was used for measuring the pressure changes. One end of this manometer was successively connected with a naris of every subject by means of a tube of india-rubber, passed through the corresponding nostril.

THE EXPERIMENT PROPER :—

Each subject was made to breathe quietly while he maintained the ordinary sitting posture. While the india-rubber tube was introduced in one nostril, the other nostril was left

free. When inhalations became normal, pressure changes were noted down at each successive inhalation. Five readings were taken in the case of every subject and an average worked out. Five such averages were put together and a final average was calculated. It indicated a fall of 20·4 mm. of water. The twenty-five readings noted down are tabulated on the next page.

REMARKS :—

It is to be noted that the result of this experiment differs from the results arrived at by Western physiologists. They record a fall of 9 or 10 mm. of water in a normal quiet inspiration. Perhaps there are two factors which have affected our result. Our readings were taken while the subjects maintained a sitting posture, while the Western physiologists *may* have taken their readings in a lying down position of their subjects. As all the Pranayamic pressure changes were studied while the subjects maintained a sitting posture, we thought it desirable to conduct even the present experiment in the same posture. We could also note that the india-rubber tube slightly irritated the mucous membrane of the nasal passage, thus rendering the inhalations a little deeper and more hurried. This naturally produced a greater negative pressure.

PRESSURE CONDITION AT THE NARES IN ORDINARY INSPIRATION

Readings of Experiment I

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	– 26 mm.	– 24 mm.	– 28 mm.	– 32 mm.	– 24 mm.	– 26·8 mm.
B	– 20 mm.	– 22 mm.	– 18 mm.	– 18 mm.	– 20 mm.	– 19·6 mm
C	– 20 mm.	– 16 mm.	– 14 mm.	– 20 mm.	– 20 mm.	– 18 mm.
D	– 24 mm.	– 20 mm.	– 18 mm.	– 20 mm.	– 24 mm.	– 21·2 mm.
E	– 20 mm.	– 16 mm.	– 18 mm.	– 14 mm.	– 14 mm.	– 16·4 mm.

Total, –102 mm.

Final Average, –30·4 mm.

EXPERIMENT II

OBJECT OF THE EXPERIMENT :—

The first experiment was made for ascertaining the pressure change at the nares in a quiet inspiration. The object of this experiment was to determine the pressure change at the nares in a normal expiration. As is well known exhalation starts when the intra-pulmonic pressure rises above one atmosphere. So the pressure change expected to develop at the nares was positive instead of negative as in the previous experiment.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it immediately after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

THE EXPERIMENT PROPER :—

This experiment was conducted exactly in the same way as the first, the averages etc., being worked out as previously. The only difference was that instead of noting down the changes in inhalation, the pressure changes in exhalation were tabulated. All the readings came out positive and the final average stood at 15·2 mm. of water indicating that much rise in the pressure at the nares. Detailed readings are tabulated on the next page.

REMARKS :—

As in the first experiment so here, our result differs from the results of the Western physiologists. The difference is, in all probability, due to the causes discussed under the previous experiment.

PRESSURE CONDITION AT THE NARES IN ORDINARY EXPIRATION

Readings of Experiment II

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	+20 mm.	+24 mm.	+22 mm.	+14 mm.	+24 mm.	+20·8 mm.
B	+22 mm.	+24 mm.	+30 mm.	+28 mm.	+22 mm.	+25·2 mm.
C	+12 mm.	+8 mm.	+10 mm.	+10 mm.	+10 mm.	+10 mm.
D	+10 mm.	+10 mm.	+8 mm.	+12 mm.	+10 mm.	+10 mm.
E	+10 mm.	+10 mm.	+8 mm.	+12 mm.	+10 mm.	+10 mm.

Total, + 76 mm.

Final Average, +15·2 mm.

EXPERIMENT III

OBJECT OF THE EXPERIMENT :—

The object of the experiment was to determine the change effected in the intra-œsophageal pressure during normal inspiration, with a view to get a rough idea about the changes made in the intra-pulmonic and intra-thoracic pressures, which, as have been shown in the general discussion on these experiments, roughly vary in proportion to the intra-œsophageal pressure. Again readings of the intra-œsophageal pressure changes during quiet inspiration would greatly help the understanding of the intra-œsophageal pressure changes in the Pranayamic processes as they were going to be determined in the subsequent experiments.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it immediately after that experiment.

THE APPARATUS :—

The piece of apparatus used in the last experiment was also used here. The free end of the india-rubber tube was, however, introduced into the œsophagus till it reached the middle of its thoracic portion.

THE EXPERIMENT PROPER :—

Subjects were made to keep up their normal respiration while they continued to have a sitting posture. Readings were noted down as they were available during successive inhalations. Averages being worked out as in the last two experiments, the final average showed a fall of 81·12 mm. of water. Detailed readings are tabulated on the next page.

REMARKS :—

This fall of 81·12 mm. of water in the intra-œsophageal pressure during normal inspiration shows very clearly that the œsopht agus largely yields to pressure changes in the thorax. The intra-thoracic pressure, as noted by Western scientists, decreases by about 102 mm. of water during normal inhalation. When we compare the fall in the intra-œsophageal pressure as determined by the present experiment with the fall in the intra-thoracic pressure as noted by the Westerners, we clearly see that the pressure changes in the thorax are very largely shared by the œsophagus.

PRESSURE CONDITION IN THE ŒSOPHAGUS IN ORDINARY INSPIRATION

Readings of Experiment III

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	- 100 mm.	- 120 mm.	- 110 mm.	- 116 mm.	- 112 mm.	- 111·6 mm.
B	- 100 mm.	- 80 mm.	- 90 mm.	- 76 mm.	- 80 mm.	- 85·2 mm.
C	- 100 mm.	- 90 mm.	- 100 mm.	- 104 mm.	- 80 mm.	- 94·8 mm.
D	- 60 mm.	- 40 mm.	- 50 mm.	- 60 mm.	- 40 mm.	- 50 mm.
E	- 70 mm.	- 60 mm.	- 50 mm.	- 60 mm.	- 80 mm.	- 64 mm.

Total, -405·6 mm.

Final Average, -81·12 mm.

EXPERIMENT IV

OBJECT OF THE EXPERIMENT :—

The object of this experiment was the same as the object of the last. Only instead of studying the changes in the intra-œsophageal pressure during normal *inspiration*, in this experiment the pressure changes in the normal *exhalation* were to be determined.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it immediately after that experiment.

THE APPARATUS :—

The piece of apparatus used in the last experiment was also used here, the free end of the india-rubber tube being introduced in the same fashion up to the middle of the thoracic part of the œsophagus.

THE EXPERIMENT PROPER :—

This experiment was conducted exactly in the same manner as the last, with this difference. Instead of noting the pressure changes during inhalations, they were noted during exhalations. The final average showed a fall of 34·88 mm. of water. Detailed readings are tabulated on the next page.

REMARKS :—

Physiologists know it very well that intra-thoracic pressure continues to be negative even during normal exhalation. It is observed to be about 61·2 mm. of water. From the present experiment we find that the œsophagus yields to the intra-thoracic pressure changes in exhalation also. As the negative intra-thoracic pressure has decreased during exhalation' so the negative intra-œsophageal pressure has also decreased.

PRESSURE CONDITION IN THE ŒSOPHAGUS IN ORDINARY EXPIRATION

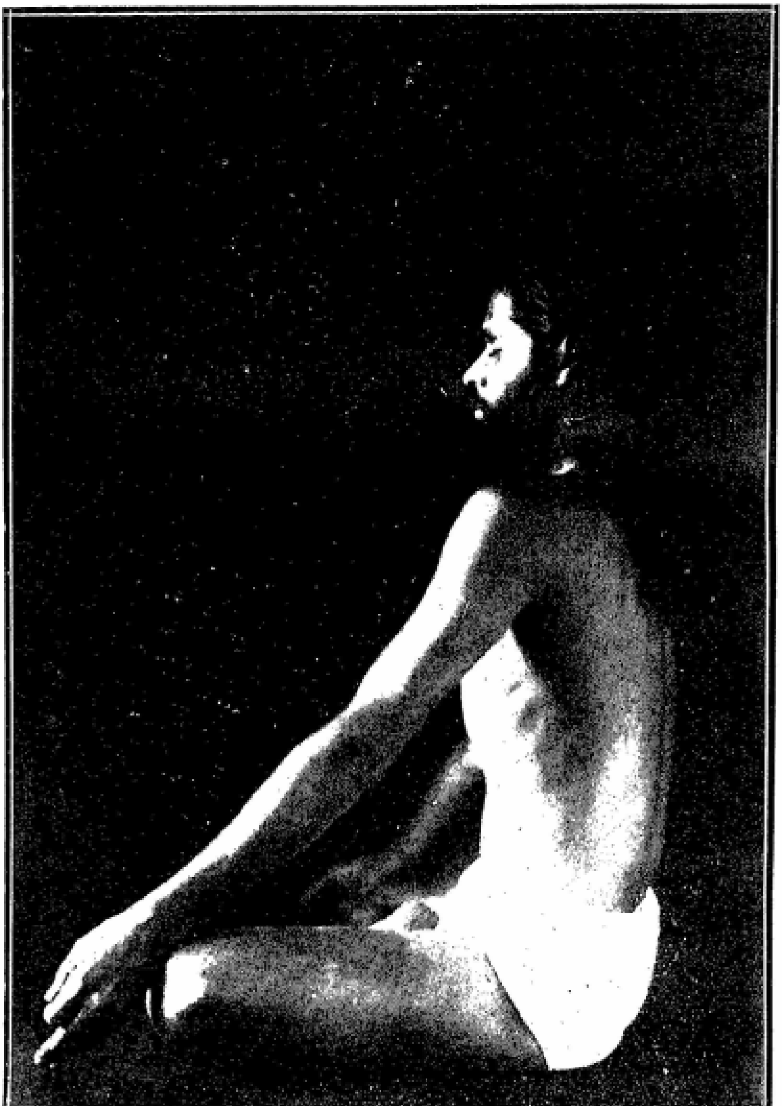
Readings of Experiment IV

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	– 60 mm.	– 48 mm.	– 40 mm.	– 64 mm.	– 48 mm.	– 52 mm.
B	– 48 mm.	– 40 mm.	– 48 mm.	– 46 mm.	– 50 mm.	– 46·4 mm.
C	– 40 mm.	– 36 mm.	– 30 mm.	– 30 mm.	– 30 mm.	– 33·2 mm.
D	– 20 mm.	– 16 mm.	– 24 mm.	– 10 mm.	– 24 mm.	– 18·8 mm.
E	– 40 mm.	– 24 mm.	– 16 mm.	– 24 mm.	– 16 mm.	– 24 mm.

Total, –174·4 mm.

Final Average, –34·88 mm.

Fig. I



Deep Inhalation with Controlled Abdomen.
(Side View)

EXPERIMENT V

OBJECT OF THE EXPERIMENT:—

The object of this experiment was to ascertain the intra-œsophageal pressure during deep inhalation when the abdominal muscles were kept *controlled*, because that is the type of inhalation practised in Prāṇāyāma. The intra-pulmonic and intra-thoracic pressures would then be roughly inferred from the intra-œsophageal pressure and the depths of Yogic and non-Yogic deep inhalations be compared.

PREPARATION OF THE SUBJECTS:—

The same subjects were tried in this experiment as in the last and were taken up for it immediately after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here but with one change. Instead of water, mercury was used to measure the pressure changes.

THE EXPERIMENT PROPER:—

Subjects were made to practise deep inhalation with the abdominal muscles kept *controlled*. A side view of one of the subjects is shown in Fig. I. The inhalations were practised in a sitting posture. Readings were noted down as they were available for each successive inhalation. Averages being worked out as in the foregoing experiments, the final average showed a fall of 21·2 mm. of mercury. Detailed readings are tabulated on the next page.

REMARKS :—

Physiologically inspiration causes negative pressure in the thorax. The deeper the inspiration the greater is the fall in the intra-thoracic pressure. Western physiologists have recorded this fall to be about 30 mm. of mercury. We have reason to believe that in the present experiment, the intra-thoracic pressure must have fallen by something more than 30 mm. Hg., because generally the fall in the intra-thoracic pressure is *much greater* than the fall in the intra-œsophageal pressure which in this experiment is as much as 21·2 mm. So we see that the Yogic inspiration is much deeper than the ordinary deep inspiration studied by the Western physiologists.

PRESSURE CONDITION IN THE ŒSOPHAGUS IN FORCED INSPIRATION

WITH CONTROLLED ABDOMEN

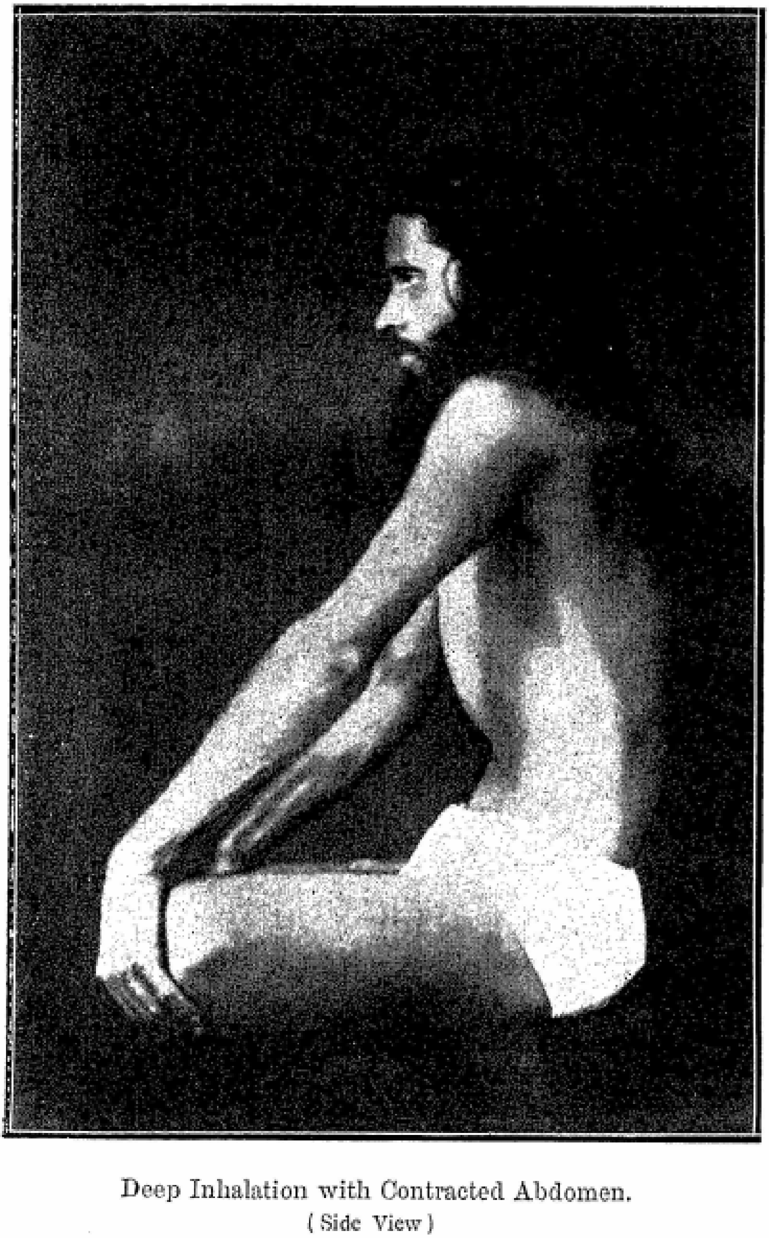
Readings of Experiment V

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	– 30 mm. Hg.	– 28 mm. Hg.	– 32 mm. Hg.	– 28 mm. Hg.	– 30 mm. Hg.	– 29·6 mm. Hg.
B	– 26 mm. Hg.	– 24 mm. Hg.	– 22 mm. Hg.	– 20 mm. Hg.	– 18 mm. Hg.	– 22 mm. Hg.
C	– 20 mm. Hg.	– 24 mm. Hg.	– 22 mm. Hg.	– 20 mm. Hg.	– 22 mm. Hg.	– 21·6 mm. Hg.
D	– 16 mm. Hg.	– 14 mm. Hg.	– 14 mm. Hg.	– 16 mm. Hg.	– 10 mm. Hg.	– 14 mm. Hg.
E	– 16 mm. Hg.	– 20 mm. Hg.	– 20 mm. Hg.	– 20 mm. Hg.	– 18 mm. Hg.	– 18·8 mm. Hg.

Total, – 106 mm. Hg.

Final Average, – 21·2 mm. Hg.

Fig. II



Deep Inhalation with Contracted Abdomen.
(Side View)

EXPERIMENT VI

OBJECT OF THE EXPERIMENT :—

The object of this experiment was to determine the intra-œsophageal pressure during deep inhalation when the abdominal muscles are kept *contracted*, so that a comparison might be instituted between the results of this experiment and the last. Because such a comparison would settle the question as to which of the two types of inhalations secured deeper inspiration.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it directly after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

THE EXPERIMENT PROPE R :—

Subjects were made to practise deep inhalation with the abdominal muscles kept *contracted*. The inhalations were practised in a sitting posture. A side view of one of the subjects is shown in Fig. II. Readings were noted down as they were available for each successive inhalation. Averages being worked out as in the foregoing experiments, the final average showed a fall of 17·36 mm. of mercury. Detailed readings are tabulated on the next page.

REMARKS :—

The fall in the intra-œsophageal pressure recorded in this experiment is much less than the fall noted in the last. Now the intra-œsophageal pressure decreases in proportion to the depth of inhalation. Hence we conclude that the inhalation secured in the last experiment is deeper than the inhalation made available in this. The contracted abdominal muscles prevented the diaphragm descending as low as in the previous case.

PRESSURE CONDITION IN THE ŒSOPHAGUS IN FORCED INSPIRATION

: WITH CONTRACTED ABDOMEN

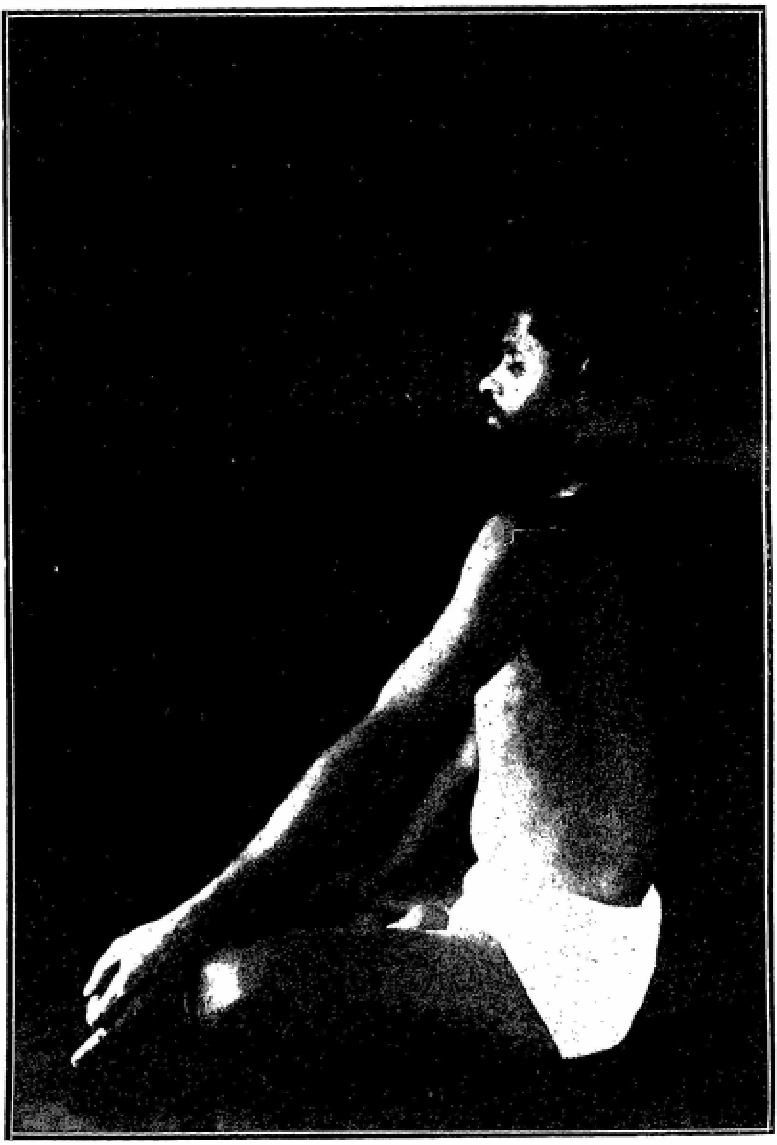
Readings of Experiment VI

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	– 20 mm. Hg.	– 20 mm Hg.	– 24 mm. Hg.	– 24 mm. Hg.	– 16 mm. Hg.	– 20·8 mm. Hg.
B	– 16 mm. Hg.	– 14 mm. Hg.	– 14 mm. Hg.	– 16 mm. Hg.	– 14 mm. Hg.	– 14·8 mm. Hg.
C	– 18 mm. Hg.	– 18 mm. Hg.	– 16 mm. Hg.	– 16 mm. Hg.	– 18 mm. Hg.	– 17·2 mm. Hg.
D	– 10 mm. Hg.	– 14 mm. Hg.	– 16 mm. Hg.	– 10 mm. Hg.	– 10 mm. Hg.	– 12 mm. Hg.
E	– 18 mm. Hg.	– 24 mm. Hg.	– 24 mm. Hg.	– 22 mm. Hg.	– 22 mm. Hg.	– 22 mm. Hg.

Total, – 86·8 mm. Hg.

Final Average, – 17·36 mm. Hg.

Fig. III



Deep Inhalation with Protracted Abdomen.
(Side View)

EXPERIMENT VII

OBJECT OF THE EXPERIMENT :—

The object of this experiment was to determine the intra-œsophageal pressure during deep inhalation when the abdominal muscles were kept *protracted*, so that a comparison might be instituted between the result of this experiment and that of the fifth. Because such a comparison was calculated to settle the question as to which of two types of inhalation secured deeper inspiration.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it directly after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

THE EXPERIMENT PROPER :—

Subjects were made to practise deep inhalation with the abdominal muscles kept *protracted*. The inhalations were practised in a sitting posture. A side view of one of the subjects is shown in Fig. III. Readings were noted down as they were available for each successive inhalation. Averages being worked out as in the foregoing experiments, the final average showed a fall of 16·83 mm. of mercury. Detailed readings are tabulated on the next page.

REMARKS :—

The fall in the intra-œsophageal pressure recorded in this experiment is much less than the fall noted in Experiment V. Now the intra-œsophageal pressure decreases in proportion to the depth of inhalation. Hence we conclude that the inhalation secured in Experiment V was deeper than the inhalation made available in this. In protracting the abdomen, the diaphragm might, indeed, descend lower, but the ribs remain depressed ; and the advantage gained by the descent of the diaphragm *is more than lost* by the depression of the ribs.

PRESSURE CONDITION IN THE ŒSOPHAGUS IN FORCED INSPIRATION

WITH PROTRACTED ABDOMEN

Readings of Experiment VII

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	– 26 mm. Hg.	– 28 mm. Hg.	– 30 mm. Hg.	– 24 mm. Hg.	– 20 mm. Hg.	– 25·6 mm. Hg.
B	– 14 mm. Hg.	– 10 mm. Hg.	– 8 mm. Hg.	– 10 mm. Hg.	– 8 mm. Hg.	– 10 mm. Hg.
C	– 16 mm. Hg.	– 20 mm. Hg.	– 22 mm. Hg.	– 20 mm. Hg.	– 20 mm. Hg.	– 19·6 mm. Hg.
D	– 14 mm. Hg.	– 8 mm. Hg.	– 12 mm. Hg.	– 12 mm. Hg.	– 8 mm. Hg.	– 10·8 mm. Hg.
E	– 24 mm. Hg.	– 20 mm. Hg.	– 18 mm. Hg.	– 14 mm. Hg.	– 16 mm. Hg.	– 18·4 mm. Hg.

Total, – 84·4 mm. Hg.

Final Average, – 16·88 mm. Hg.

Fig. IV

Deep Exhalation.
(Side View)

EXPERIMENT VIII

OBJECT OF THE EXPERIMENT :—

According to the accepted physiological principles the intra-thoracic pressure continues to be slightly negative even in the deepest expiration. The object of this experiment was to find whether or not the œsophagus shares the negative pressure prevailing in the mediastinal cavity during deep expiration.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it immediately after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

THE EXPERIMENT PROPER :—

Subjects were made to practise deep exhalation in a sitting posture. A side view of one of the subjects is shown in Fig. IV. Readings were noted down as they were available for each successive exhalation. Averages being worked out as in the foregoing experiments, the final average showed a rise of 15·12 mm. of mercury. Detailed readings are tabulated on the next page.

REMARKS :—

The result shows that the œsophagus is not affected by the negative pressure available in the mediastinal cavity even during deep expiration. On the contrary the œsophagus shows a rise in positive pressure. This looks to be due to the pressure of the surrounding organs applied individually to the œsophagus during the act of forced expiration.

PRESSURE CONDITION IN THE ŒSOPHAGUS IN FORCED EXPIRATION

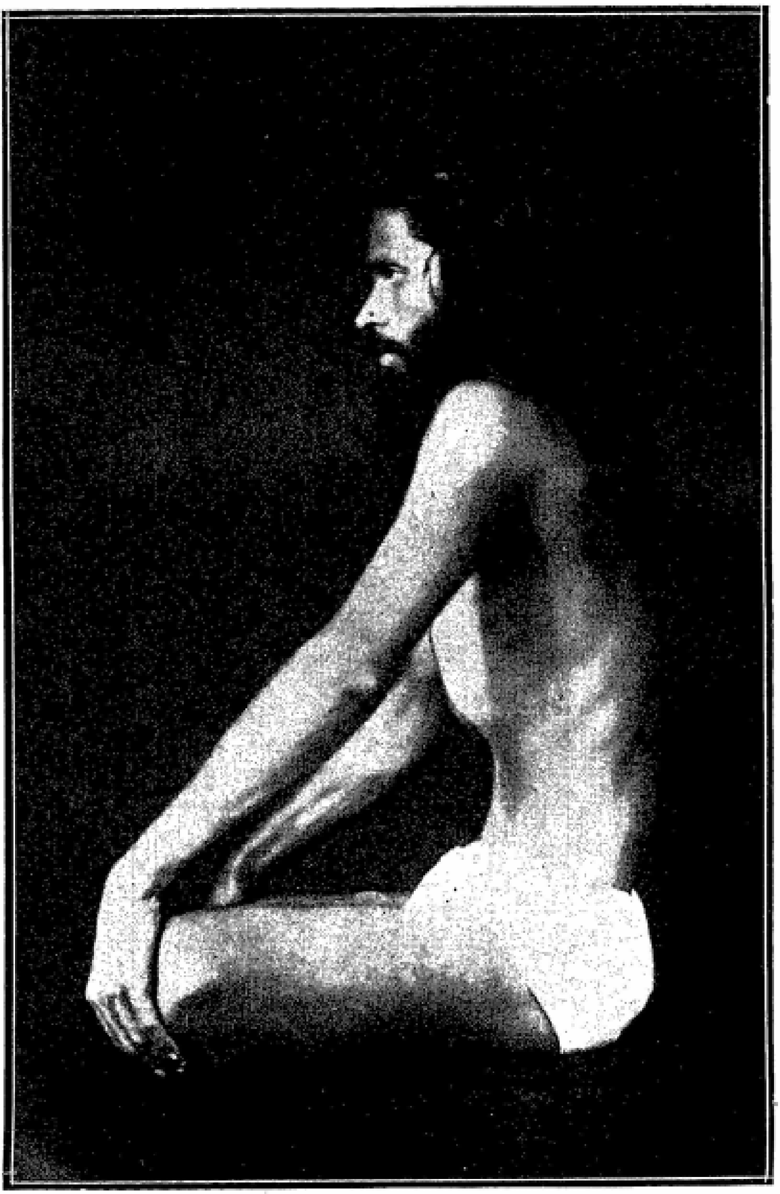
Readings of Experiment VIII

Subjects	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	+ 20 mm. Hg.	+ 14 mm. Hg.	+ 16 mm. Hg.	+ 10 mm. Hg.	+ 10 mm. Hg.	+ 14 mm. Hg.
B	+ 14 mm. Hg.	+ 8 mm. Hg.	+ 6 mm. Hg.	+ 6 mm. Hg.	+ 8 mm. Hg.	+ 8·4 mm. Hg.
C	+ 10 mm. Hg.	+ 8 mm. Hg.	+ 10 mm. Hg.	+ 8 mm. Hg.	+ 8 mm. Hg.	+ 8·8 mm. Hg.
D	+ 10 mm. Hg.	+ 8 mm. Hg.	+ 12 mm. Hg.	+ 10 mm. Hg.	+ 20 mm. Hg.	+ 12 mm. Hg.
E	+ 30 mm. Hg.	+ 40 mm. Hg.	+ 32 mm. Hg.	+ 30 mm. Hg.	+ 30 mm. Hg.	+ 32·4 mm. Hg.

Total, + 75·6 mm. Hg.

Final Average, + 15·12 mm. Hg.

Fig. V



After Deep Expiration if Inspiration is Maintained with Closed Glottis.
(Side View)

EXPERIMENT IX

OBJECT OF THE EXPERIMENT :—

The object of this experiment was to determine the intra-œsophageal pressure after deep expiration if inspiration was maintained with closed glottis. It is to be noted that the respiratory conditions required in this experiment form the first factor in the technique of Uḍḍiyāna. For in that exercise after deep expiration one tries to inhale while he keeps his glottis closed. The other factor in Uḍḍiyāna consists of further elevation of the ribs by a more thorough contraction of the intercostals. Now this experiment is important from the Yogic point of view, because it determines the pressure changes due to the first factor in the execution of Uḍḍiyāna. It would also enable us to calculate the pressure changes due to the second factor, when we compare the results of this experiment with that of the eleventh which records the pressure changes due to full Uḍḍiyāna.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last, and were taken up for it directly after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

THE EXPERIMENT PROPER :—

Subjects were made to attempt inhalation after they had deeply exhaled, while they held out their breath by keeping the glottis closed. This they were required to do in a sitting posture. A side view of one of the subjects is shown in Fig. V. Readings were noted down as they were available for each successive attempt to produce the necessary condition in respiration. Averages being worked out as in the foregoing experiments, the final average showed a fall of

33·68 mm. of mercury. Detailed readings are tabulated on the next page.

REMARKS :—

Western physiologists have conducted experiments on the respiratory conditions taken up for the present experiment. In determining the intra-thoracic pressure, they found a minimum fall of 30 and a maximum fall of 80 mm. of mercury. When we compare the result of our experiment with their findings, we obviously see that the œsophagus is greatly affected by the decrease of the intra-thoracic pressure during the respiratory conditions under experiment here.

Again when we compare the result of the present experiment with that of the eleventh, we find that the fall in the intra-œsophageal pressure caused by the first factor in the technique of Uḍḍiyāna, is smaller than the fall caused by the second factor. For this experiment records a fall of 33·68 mm. Hg., whereas the eleventh experiment records a fall of 78·8 mm. Hg. By deducting 33·68 from 78·8 we get 45·12 mm. Hg., as the decrease in the intra-œsophageal pressure due to the second factor in the performance of Uḍḍiyāna. According to Experiment XI, 78·8 mm. of mercury represents the fall in the intra-œsophageal pressure caused by the full execution of Uḍḍiyāna.

PRESSURE CONDITION IN THE ŒSOPHAGUS AFTER FORCED EXPIRATION

IF INSPIRATION IS MAINTAINED WITH CLOSED GLOTTIS

Readings of Experiment IX

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	- 30 mm. Hg.	- 26 mm. Hg.	- 20 mm. Hg.	- 24 mm. Hg.	- 26 mm. Hg.	-25·2 mm. Hg.
B	- 30 mm. Hg.	- 34 mm. Hg.	- 50 mm. Hg.	- 50 mm. Hg.	- 60 mm. Hg.	-44·8 mm. Hg.
C	- 70 mm. Hg.	- 64 mm. Hg.	- 50 mm. Hg.	- 56 mm. Hg.	- 70 mm. Hg.	- 62 mm. Hg.
D	- 16 mm. Hg.	- 20 mm. Hg.	- 16 mm. Hg.	- 18 mm. Hg.	- 18 mm. Hg.	-17·6 mm. Hg.
E	- 16 mm. Hg.	- 20 mm. Hg.	- 18 mm. Hg.	- 16 mm. Hg.	- 24 mm. Hg.	-18·8 mm. Hg.

Total, - 168·4 mm. Hg.

Final Average, - 33·68 mm. Hg.

EXPERIMENT X

OBJECT OF THE EXPERIMENT :—

The object of this experiment was to determine the intra-œsophageal pressure produced after inspiration, if expiration is maintained with closed glottis. The importance of this experiment will be fully understood when we study Experiment XII.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last and were taken up for it immediately after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

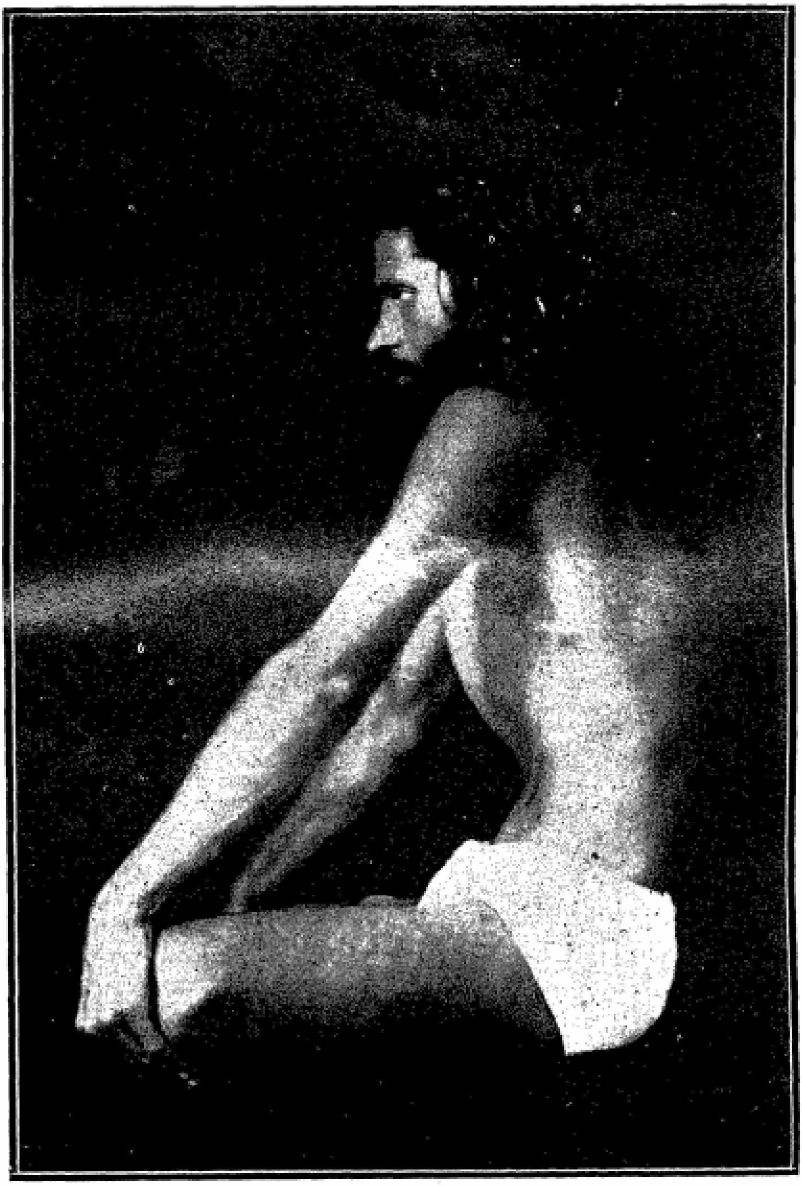
THE EXPERIMENT PROPER :—

Subjects were made to attempt exhalation with closed glottis after they had deeply inhaled. They were required to do this in a sitting posture. A side view of one of the subjects is shown in Fig. VI. Readings were noted down as they were available at each successive attempt to produce the necessary condition in respiration. Averages being worked out as in the foregoing experiments, the final average showed a rise of 50·56 mm. of mercury. Detailed readings are tabulated on the next page.

REMARKS :—

According to the Western physiologists the rise in the intra-thoracic pressure available in conditions under experiment here, is from 60 to 100 mm. Hg. When we compare with this a rise of 50·56 mm. Hg. in the intra-œsophageal pressure, we at once see that under the conditions produced here, the œsophagus very largely yields to the pressure produced in the mediastinal cavity.

Fig. VI



After Deep Inhalation if Exhalation is Maintained with Closed Glottis.
(Side View)

PRESSURE CONDITION IN THE ŒSOPHAGUS AFTER FORCED INSPIRATION

IF EXPIRATION IS MAINTAINED WITH CLOSED GLOTTIS

Readings of Experiment X

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	+ 56 mm. Hg.	+ 74 mm. Hg.	+ 50 mm. Hg.	+ 54 mm. Hg.	+ 44 mm. Hg.	+ 55·6 mm. Hg.
B	+ 40 mm. Hg.	+ 40 mm. Hg.	+ 30 mm. Hg.	+ 50 mm. Hg.	+ 50 mm. Hg.	+ 42 mm. Hg.
C	+ 50 mm. Hg.	+ 64 mm. Hg.	+ 70 mm. Hg.	+ 80 mm. Hg.	+ 70 mm. Hg.	+ 66·8 mm. Hg.
D	+ 24 mm. Hg.	+ 34 mm. Hg.	+ 24 mm. Hg.	+ 20 mm. Hg.	+ 30 mm. Hg.	+ 26·4 mm. Hg.
E	+ 60 mm. Hg.	+ 80 mm. Hg.	+ 70 mm. Hg.	+ 70 mm. Hg.	+ 30 mm. Hg.	+ 62 mm. Hg.

Total, + 252·8 mm. Hg.

Final Average, + 50·56 mm. Hg.

EXPERIMENT XI

OBJECT OF THE EXPERIMENT :—

The object of the experiment was to ascertain the intra-œsophageal pressure during Uḍḍiyāna, with a view to understand by inference the intra-pulmonic and intra-thoracic pressures that would prevail during that practice.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last, and were taken up for it immediately after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

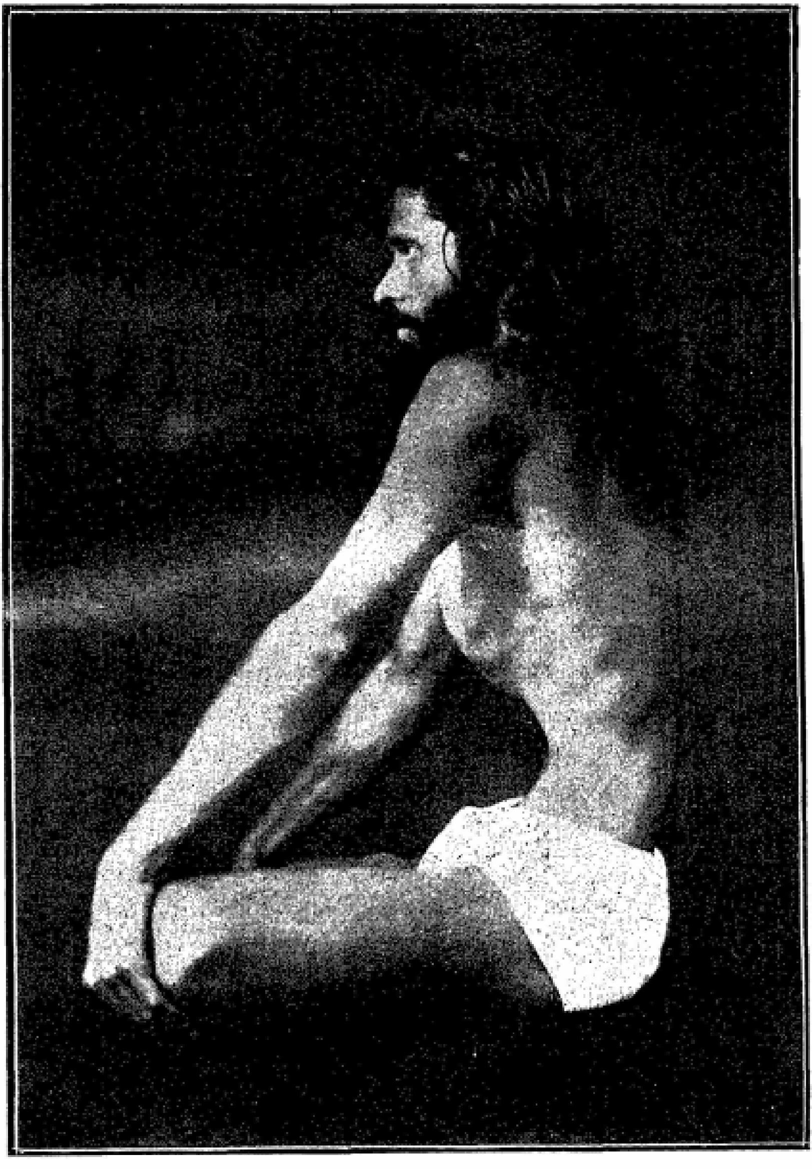
THE EXPERIMENT PROPER :—

Subjects were made to practise Uḍḍiyāna in a sitting posture. A side view of one of the subjects is shown in Fig. VII. Readings were noted down as they were available in each successive attempt at Uḍḍiyāna. Averages being worked out as in the foregoing experiments, the final average showed a fall of 78·8 mm. Hg. Detailed readings are tabulated on the next page.

REMAKS :—

This high negative pressure of 78·8 mm. Hg. in the œsophagus unmistakably points to a higher negative pressure in the thorax and a still higher negative pressure in the lungs during the practise of Uḍḍiyāna.

Fig. VII



Uḍḍiyâna.
(Side View)

PRESSURE CONDITION IN THE ŒSOPHAGUS IN UḌḌIYĀNA

AFTER FORCED EXPIRATION

Readings of Experiment XI

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	- 56 mm. Hg.	- 64 mm. Hg.	- 72 mm. Hg.	- 56 mm. Hg.	- 70 mm. Hg.	-63·6 mm. Hg.
B	- 70 mm. Hg.	- 74 mm. Hg.	- 90 mm. Hg.	- 80 mm. Hg.	- 90 mm. Hg.	-80·8 mm. Hg.
C	- 110 mm. Hg.	- 120 mm. Hg.	- 120 mm. Hg.	- 124 mm. Hg.	- 130 mm. Hg.	-120·8 mm. Hg.
D	- 50 mm. Hg.	- 44 mm. Hg.	- 46 mm. Hg.	- 44 mm. Hg.	- 50 mm. Hg.	-46·8 mm. Hg.
E	- 80 mm. Hg.	- 100 mm. Hg.	- 80 mm. Hg.	- 70 mm. Hg.	- 80 mm. Hg.	- 82 mm. Hg.

Total, - 394 mm. Hg.

Final Average, - 78·8 mm. Hg.

EXPERIMENT XII

OBJECT OF THE EXPERIMENT :—

The object of this experiment was to determine the intra-œsophageal pressure during Uḍḍiyāna practised after full inhalation and thus to infer the intra-pulmonic and intra-œsophageal pressures in this particular development of Prāṇāyāma.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried in this experiment as in the last, and were taken up for it directly after that experiment.

THE APPARATUS :—

The apparatus used in the last experiment was also used here.

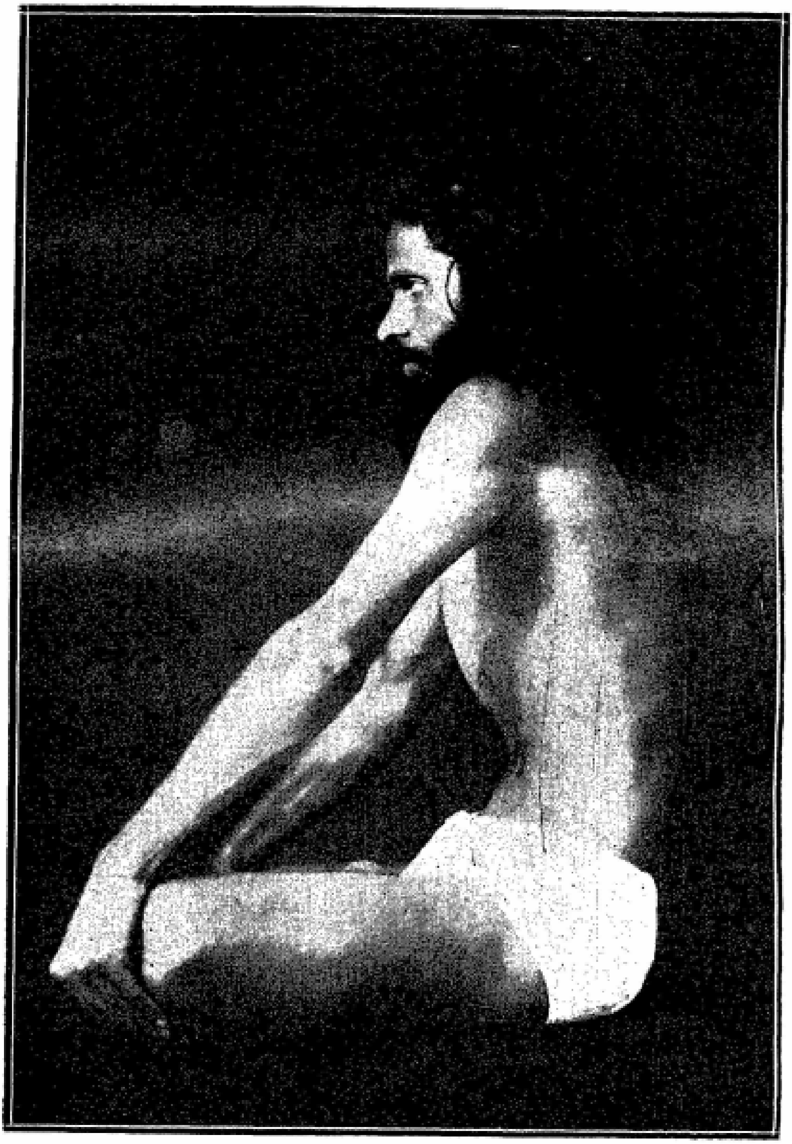
THE EXPERIMENT PROPER :—

Subjects were made to practise Uḍḍiyāna after deep inhalation, in a sitting posture. A side view of one of the subjects is shown in Fig. VIII. Readings were noted down as they were available for each successive Uḍḍiyāna. Averages being worked out as in the foregoing experiments, the final average showed a rise of 36·96 mm. Hg. Detailed readings are tabulated on the next page.

REMARKS :—

The difference between this experiment and the tenth is that in Experiment X after deep inhalation the glottis was closed and an exhalation was maintained; whereas here instead of maintaining exhalation, *further* attempt is made at inhalation. This difference in technique explains the difference of 13·6 mm. Hg. in the two pressures. The respiratory condition required in this experiment is an important development in Prāṇāyāma. We can infer that the intra-thoracic and intra-pulmonic pressures produced in the respiratory condition of this experiment, must be lower than these pressures produced by respiratory conditions required in Experiment X.

Fig. VIII



Uḍḍiyâna after Deep Inhalation.
(Side View)

PRESSURE CONDITION IN THE ŒSOPHAGUS IN UḌḌIYĀNA

AFTER FORCED INSPIRATION

Readings of Experiment XII

Subject	1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt	Average
A	+ 28 mm. Hg.	+ 24 mm. Hg.	+ 64 mm. Hg.	+ 10 mm. Hg.	+ 12 mm. Hg.	+27·6mm.Hg.
B	+ 30 mm. Hg.	+ 14 mm. Hg.	+ 26 mm. Hg.	+ 34 mm. Hg.	+ 36 mm. Hg.	+28 mm. Hg.
C	+ 50 mm. Hg.	+ 40 mm. Hg.	+ 40 mm. Hg.	+ 30 mm. Hg.	+ 50 mm. Hg.	+42 mm.Hg.
D	+ 34 mm. Hg.	+ 40 mm. Hg.	+ 30 mm. Hg.	+ 40 mm. Hg.	+ 34 mm. Hg.	+35·6mm.Hg.
E	+ 50 mm. Hg.	+ 50 mm. Hg.	+ 48 mm. Hg.	+ 60 mm. Hg.	+ 50 mm. Hg.	+51·6mm.Hg.

Total, + 184·8 mm. Hg.

Final Average, + 36·96 mm. Hg.

Experiment	Location of Pressure	Description of Pressure	1st Average	2nd Average
1	At the Nares	During Ordinary Inspiration	+ 26·8 mm. of water	- 19·6 mm. of water
2	" " "	During Ordinary Expiration	+ 20·8 mm. of water	+ 25·2 mm. of water
3	Intra-Œsophageal	During Ordinary Inspiration	- 111·6 mm. of water	- 85·2 mm. of water
4	"	During Ordinary Expiration	- 52 mm. of water	- 46·4 mm. of water
5	"	During Forced Inspiration with Controlled Abdomen	- 29 6 mm. Hg.	- 22 mm. Hg.
6	"	During Forced Inspiration with Contracted Abdomen	- 20·8 mm. Hg.	- 14·8 mm. Hg.
7	"	During Forced Inspiration with Protracted Abdomen	- 25·6 mm. Hg.	- 10 mm. Hg.
8	"	During Forced Expiration	+ 14 mm. Hg.	+ 8·4 mm. Hg.
9	"	After Forced Expiration if Inspiration is Maintained with Closed Glottis	- 25·2 mm. Hg.	- 44·8 mm. Hg.
10	"	After Forced Inspiration if Expiration is Maintained with Closed Glottis	+ 55·6 mm. Hg.	+ 42 mm. Hg.
11	"	In Uddiyana after Forced Expiration	- 63·6 mm. Hg.	- 80·8 mm. Hg.
12	"	In Uddiyana after Forced Inspiration	+ 27·6 mm. Hg.	+ 28 mm. Hg.

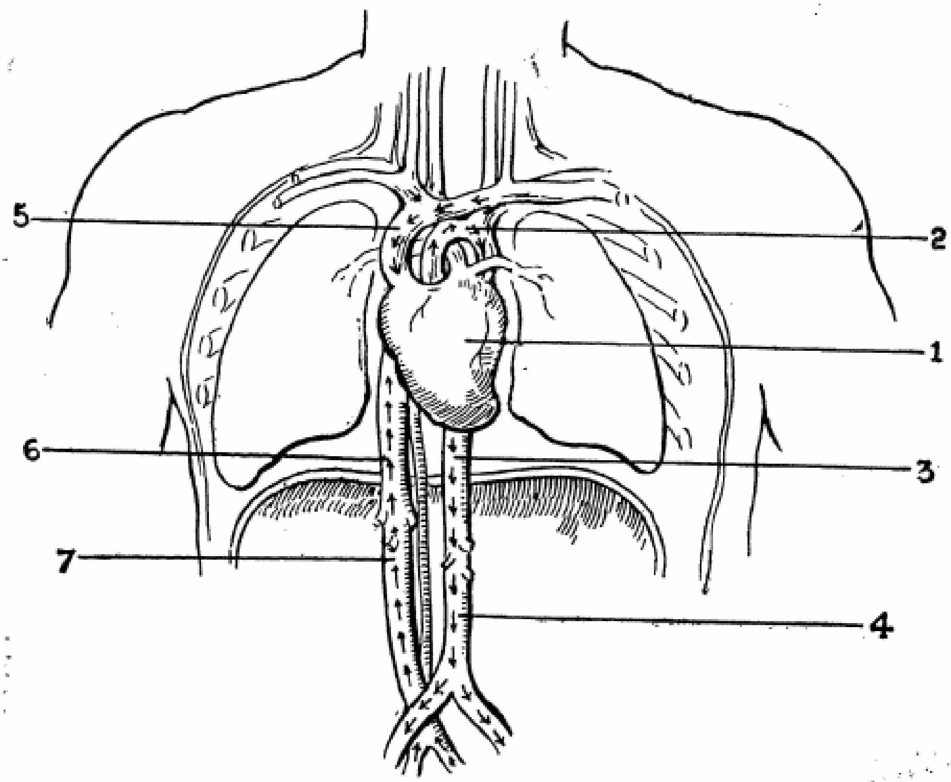
PRĀṆĀYĀMA AT A GLANCE

3rd Average	4th Average	5th Average	Final Average
- 18 mm. of water	- 21·2 mm. of water	- 16·4 mm. of water	- 20·4 mm. of water
+ 10 mm. of water	+ 10 mm. of water	+ 10 mm. of water	+ 15·2 mm. of water
- 94·8 mm. of water	- 50 mm. of water	- 64 mm. of water	- 81·12 mm. of water
- 33·2 mm. of water	- 18·8 mm. of water	- 24 mm. of water	- 34·88 mm. of water
- 21·6 mm. Hg.	- 14 mm. Hg.	- 18·8 mm. Hg.	- 21·2 mm. Hg.
- 17·2 mm. Hg.	- 12 mm. Hg.	- 22 mm. Hg.	- 17·36 mm. Hg.
- 19·6 mm. Hg.	- 10·8 mm. Hg.	- 18·4 mm. Hg.	- 16·88 mm. Hg.
+ 8·8 mm. Hg.	+ 12 mm. Hg.	+ 32·4 mm. Hg.	+ 15·12 mm. Hg.
- 62 mm. Hg.	- 17·6 mm. Hg.	- 18·8 mm. Hg.	- 33·68 mm. Hg.
+ 66·8 mm. Hg.	+ 26·4 mm. Hg.	+ 62 mm. Hg.	+ 50·56 mm. Hg.
- 120·8 mm. Hg.	- 46·8 mm. Hg.	- 82 mm. Hg.	- 78·8 mm. Hg.
+ 42 mm. Hg.	+ 35·6 mm. Hg.	+ 51·6 mm. Hg.	+ 36·96 mm. Hg.

The Director of the Kaivalyadhāma is ever willing to help those who are in earnest about their spiritual advancement, as he confidently feels that this help will in a way help his cause.

THE SEMI-SCIENTIFIC SECTION

Fig. X



The Circulatory System and the Diaphragm.

1 The Heart.
2 The Arch of the Aorta.
3 The Thoracic Aorta.
4 The Abdominal Aorta.
5 The Superior Vena Cava.
6 The Inferior Vena Cava—Thoracic.
7 The Inferior Vena Cava—Abdominal.

PRESSURE CHANGES IN PRĀṆĀYĀMA

PRESSURE changes in Prāṇāyāma can best be understood when they are studied along with the pressure conditions in ordinary respiration In this note, we shall, therefore, discuss both the types of pressure changes side by side.

Three types of pressures will be taken into account, namely, intra-pulmonic, intra-thoracic and intra-œsophageal, although we may refer to some other pressures induced by the respiratory actions, normal and abnormal. Before we proceed to deal with the development of these pressures, however, we shall briefly refer to some anatomical points about the thorax and the organs situated in it, so that our readers can easily understand the discussion that follows.

ANATOMY OF THE THORAX

The thorax is an air-tight compartment closed at the bottom by means of the diaphragm and covered over by the dome of the ribs. This thoracic compartment is elastic, shrinking and swelling alternately, several times every minute. It has no direct communication with the atmosphere outside. In this compartment are accommodated two elastic bags in the form of the lungs covered with the pleuræ. These pulmonary bags are not air-tight, but have communication with the atmosphere through the air tubes. The lungs, however, do not occupy all the space that is available in the thorax. Some of it has been left vacant and is occupied principally by such organs as the heart, the aorta and its branches, the inferior and superior venæ cavæ, and the œsophagus.. Even in their most contracted form, the lungs keep pressing upon these organs. Figs. IX and X taken together illustrate these organs as contained in the thorax. The cavity which contains the heart, the œsophagus etc., lies between the two lungs and is known as the mediastinal cavity. It has no direct communication with the external air.

THE INTRA-PULMONIC PRESSURE

Intra-pulmonic pressure may be defined as the pressure exerted on the lungs by the air contained therein. During the act of respiration, whether it is normal or abnormal, this pre-

ssure is constantly undergoing changes. We shall first try to understand the changes going on in the intra-pulmonic pressure during normal breathing. Let us start with the act of inhalation.

According to science three conditions must always be fulfilled before air can move from one place to another.

(*i*) There must be difference in pressures of the two places between which air is to move.

(*ii*) These two places must have a free communication with each other.

(*iii*) The place to which air is to move must be under lower pressure.

Now in inhalation external air moves into the lungs. This is because the three conditions laid down just now are fully satisfied. Throughout the act of inhalation, the thorax is being opened out, by the progressive elevation of the ribs, and the contraction and descent of the diaphragm. Thus the thoracic capacity is increased and along with it the capacity of the lungs. This increase in the capacity of the lungs, leads to the rarefaction of the air contained in them and the intra-pulmonic pressure is lowered. Before the expansion of the thorax, the air inside the lungs is at the same pressure as the atmosphere outside. But afterwards owing to rarefaction, the air inside the lungs stands at a lower pressure than the external air which continues to be at the atmospheric pressure. In this way the first and the third conditions are satisfied. The air passage affords free communication between the lungs and the external air, thus fulfilling the second condition.

As soon, however, as the thorax ceases to expand, the air pressure inside the lungs and outside them, becomes equal, and the movement of air stops. There is a *pause*. *So we find that throughout inhalation the intra-pulmonic pressure is less than one atmosphere and that in the pause which follows, this pressure becomes equal to the atmosphere.*

After the pause the thorax begins to sink, the lungs begin to contract and consequently the air inside the lungs

becomes more dense. This increases the intra-pulmonic pressure which becomes greater than one atmosphere. Naturally the movement of air is from the lungs to the external atmosphere. *Throughout the act of exhalation the intra-pulmonic pressure continues to be higher than one atmosphere; and when the lungs cease to contract any further, it again becomes equal to the atmosphere and leads to another pause.*

The pressure changes taking place in *deep* breathing are not different from the pressure changes occurring in *normal* respiration. Throughout the act of deep inhalation, the intra-pulmonic pressure is lower than the atmosphere, whereas throughout the act of deep exhalation, the intra-pulmonic pressure is higher than one atmosphere. The two pauses, one following deep inhalation and the other following deep exhalation, are characterized by an atmospheric pressure in the lungs, just as in the normal breathing.

Some of our readers may find it difficult to follow the statement made in the last paragraph. They are likely to be under the impression that deep inhalation and exhalation must record greater pressure changes than normal inhalation and exhalation; and that the pauses occurring in deep respiration must show higher intra-pulmonic pressure than the ordinary pauses in breathing. But this impression is not based on facts. We shall explain how.

First of all we have to remember one physiological principle. The amount of air to be breathed in or breathed out will invariably depend upon the capacity of the lungs to contain air at the atmospheric pressure. At no stage either in deep or normal respiration can a man take in or give out even one c. c. of air over and above the amount his lungs can contain. That means at any stage in respiration, so long as there is free communication between the lungs and the atmosphere outside, the volume of the air contained in the lungs and the capacity of the lungs are equal. The reason is obvious. As there is free communication, the air inside the lungs always tries to maintain itself at the atmospheric pressure either by getting rid of the excess or by making up the shortage.

Now in deep inspiration we admittedly take in a larger volume of air than in ordinary inspiration. But this is because in deep inspiration we increase the capacity of lungs far more than in ordinary inspiration. Hence even when the volume of air inhaled in deep inspiration is larger, it is not larger than the capacity of the lungs. For this reason even in deep inspiration intra-pulmonic pressure is the same as in ordinary inspiration. It continues to be slightly lower than one atmosphere.

During the pause that follows deep inhalation, the intra-pulmonic pressure becomes equal to the atmosphere outside the lungs.

The pressure changes occurring in deep exhalation are the same as those occurring in normal exhalation, because in both the cases, the change in the intra-pulmonic pressure is due to the shrinkage in the capacity of the lungs. The pressure is slightly above the atmosphere.

Again at the end of deep exhalation, the intra-pulmonic pressure becomes equal to the atmospheric, during the short pause that follows.

Up to now in this discussion about the pressure changes in deep breathing, we have taken for granted two things, namely, the air passage to be fully open throughout and the respiratory movement to be smooth in all its stages. If for any reason, however, the air passage becomes partially closed or the respiratory movement becomes hurried, different pressure changes will take place in the lungs. First we shall take up hurried respiration.

Hurried respiration means quick expansion and contraction of the lungs which in its turn means sudden increase and decrease in the capacity of the lungs. Now when the lung capacity increases suddenly, there will be a proportionately sudden fall in the intra-pulmonic pressure, and this pressure will be much lower than the pressure in smooth inhalation, because the incoming air will take some time before it can raise the pre-

ssure. In smooth inhalation, as soon as there is a little lowering of the intra-pulmonic pressure, the external air gets in and raises it to one atmosphere; but in hurried inhalation the fall in pressure is sudden and it takes some time before the external air can get in and re-establish the atmospheric pressure. Hence in hurried inhalation the intra-pulmonic pressure is lower than in smooth inhalation. Whether the inhalation is normal or deep is immaterial.

Similarly if the contraction of the thorax is quick, there is a sudden decrease in the capacity of the lungs. The compressed air cannot get out as quickly as it is being compressed. Hence the pressure is raised much higher than in smooth exhalation. The air in the compressed lungs takes some time to flow out and thus to reduce the pressure to one atmosphere. In smooth exhalation as the process of the pulmonic contraction is slow, air begins to flow out as soon as there is a little rise in the intra-pulmonic pressure. So we find that in hurried exhalation, the rise in the intra-pulmonic pressure is greater than in smooth exhalation. It does not matter whether the exhalation is normal or deep.

Similar changes in the intra-pulmonic pressure will take place, if the air passage to and from the lungs is not fully open. This passage may become narrow under certain pathological conditions. It may also be voluntarily narrowed down by a partial closer of the glottis. This latter procedure often forms a part of the technique of Prāṇāyāma.

Even when the contraction and expansion of the lungs is slow and progressive, if the glottis is partially closed, air will take more time than ordinarily, either to get out or to get in for re-establishing atmospheric pressure in the lungs. Hence the rise or fall in the intra-pulmonic pressure will be greater than when the glottis is fully open and will last longer than ordinarily.

If the movement of the lungs is sudden and is at the same time accompanied by a partial closure of the glottis, the rise or fall in the intra-pulmonic pressure will still be greater.

Up to now we have studied changes in the intra-pulmonic pressure as they occur during normal or deep breathing, with the glottis fully open or partially closed. Now we proceed to discuss those pressure changes which can be produced in the lungs, when the glottis is completely closed.

It does not require any physiological study to know that the glottis can be closed at any stage in inhalation or exhalation, either normal or forced. After this is done, the respiratory muscles can be manipulated in a number of ways, thus producing any number of varieties in the intra-pulmonic pressures. Because when the glottis is closed, the air in the lungs remains a constant quantity and every change in the capacity of the lungs will give a different pressure. As students of Pranayamic pressure changes, we are not, however, concerned with these infinite varieties of pressures. In Prāṇāyāma we have to deal with pressures produced after deepest exhalations or deepest inhalations followed by a complete closure of the glottis. We shall first discuss the pressure changes produced after exhalation.

After the deepest exhalation, the only possible manipulation of the respiratory apparatus is towards inhalation. Now as the glottis is to be kept closed, this inhalation will only be a mock inhalation, accompanied by void movements of the inspiratory muscles without any movement of breath. It will be easily seen that this mock inspiration may be normal or may be of the deepest possible type. The Western physiologists have taken notice of the normal void inspiratory movement, but have left out the other. It is to be noted that from the Pranayamic point of view the other movement alone is important.

Even in the void inspiration, the lung capacity is increased and as the quantity of air in the lungs continues to be the same, the intra-pulmonic pressure is greatly lowered. Even if the inspiratory movement is normal, the decrease in the intra-pulmonic pressure is considerable ; but the attempt at deepest inspiration is capable of producing extreme negative pressure in the lungs. On the strength of the experiments

published in the Scientific Section, we can safely state this negative pressure to be as great as 90 mm. Hg., if not greater. In Yogic language this deepest void inhalation following the deepest exhalation is known as Uḍḍiyāna.

Now we take up pressure changes produced after deep inhalation. Naturally these changes are produced by void attempts at expiration, and the results tend to increase the intra-pulmonic pressure. During all these attempts the capacity of the lungs decreases. And as the quantity of air in the lungs remains constant, the intra-pulmonic pressure is raised. If the expiration attempted is the deepest, it produces extreme pressure in the lungs, raising it even above 100 mm. of mercury. As this extreme pressure, repeatedly produced, is likely to do considerable damage to the system, Yogic exercises do not go to this length. There is one practice in Prāṇāyāma where very high intra-pulmonic pressure is created, but it is considerably lower than the extreme pressure noted above. This practice consists of maintaining Uḍḍiyāna after the deepest inhalation.

To summarize our discussion on the intra-pulmonic pressure changes, we find that the inspiratory movement, whether normal or forced, slightly lowers the pressure whereas the expiratory movement slightly raises it. The two pauses are characterized by an intra-pulmonic pressure equal to one atmosphere. Void and deep inspiratory movements after the deepest expiration lead to extreme negative pressure, while void and deep expiratory attemps raise the intra-pulmonic pressure to an extreme point.

THE INTRA-THORACIC PRESSURE

Intra-thoracic pressure may be defined as the pressure prevailing in the thorax outside the lungs, that is, the pressure existing in the pleural and the mediastinal cavities. In this note we shall not discuss the pressure changes in the pleural cavity; but shall satisfy ourselves with a study of the pressures in the other cavity only.

In the few points regarding the anatomy of the thorax that we noticed at the beginning of this note, we saw that the mediastinal cavity is an air-tight compartment. Hence it is clear that the atmosphere cannot directly influence the pressure changes in the thorax. It is to be noted, however, that the lungs keep constantly pressing upon the organs contained in the mediastinal cavity. And as the atmosphere perpetually presses upon the lungs, the organs situated in the mediastinal cavity are always influenced by the atmosphere through the lungs, though not directly. Now the lungs standing between the atmosphere and the intra-thoracic organs, that is, the organs in the mediastinal cavity, do not allow the whole of the atmospheric pressure to be put upon these organs, but try to reduce it by their constant tendency to contract or recoil. It is to be remembered that the lungs are perpetually on a stretch and even during the deepest expiration they cannot contract themselves to their normal size. Hence and owing to their constant tendency to recoil upon themselves, the lungs are perpetually counteracting the intra-pulmonic pressure, this counteracting pressure being equal to the force created by the elastic recoil of the lungs. In Fig. IX we have illustrated these two pressures by two types of arrow-heads pointing in the opposite direction. It will be clear to our readers, therefore, that the pressure put upon the mediastinal organs, that is, the intra-thoracic pressure, must be equal to the difference between the two pressures, namely, the intra pulmonic pressure and the pressure created by the elastic recoil of the lungs.

Now since under ordinary circumstances, the intra-pulmonic pressure is equal to one atmosphere, the intra-thoracic pressure must be negative, because it is always less than the intra-pulmonic pressure by an amount equal to the recoil of the lungs. The negative pressure is measured by this pulmonic recoil.

The force exerted by the recoiling lungs will vary according to the condition of contraction or expansion in which the lungs will be at a particular point of time. If the lungs are put on the fullest stretch this force will be maximum, as is the

case in the deepest inspiration; but the force will be minimum when the lungs are fully contracted, as they are in the deepest expiration. Western physiologists have tried to measure the pressure of this elastic recoil. On an average they found that the pulmonic recoil is equal to 7·5 mm. Hg. at the end of an ordinary inspiration and equal to 4·5 mm. Hg. at the end of an ordinary expiration. In the deepest inspiration this recoil is 30 mm. Hg.

From the figures quoted just now we understand the measure of the negative pressure present in the intra-thoracic region. If we take the usual amount of pressure in the lungs to be 760 mm. of mercury, that is, the ordinary atmospheric pressure, we can work out the intra-thoracic pressure therefrom. Deducting 4·5 from 760, we get 755·5 mm. Hg. to be the intra-thoracic pressure at the end of an ordinary expiration. In the same way (760 – 7·5) 752·5 mm. Hg. would be the intra-thoracic pressure at the end of a normal inspiration. But at the end of a deep inspiration, the intra-thoracic pressure will be as low as (760 – 30) 730 mm. of mercury.

Thus far we have discussed intra-thoracic pressure changes that occur while the glottis is open. The same rule, however, will apply to intra-thoracic pressures produced with the glottis closed. Because the intra-thoracic pressure will always be equal to the intra-pulmonic pressure minus the recoil of the lungs, even when extreme negative and positive pressures are produced in the lungs themselves. Thus in Uḍḍiyāna if the intra-pulmonic pressure is 680 mm. of mercury and the recoil of the lungs amounts to 10 mm. Hg., then the intra-thoracic pressure will be equal to (680 – 10) 670 mm. of mercury. So also when expiration is maintained after deep inspiration, and the intra-pulmonic pressure rises as high as 860 mm. of mercury, if the recoil of the lungs is 10 mm. Hg.; the intra-thoracic pressure will be (860 – 10) 850 mm. of mercury.

To sum up this discussion on the intra-thoracic pressure we find that it closely follows the intra-pulmonic pressure, the difference between them being always equal to the recoil of the lungs. The intra-thoracic pressure, under ordi-

nary circumstances, is generally negative, although it can rise or fall to an extreme, in correspondence with the intra-pulmonic pressure.

THE INTRA-ŒSOPHAGEAL PRESSURE

The organs situated in the mediastinal cavity, such as the heart, the œsophagus, the aorta and its branches, the two venæ cavæ, are all externally exposed to the intra-thoracic pressure, and more or less yield to it. The degree to which these organs are affected depends partly upon their internal pressure and partly upon the toughness of their walls. We now turn to the œsophagus and try to study its internal pressure as it is affected by the intra-thoracic pressure to which it is exposed.

After a number of experiments it has been found that the intra-œsophageal pressure is very largely affected by the intra-thoracic pressure, and keeps close correspondence with it. If there is a fall in the intra-thoracic pressure, there is a corresponding fall in the intra-œsophageal pressure, although on a smallar scale. Again if there is a rise in the intra-thoracic pressure, there is a corresponding rise in the intra-œsophageal pressure although on a smaller scale. So whenever there are variations in the intra-thoracic pressure, there are invariably corresponding variations in the intra-œsphageal pressure, although the variations do not take place in any exact proportion.

If we now remember that there is always an agreement between the different changes in the intra-thoracic and the intra-pulmonic pressures, we can safely conclude, that the three pressures, namely, intra-œsophageal, intra-thoracic and intra-pulmonary, vary as one another, though not in any exact proportion. We can also state it as a general proposition that in a particular condition of respiration, the intra-œsophageal pressure is less positive or less negative than the intra-thoracic and the intra-thoracic, lower than the intra-pulmonary. Thus in a particular condition of respiration, if one of the three pressures could be known, the other two may be roughly inferred.

The matter will at once become clear to our readers, if we quote a few figures here.

Description of Pressure	Intra-Œsophageal	Intra-Thoracic
During Ordinary Inspiration	− 81·12 mm. of water	− 102 mm. of water
During Ordinary Expiration	− 34·88 mm. of water	− 61·2 mm. of water
During Forced Inspiration	− 21·2 mm. of mercury	− 30 mm. of mercury
After Forced Expiration if Inspiration is Maintained with Closed Glottis.	− 33·68 mm. of mercury	− 55 mm. of mercury
After Forced Inspiration if Expiration is Maintained with Closed Glottis.	+ 50·5 mm. of mercury	+ 80 mm. of mercury

In the twelve experiments published in this issue, we have tried to know the intra-œsophageal pressures prevailing in the different stages of Prāṇāyāma. From these pressures we should be able to get a rough idea about the corresponding pressure conditions in the thorax and in the lungs.

EFFECTS OF PRESSURE CHANGES ON BLOOD FLOW

The three types of pressures that we have studied thus far, greatly affect the flow of the venous blood. But before we can clearly understand this subject, it is necessary for us to take notice of a fourth type of pressure, we mean the intra-abdominal pressure. Just like the thorax, the abdomen is an air-tight compartment. Ordinarily pressure conditions inside this compartment are not negative. The intra-abdominal pressure is raised either by the descent of the diaphragm or by the contraction of the abdomen. If both these things

simultaneously occur, the rise in pressure is considerable. Perhaps Uḍḍiyāna and Nauli are the only exercises which make the intra-abdominal pressure negative.

In our discussion on the intra-thoracic pressure, we have seen that under ordinary circumstances, that pressure remains always negative. Thus if we compare the abdomen and the thorax, we find that under ordinary conditions the thorax stands at a lower pressure than the abdomen.

Now if we take the inferior vena cava, we find that the lower part of it is situated in the abdomen, while the upper part lies in the thorax. (Vide Fig. X). It means that the lower part of the vena cava stands under a higher pressure than the upper part of it. The natural result is that the blood flow towards the heart is greatly accelerated. The right auricle of the heart into which the inferior vena cava ends also stands at a lower pressure than the abdomen. Hence it is able to suck up the blood from the lower part of that vein. What happens in the case of the inferior cava also happens in the case of the superior cava. That vein also is exposed to unequal pressures, the intra-thoracic pressure being lower than the extra-thoracic pressure. Hence we find that the negative pressure in the thorax enables the heart to suck up venous blood from all the extra-thoracic parts. This effect is often called the *aspiratory action of the thorax*.

In normal inspiration, the thorax becomes more favourably situated for executing its aspiratory action. Owing to the descent of the diaphragm, the intra-abdominal pressure is raised and the intra-thoracic pressure is lowered because the lungs are put upon a stretch. The difference in the two pressures increases, which proves more favourable for the suction of the venous blood. It may be easily seen that the deeper the inspiration, the more favourable are the conditions established for raising the venous blood to the heart. If after deepest inspiration, the abdominal muscles are vigorously contracted, the pressure condition becomes most favourable for the suction of the venous blood.

We have noticed in our discussion on the intra-thoracic pressure, that this pressure remains negative even after the deepest exhalation. Owing to the contraction of the abdominal muscles, the abdominal pressure is, however, raised. In this way even after the deepest exhalation, the difference between the intra-thoracic and extra-thoracic pressures remains great and favours the aspiratory action of the thorax.

If we take into consideration the flow of the arterialized blood from the lungs to the heart, we find that even normally pressure conditions are favourable to it. We have seen that the intra-pulmonic pressure is always higher than the intra-thoracic pressure. Here too it may be noted that deep inspirations will increase the difference between these two pressures and establish more favourable conditions for the blood flow to the heart. Deep expirations, however, will tend to make the conditions less favourable, because they lead to a decrease in the difference of the two pressures concerned.

To sum up, we find that inspiration, whether normal or deep, always helps the blood flow towards the heart, whether the blood comes through the venæ cavæ or the pulmonary veins. Expiration, whether normal or deep, also helps the flow through the cavæ, but establishes less favourable conditions for the blood flow through the pulmonary veins.

Now only one question remains to be discussed. What is the effect of these pressure changes upon the arterial blood flow ?

As a general rule arteries are far less affected by external pressure changes than the veins. The reason is threefold. The walls of the arteries are thick and tough, whereas the walls of the veins are thin and weak. Again the internal pressure in the arteries is very high while the internal pressure in the veins is quite low. Thirdly the veins are distensible, but the arteries are otherwise. Hence external pressures can easily affect the veins, but not the arteries.

This should not be interpreted to mean that the pressure changes in ordinary respiration and also in Prāṇāyāma

are not able to influence the arterial blood flow. As a matter of fact even the normal inspiration does improve the circulation in the arteries. Pranayamic inspiration must, therefore, affect arterial blood flow far more favourably. In order to understand this position, we must note a few points in the cardiac work.

We know that the two cavæ collect the venous blood from all over the body and pour it into the right auricle. This auricle remains relaxed for receiving this blood across nearly seven-eighths of a second, when it contracts suddenly and pours down the venous blood into the right ventricle in about one-eighth of a second. From the right ventricle, the blood is pressed into the lungs by its contraction. After being arterialized there, it comes again to the heart, being collected into the left auricle through four pulmonary veins. This left auricle also just like the right one, keeps itself relaxed for receiving the incoming blood and then by its sudden contraction, empties itself into the left ventricle. Thereafter this ventricle in its turn contracts vigorously and forces out blood through the aorta to be circulated over the whole body and to be ultimately returned to the right auricle.

Having followed the blood flow along its complete cycle of circulation, we shall now proceed to see how this blood flow is affected by the respiratory pressure changes. We have already seen that during inspiration, owing to a higher pressure in the extra-thoracic region and a lower pressure in the intra-thoracic part, larger quantities of venous blood are drawn towards the heart through the two cavæ. This venous blood is collected in the right auricle for the following reason. The external pressure, namely, the intra-thoracic pressure is the same so far as the thoracic cavæ and the right auricle are concerned. But during relaxation, being empty, the right auricle is at a far lower internal pressure than the loaded veins. Hence the whole quantity of venous blood flowing through the cavæ is collected in that auricle. It is to be remembered here that this right auricle itself,

being under a negative external pressure, becomes more than usually distended during inspiration and is thus capable of admitting larger quantities of blood than ordinarily. *This larger quantity* is then poured into the right ventricle and from there is pushed into the lungs. The pulmonic veins drain *this larger quantity* from the lungs, because of the lower intra-thoracic pressure, and the left auricle collects it all because of its lowest internal pressure. Then the left auricle sends *this whole larger quantity* into the left ventricle, which in its turn finally pushes it to the different parts of the system through the aorta and its branches.

Thus we see that inspiration though it does not distend arteries, does send through them a richer blood supply and thus favourably influences the arterial flow. If the inspiration is deep, as in Prāṇāyāma, the favourable effect will be greater.

We have seen above that, even during the deepest expiration, the intra-thoracic pressure continues to be negative although on a smaller scale. Hence pressure conditions are still somewhat favourable for the venous flow. And as the arterial flow would depend ordinarily upon the venous flow, even the deepest expiration, does not adversely affect the arteries.

N. B.—Instruction in Yogic culture higher as well as lower will be given gratis at the Āśrama to everyone that earnestly seeks it.

THE POPULAR SECTION

UJJĀYĪ PRĀṆĀYĀMA EXPLAINED

In this article we propose to offer physiological explanations for the different parts of the technique of Ujjāyī. Research work required to be done for a clear and thorough understanding of any type of Prāṇāyāma is so vast, that we have not succeeded in covering even a small fraction of it. However, we think it desirable to present to our readers whatever we could understand of the physiology of Ujjāyī from our researches and reserve further explanations for the time when additional investigation would be done. In discussing the physiology of Ujjāyī, we might discuss some of the points common to all varieties of Prāṇāyāma.

First we shall try to understand scientifically the question of the posture required to be assumed, in Ujjāyī. On p. 272 of the third volume, we have stated that Ujjāyī can be practised either in sitting or in standing or even in walking. There we have also pointed out that these options are available for a physical culturist only. A spiritual culturist has been advised to prefer the sitting posture. Before discussing the physiological aspects of these different positions of the body, we shall notice two features which are common to them all.

A physical culturist as well as a spiritual culturist, practising Ujjāyī has to keep his spine erect, whether the exercise is gone through while one is sitting, standing or walking, being immaterial. We have discussed at length the physiology of this part of the technique of Ujjāyī in our article on the meditative poses in the last two issues. There we have rejected the view which holds that the erect spine is essential for the right functioning of the spinal cord. It has been pointed out in that article that even in the most erect position of the spine, that organ continues to have two natural curves which cannot be effaced and that the right functioning of the spinal cord is not interfered

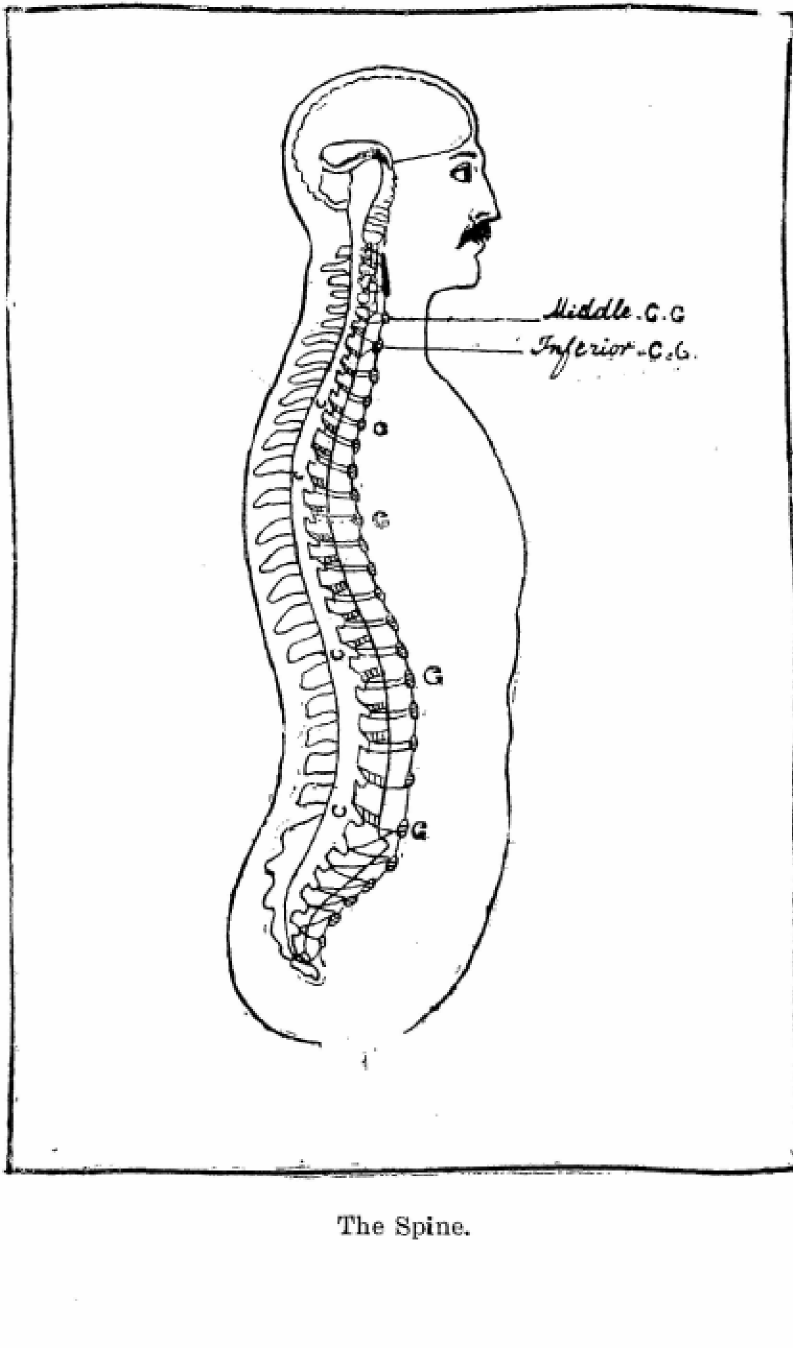
with by any spinal curves at all. Fig. XI illustrates the natural curves in the vertebral column. In the same article we have shown that owing to the surrounding membranes, the fluid, and the fatty tissues, the spinal cord is left unaffected by any bends, shocks or jerks of the spine. After thus criticizing the popular view, we have advanced our own view regarding the physiological advantages of an erect spine. The elimination of the possibility of the compression of abdominal viscera was claimed to be the principal advantage of an erect spine. The other advantage pointed out there, is the minimizing of the spinal burden. It has been stated that an erect posture puts minimum burden on the spine.

There is, however, a third advantage in keeping the spine erect. It ensures freedom for the diaphragm in its respiratory movements. When a man sits stooping, the compressed abdominal viscera seriously interfere with the movements of the diaphragm. All the three advantages due to the erect spine must be secured by a student of Yogic culture, whether he practises Ujjāyī in sitting, standing or walking.

When Ujjāyī is practised while one is standing or walking, one is likely to commit the following error as regards the position of the spine. A student of Yoga is likely to throw out his chest as shown in Fig. XII, and give his spine a backward bent. This is physiologically incorrect. In throwing out his chest, the student stretches his abdominal muscles which cannot, therefore, move freely and thus interfere with respiration. Fig. XIII represents the correct standing position for the exercise of Ujjāyī.

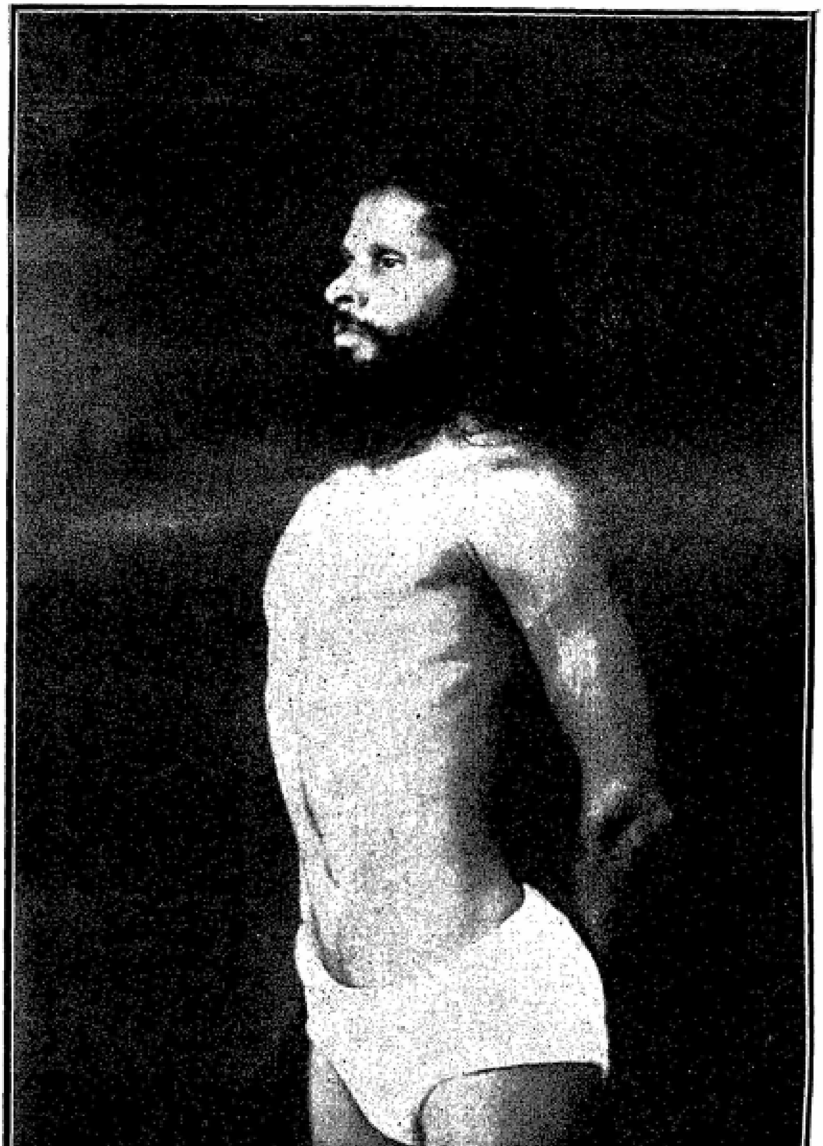
Having considered the advantages of an erect spine, we now proceed to discuss the physiological significance of the position of the hands. In Ujjāyī, the hands must rest on the knees as shown in Fig. LXXII or LXXIV in the third volume, if Prāṇāyāma is being practised in sitting. Or they may rest in front as illustrated in Fig. XIV. If the exercise is being undergone while the student is standing or walking, the hands

Fig. XI



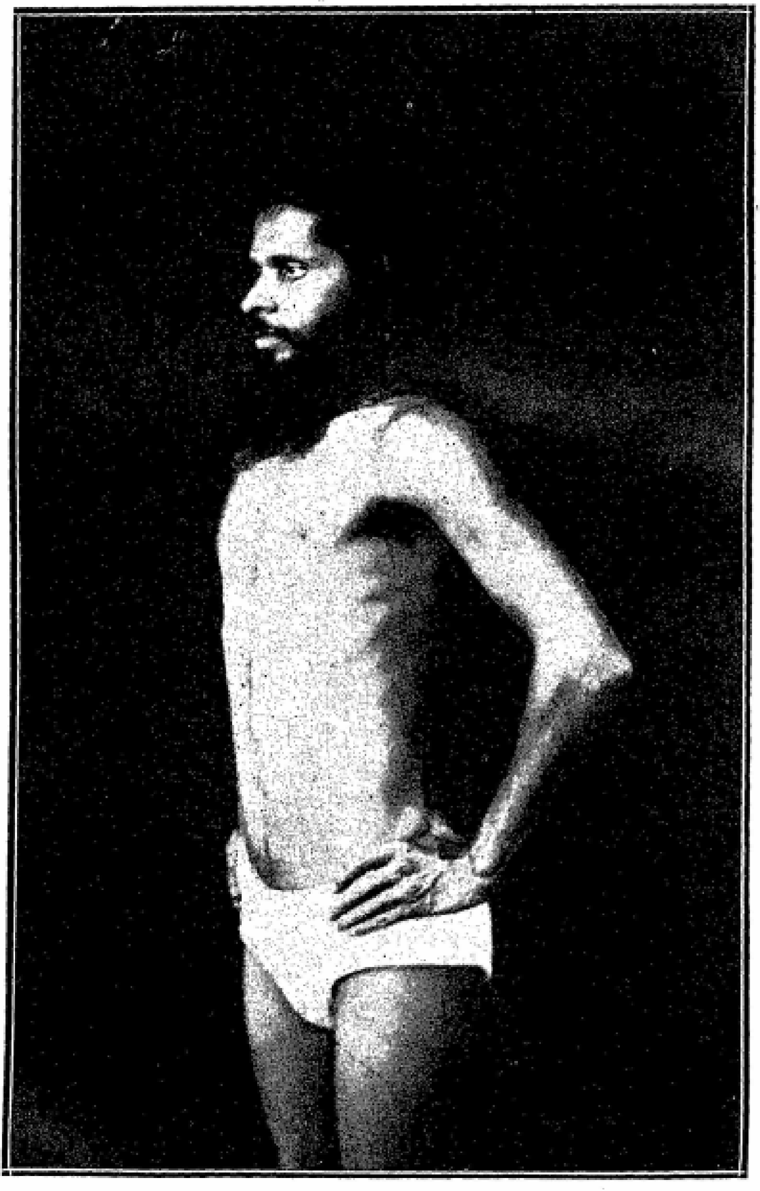
The Spine.

Fig. XII



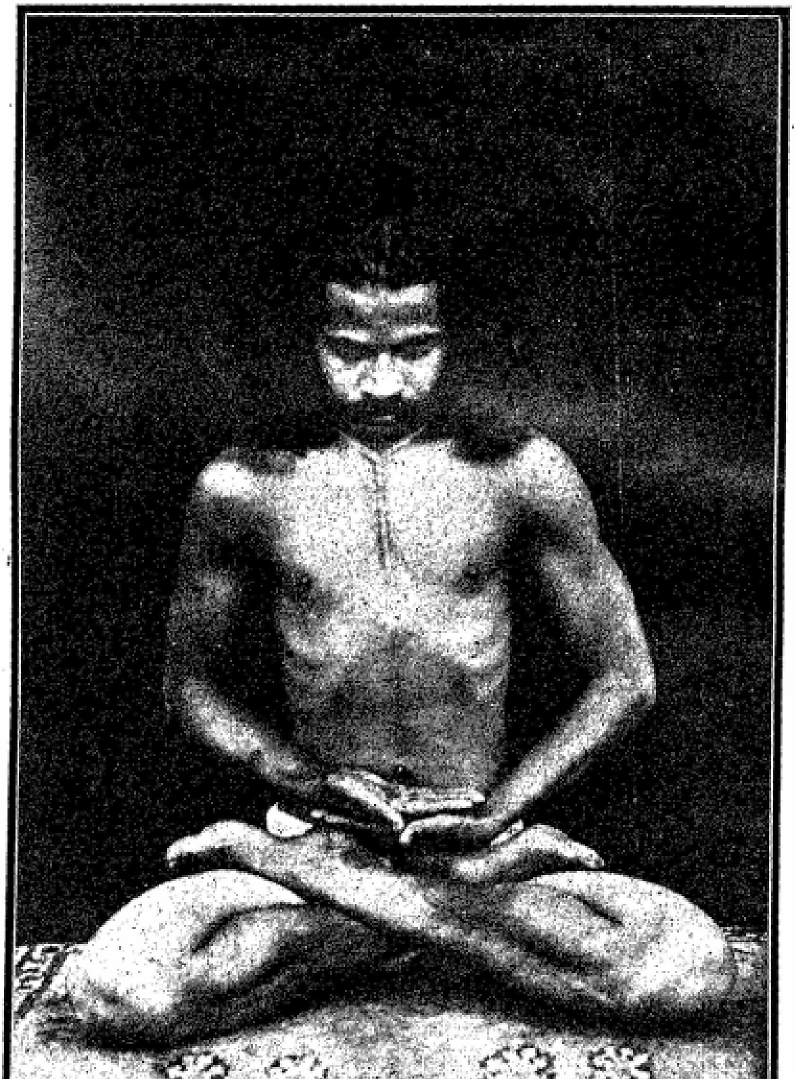
Chest Thrown out in Standing.

Fig. XIII



Correct Standing Position for Ujjâyî.

Fig. XIV



Hands Resting in Front.

must rest on the iliac bones as pictured in Fig. XIII. If the full orthodox technique is to be strictly followed, during exhalation the right hand may rest on the nose. Under no circumstances should the hands hang from the shoulders, thus putting their burden on the chest.

For any exercise in respiration whether it is Prāṇāyāma or any other type of breathing, the chest must be entirely free from burden, so that the respiratory movements may be as complete as possible. Hands, if they keep hanging from the shoulders, do put a burden upon the chest and do not allow inspiration as thorough as it would otherwise be. When the hands are given any of the resting positions pointed out above, this burden is partly removed and a freer inhalation is the result. Any one that practises Ujjāyī first with hands hanging and then with hands resting, can easily verify this statement. When the exercise is to continue for a considerable length of time, the burden of the hanging hands begins to be felt seriously. It is, however, immediately relieved, if the hands are given any of the resting positions available in this practice. Weak persons sitting in the meditative poses for a long time, will find it more comfortable to rest the hands in front than to rest them on the knees.

After the spine and the hands, the abdominal muscles come up for consideration. We mean the muscles comprising the front wall of the abdomen. We wish to examine Prāṇāyāma mainly for two values, for the oxygen value and for the nerve culture value. So the study of the abdominal muscles will also proceed from the point of view of these two values.

Taking for our examination the oxygen value first, we have to determine which position of the abdominal muscles will enable a student to inhale a larger quantity of oxygen for his system. Two positions have been advocated for inhalation. Western physical culturists, so far as we know, recommend the muscles to be relaxed and kept protracted, being

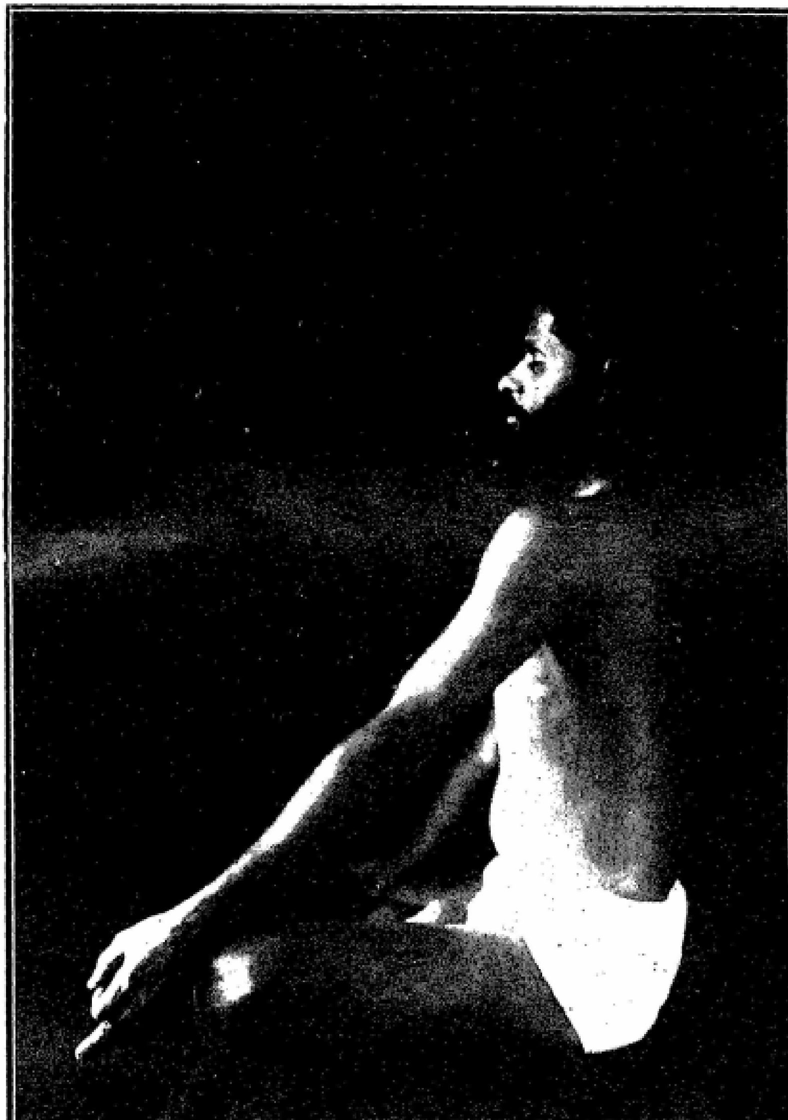
pushed out by the abdominal viscera. Yogic technique requires these muscles to be kept controlled. Figs. XV and XVI respectively illustrate the protracted abdomen and the controlled abdomen in inhalation. Which of the two positions of the abdominal muscles will secure more oxygen in inhalation?

Western physical culturists have claimed that the protracted abdomen allows the diaphragm to descend lower, thus ensuring larger thoracic capacity and a richer quantity of oxygen in inhalation. According to them the controlled abdominal muscles will retard the diaphragmatic descent and thus would lead to a smaller expansion of the thorax and a lesser quantity of oxygen in inhalation. We have performed a number of experiments in this connection and we have found that the position taken by the Western physical culturists is more imaginary than real.

For verification we have to revert to Experiments V and VII given in the Scientific Section of this issue. There we have studied the intra-œsophageal pressure caused by inhalation, both with protracted abdomen and with controlled abdomen. In the case of the controlled abdomen, the intra-œsophageal pressure turned out to be $-21{\cdot}2$ mm. of mercury whereas in the case of the protracted abdomen it was found to be $-16{\cdot}88$ mm. of mercury. Now as shown in our article on the pressure changes in Prāṇāyāma, there is *correspondence* in their variations between the intra-œsophageal pressure and the intra-pulmonic pressure. Hence we can conclude that the fall in the intra-pulmonic pressure, is greater in inhalations with controlled abdomen than in inhalations with protracted abdomen. These results lead us to the conclusion that the pulmonic capacity becomes much larger in inhalations with controlled abdomen than in inhalations with protracted abdomen. That means, one is able to inhale larger quantities of oxygen when the abdomen is kept controlled than when the abdomen is kept protracted.

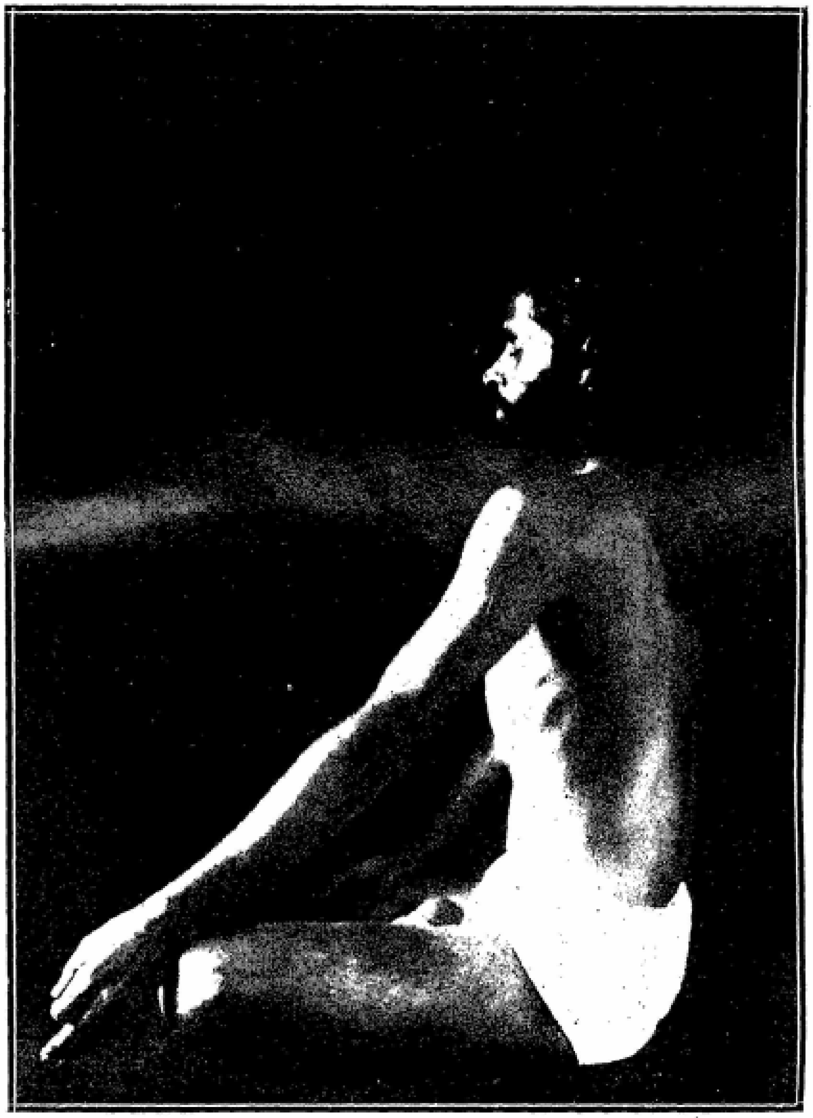
We have discussed the reason of this phenomenon in our remarks on Experiment VII. It is this: The protracted ab-

Fig. XV



Protracted Abdomen in Inhalation.
(Side View)

Fig. XVI



Controlled Abdomen in Inhalation.
(Side View)

domen does, indeed, allow the diaphragm to descend lower than the controlled abdomen, but the protracted abdomen depresses the ribs, and this more than counterbalances, the advantage gained by the lower descent of the diaphragm. Without going into details, we may also point out, that the X-Ray experiments on the diaphragm and the ribs published in the third volume lead to the same conclusion as the experiments on pressure changes published in the current number. Thus we find that all experimental evidence conclusively proves that with the controlled abdomen one secures a larger quantity of oxygen in his inhalation than with the protracted abdomen. That is the reason why we think that the position taken up by the Western physical culturists is more imaginary than real. Thus we see that the Yogic technique of inhalation is physiologically sound, so far as the oxygen value is concerned.

(To be continued)

A SHORT COURSE
in
YOGIC PHYSICAL CULTURE

1	Bhujangāsana	3 to 7 turns each; the pose being maintained for 2 to 5 seconds, one more turn being added to each, every fortnight. First only Ardha-Halāsana to be tried for 2 seconds in each stage. Then the full pose may be taken through the four different stages, each stage being maintained for 2 seconds only. 3 to 5 turns, adding one turn every fortnight.
2	Ardha-S'alabhāsana	
3	Dhanurāsana	
4	Halāsana	
5	Pas'chimatāna	To be maintained for 5 seconds. 3 to 7 turns, adding one turn every fortnight.
6	Ardha-Matsyendrāsana	To be maintained for 5 seconds. 3 to 7 turns, adding one turn every fortnight.
7	Yoga-Mudrā *or* Uḍḍiyāna	To be maintained for 10 seconds. 3 to 5 turns, adding one turn per week.
8	Viparīta Karaṇī	First Ardha to be practised with 2 seconds' pause at every stage. Afterwards the full pose to be taken with 10 seconds' pause. 2 to 5 turns, adding one turn every fortnight.
9	Ujjāyī	7 to 21 turns, adding 3 per week.

A FEW GENERAL HINTS

1 This Short Course is framed for those people who cannot, for want of time, strength or wish, follow the Complete Course given on pp. 288–292 of the second volume.

2 All the hints given to Yogic physical culturists in the Complete Course should be applicable to this Short Course also.

3 All the exercises may be started at the age of 9. Ujjāyī and Uḍḍiyāna should not be begun, however, before 12 or even 13.

4 This Short Course is available to females as well as to males.

5 In the case of females it is desirable to suspend all the Yogic exercises during the monthly illness and pregnancy.

6 Those that can tolerate Yogic exercises in the morning, may, if they so choose, undergo this Short Course both morning and evening. Others should practise Ujjāyī and Uḍḍiyāna in the morning and the rest of the exercises in the evening. Ujjāyī is to be practised in the evening also.

7 If there is a considerable break in the practice of these exercises, whenever the exercises are to be started again, they should start on a humbler scale, although the full measure may be reached somewhat rapidly.

8 After severe illness the Yogic exercises should be undertaken only when the patient recovers sufficient energy for their practices. It would always be desirable, by way of a cautious measure, to prefix to the practice of these exercises, a moderately long walk every day for a week or so.

9 This Short Course may be made shorter not by omitting any of the practices tabled here, but by undergoing all the exercises on a smaller scale.

10 Although the practice of this Short Course is comparatively innocent, people suffering from any serious disorder should not undertake these exercises on their own responsibility.

Following diseases, especially in their chronic condition, can be effectively treated by the Yogic methods :

1 *Constipation*
2 *Dyspepsia*
3 *Head-ache*
4 *Piles*
5 *Heart-disease (functional)*
6 *Neuralgia*
7 *Diabetes*
8 *Hysteria*
9 *Consumption*
10 *Obesity*
11 *Sterility (certain types)*
12 *Impotence*
13 *Appendicitis, &c.*

Therapeutical advice is given gratis at the Ās'rama to patients coming for consultation.

Arrangements have been made under the supervision of the Ās'rama for patients to stay on payment of actual expenses, Rs. 45/– per mensem.

MISCELLANEOUS

THE KAIVALYADHĀMA

A REVIEW OF ITS ACTIVITIES

FROM OCTOBER 1924 TO MARCH 1930

FOUNDATION AND IDEALS

THE Kaivalyadhāma was founded at Lonavla by S'rīmat Kuvalayānanda with himself as the Director on the Vijayādas'amī day in 1846 of the S'aka era, that is, on the 7th of October, 1924, A. D. In a statement issued by the founder some six months earlier in connection with the then proposed institute, the following lines appeared regarding its principal ideal.

"The Kaivalyadhāma has for its principal ideal the co-ordination of the Western and Eastern thought; and hopes, by their assimilation, to work out a philosophy which will, perhaps, give satisfaction to the greater part of humanity."

The founder is of opinion that the Western thought is in essence the result of modern sciences, whereas the Eastern thought is mainly based on the spiritual experiences of the mystics. He, therefore, believes that a co-ination of the modern sciences and the mystic experiences will lead toord the assimilation of the Western and Eastern thought. The following paragraph may be quoted here from the statement referred to above.

"The Yogins, right from Patan'jali, the greatest exponent of Yogic science, knew how to induce the highest spiritual stages. As the objective sciences had not developed till late, it was not possible for these stages to be experimented upon; and though lately there has been a startling advance in modern sciences, their exclusive material tendency and equally exclusive spiritual tendency of the Yogins, have led to a complete but an unlucky divorce of the two schools of thought. The Kaivalyadhāma is anxious to wed these together and produce results which will lead to the realization of the ideal indicated above."

Along with the principal ideal, the subordinate ideals of the Ās'rama were also enunciated in the same statement in the following words.

"The Kaivalyadhāma, however, proposes not only to conduct the above mentioned research, but also wants to start institutions of higher education in sociology, spiritual and physical culture. It also intends sending out youths that will selflessly help the building up of their nation."

It may be noted at this place that in the case of the Kaivalyadhāma, the adoption of the subordinate ideals was absolutely necessary for the realization of its principal ideal. This point requires a little elucidation. The co-ordination of modern sciences with mysticism means laboratory research in the field of Yoga. Now this research work requires the

services of two classes of men, namely, research scholars who would conduct the experiments etc., and the subjects upon whom the experiments would be done. It is essential that both these types of men are advanced students of Yoga and have a very very good intellectual equipment also, although the subjects do not require it as much as the research scholars. No Indian university produces this type of graduates. Hence the establishment of an academy where along with Yogic training students would be given intellectual instruction, had to be kept as one of the subordinate ideals.

Again research scholarship is a matter of aptitude, so also advanced studentship in Yoga. Out of a large number of candidates under training only a few would develop themselves into research scholars or advanced students of Yoga that may make useful subjects. The remaining would be useless for research work, although they were likely to be of great service to humanity, in any other spiritual work. Hence it became desirable to think of utilizing their services, and the spiritual uplift of humanity in general, was, therefore, fixed up as another subordinate ideal of the Ās'rama.

Moreover out of the candidates selected at the Kaivalyadhāma for training, there would be some who would be highly intelligent and capable of carrying on research though not in the field of modern sciences. Their Yogic equipment or their native intuition would be such as would enable them to study civilizations, ancient and modern, from the spiritual point of view. Such men had to be given a field of activity. Hence it was thought desirable that the ideals included the study of different civilizations. This ideal of a study of different civilizations, was not expressly enunciated in the statement referred to above, but has been clearly defined in the aims and objects of the Kaivalyadhāma Spiritual Service. (*Vide* 288, Vol. III.)

Further, among the students being trained in the Kaivalyadhāma there would be a large number of youths who would make good subjects and whose Yogic culture would qualify them for a variety of selfless service of humanity, although their intellectual equipment would be moderate. These youths, it was thought, would be of great use in the spiritual uplift of Indian villages. Hence Village Service has also been adopted as another subordinate ideal of the Ās'rama. (*Vide* 292, Vol. III.)

Again according to the East, philosophy is something to be lived, not merely to be theorized. Hence such philosophical principles as would be evolved by the Kaivalyadhāma, are to be translated into action. The members of the Ās'rama are not to be satisfied only by themselves putting these principles in practice, but it is their duty to get their fellow beings to act according to them. Hence the organization of an active service had to be kept as still another subordinate ideal of the Kaivalyadhāma.

The foregoing paragraphs will make it amply clear that so far as the Kaivalyadhāma is concerned, the subordinate ideals are a necessary and logical outcome of its principal ideal. The founder is happy to see that dur-

ing the last five years' time, he has been keeping himself strictly within the limits of these ideals; and had absolutely no occasion to depart from them.

THE RESEARCH

The principal ideal of the Ās'rama is the co-ordination of modern sciences and Yoga. Although the most important part of this co-ordination would and should refer to the advanced stages of Yogic culture, the scientific interpretation of the lower Yogic processes was also considered to be a valuable work. The Director could also see that his way to higher co-ordination would be prepared if he undertook the lower work first. Again there were extraneous circumstances which made metaphysical or psycho-physiological work impossible to begin with. The ideal of the Kaivalyadhāma was an altogether new ideal in India. Hence before it became popular, it was impossible for the Director to get the necessary men and money. The researches in the field of metaphysics or psycho-physiology were not likely to appeal to the imagination of the monied section of the Indian population. Hence the scientific interpretation of the physical culture and therapeutical sides of Yoga, was considered by the founder to be the best way to popularize higher scientific research in Yoga. That the Director's calculations in this regard, have tolerably come true can best be seen from the popularity the Ās'rama has attained throughout India within such a short period of its existence. A number of appreciations appearing on different pages in this number will bear eloquent testimony in this connection. That is why it was decided to begin the scientific research with reference to Yoga as a system of physical culture and therapeutics. Needless to say that such a research was bound to be mainly physiological and anatomical.

During the last five years or more for which the Ās'rama is in existence, the research has progressed satisfactorily. X-Ray and other laboratory means have been very largely used and a number of Yogic exercises such as Āsanas, Bandhas, Kriyās, Mudrās and Prāṇāyāmas have been studied scientifically. Their physical culture value and therapeutical value have been critically examined. The results arrived at are found to be as interesting as they are useful. The work thus far done has attracted the attention not only of many eminent Indians individually, but also of several Indian States and even of two Provincial Governments. On the strength of it, it has become possible for the Ās'rama to spread its influence even beyond the limits of India. All these statements will be borne out from the short sketch of the developments of the Ās'rama that is attempted in the following pages.

THE YOGA MĪMĀNSĀ

Although the Ās'rama was founded in October, 1924, the founder had begun his research work much earlier. Thus by the time the Ās'rama came into existence the Director had with him material enough for starting a quarterly journal for the dissemination of the results of his research work. So the journal Yoga-Mīmāṅsā came into existence along with the Ās'rama.

Even during the short career it has had up to now, the Yoga-Mīmāṅsā has commanded circulation throughout the length and breadth of India and even abroad. Papers and periodicals, medical men and physical culturists, so also eminent men of light and leading, all have very warmly appreciated the material published in this journal. The testimonials extracted elsewhere in this number are a clear evidence of the high esteem in which this journal is held by the public. The Director begs to draw the readers' attention especially to the appreciation of Dr. Rissom, professor of Physical Culture, Heidelberg University, Germany; Dr. Clare, M. D., Carlton, Minn., U. S. A.; Dr. Caldwell of the Caldwell Health Home, Calif. U. S. A.; Dr. A. C. Bisharad, M. R. A. S. (Lon.), Calcutta; Prof. Manikrao, the most eminent Indian Physical Culturist, Baroda and Dr. Gananath Sen, M. A., L. M. S., Calcutta. The view of Mr. Mead, Editor of the Quest, London, is typical of the press notices. Dr. Sanjivi's opinion shows how the work is finding favour with France. The extract from the report of Dr. A. Sousa, the Deputy Director of Public Health, United Provinces, so also the opinions of Sir C. V. Mehta and Diwan Bahadur Harilal Desai indicate the appreciation of high government officials. The notes of Pandit Motilal Nehru and Sir Shankaran Nair record the opinion of eminent Indians of light and leading.

It is, however, very unlucky that the Yoga-Mīmāṅsā has always been running an irregular course. Still the Director feels confident that hereafter the journal will be punctually published.

In the three volumes that have just been completed quite a large field of Yogic exercises has been covered. Uḍḍiyāna, Nauli, Basti, Dhauti, Prāṇāyāma etc., have been scientifically investigated and proved to be of great value as exercises for physical culture and therapeutics. Diseases such as constipation, auto-intoxication, appendicitis, epilepsy, thyroid-insufficiency have been discussed and their treatment through Yogic Therapy has been indicated at length. Most of the hygienic exercises from Yoga have been treated in detail, and their technique has been described with utmost accuracy. For a practical student of Yoga, this journal has become a reliable guide.

That the paper occupies a high level in the journalistic world, is to be seen from the very valuable literature that is being exchanged with it. The Quest Society, London; The Open Court Publishing Company, Chicago (U.S. A.); The Eastern Buddhist Society, Kyoto (Japan); Indian Psychological Association, Calcutta; The Madras University, Madras; The Mythic Society, Bangalore; The Andhra Historical Research Society, Rajahmundry; The Visva-Bharati, Santiniketan (Bengal); The Academy of Philosophy and Religion, Nimbal; The Indian Institute of Philosophy, Amalner; The Royal Asiatic Society, Bombay; The Bhandarkar Oriental Research Institute, Poona; Government of India Archæological Department, Simla; The Nizam's Archæological Department, Hyderabad (Deccan); The Indian

Philosophical Congress are all exchanging their periodical publications for the Yoga-Mīmāṅsā.

S'RĪ SARASVATĪ MANDIRA

The response by way of exchanges for the Yoga-Mīmāṅsā was almost immediate. Within a year's time the Ās'rama began to receive a very large amount of periodical literature in exchange for its organ, the Yoga-Mīmāṅsā. It was, therefore, thought desirable to supplement these exchanges by a few papers and periodicals specially subscribed, so that the whole literature put together would constitute a fairly rich reading room. Accordingly on the 27th of September, 1925, that is, on the Vijayā Das'amī day of the Āryan calendar, a free reading room was started in the Ās'rama. A beginning was also made at the same time towards developing the Ās'rama Library, the Free Reading Room and the Library being combined into one department called S'rī Sarasvatī Mandira. The Free Reading Room is very largely availed of not only by the workers and students of the Ās'rama but also by the indoor and outdoor patients and visitors. The Library is yet in the making and requires much addition of books in different subjects. It is hoped that in about a couple of years the Library will have a decent degree of equipment.

THE RANA NATAVARASINGH CLINICAL LABORATORY

Ever from the foundation of the Ās'rama patients began to seek therapeutical relief from the Director. The spread of the Yoga-Mīmāṅsā put different provinces of the country in touch with the Kaivalyadhāma. The result was that in a short time the number of patients began to be so large that a clinical laboratory for their examination, under the management of a competent medical graduate became necessary. Early in 1926 a medical graduate was engaged to work as the House Surgeon of the Ās'rama. His duty was and has been to conduct a thorough medical examination of the patient and to present the report to the Director. A moderately equipped clinical laboratory was organized under the auspices of the Kaivalyadhāma. At this juncture very luckily for the Ās'rama, His Highness the Maharaja Ranasa heb of Porbandar promised a liberal grant of three thousand rupees a year. Out of gratitude to his Highness, the Director requested permission to associate the clinical laboratory with the royal name of the Maharaja Ranasaheb. The permission obtained, the then existing clinical laboratory was very decently equipped and started under the new name of the Rana Natavarasingh Clinical Laboratory on the 16th of October, 1926, that is, the Vijayā Das'amī day of the S'aka era.

During the last three years or more for which the Laboratory has been working, about thirteen hundred patients have been medically examined by the officer in charge. The facilities of medical examination available here are given not only to patients who come for Yogic Therapy, but also to outsiders who do not come to us for treatment. Many of the local medical

institutions along with the Government Hospital at Khandala and the Hindu Sanatorium for Tuberculosis at Karla, take advantage of the Rana Natavarasingh Clinical Laboratory. All examinations are offered free of charge. The Clinical Laboratory has been found to be a great advantage by the public in and roundabout Lonavla. From the beginning of 1929 the Rana Natavarasingh Clinical Laboratory is being used by Probationers under training at the Academy for being instructed in Clinical Methods.

RUGṆA SEVĀ MANDIRA

In less than two years and a half after the foundation of the Ās'rama, the Kaivalyadhāma began to attract patients from all parts of India on a large scale. Up to the end of 1926 these patients were housed in the same buildings as the permanent inmates of the Ās'rama. It was, however, deemed desirable, because of the increasing number of patients, to have a separate house for them. Accordingly a new bungalow was taken on hire, and a special health resort called Rugṇa Sevā Mandira was established therein. The Director now finds this bungalow to be quite inadequate for the requirements of his therapeutical activities. At times, especially in the months of summer, there are as many as twenty-five indoor patients, whereas the provision is only of nine beds. It has become, therefore, imperative to have a special commodious building for Rugṇa Sevā Mandira. Many patients stay outside the Ās'rama and come to the Director for outdoor treatment.

Since the foundation of the Ās'rama nearly two thousand people have been treated either as indoor or outdoor patients. People suffering from constipation, dyspepsia, auto-intoxication, nervous debility, asthma, piles, seminal weakness, heart troubles and a variety of other diseases have found great relief from Yogic Therapy.

Yogic treatment, whether indoor or outdoor, is offered gratis to all patients coming to the Ās'rama. The indoor patients are even boarded and lodged free of charge for the first two days. Even afterwards patients are made to pay only the actual expenses. The Director feels extremely happy for thus being able to conduct the examinations and treatment of patients free of charge. Every day, however, this charitable work is putting an additional economic burden upon the Ās'rama; and it is reasonably feared that financial considerations may oblige the Director to put a check on this activity, unless liberal monetary support is accorded to the Kaivalyadhāma by the public.

A reference to the Probationers under training at the Academy will be presently made. These Probationers have to be trained in Yogic Therapy along with other subjects. Rugṇa Sevā Mandira affords these Probationers very good opportunity for getting clinical experience. This therapeutical department is a valuable help also to the Director in conducting his clinical research. Thus it will be seen that the Rugṇa Sevā Mandira has not only a clinical value but educative and research values also.

YOGIC PHYSICAL CULTURE

One of the ideals of the Kaivalyadhāma is to evolve a system of physical culture based on Yoga and to take steps to popularize that system. Research work done in the field of Yogic exercises from the physical culture point of view, and published in the Yoga-Mīmāṅsā, went a long way in realizing this ideal. Institutions from different provinces sought the help of the Director in organizing physical culture courses based on Yoga. The activities of the Ās'rama in this field of Yogic physical culture proved to be so valuable that two Provincial Governments thought it desirable to take advantage of the Director's knowledge of this subject. Late in 1927 the Government of Bombay appointed a committee to inquire into the problem of physical training. S'rīmat Kuvalayānanda, the Director of the Ās'rama, was requested to be a member of this Committee. In their report submitted to the Government, this Physical Training Committee has highly spoken of the Yogic physical culture as it is being systematized by the Kaivalyadhāma. An extract relevant to this subject will be found at the end of this report. The other Provincial Government that interested itself in the Yogic system of physical culture was the Government of the United Provinces. In the summer of 1928 this Government deputed to the Ās'rama their Deputy Director of Public Health. Dr. A. Sousa who came out on this deputation was to report on the possibility of the Yogic exercises being introduced in the educational institutions of the United Provinces. The Deputy Director stayed in the Ās'rama for two weeks and after a thorough study of the Yogic exercises from scientific and educational points of view, submitted an excellent report to his Government. He has recommended very strongly the physical culture exercises as they have been systematized by the Ās'rama. The U. P. Government have since then printed and published this report of Dr. A. Sousa. In the appreciations appearing at the end of this review, quotations from the report under reference will be found.

A very large number of educational institutions scattered throughout the Indian Nation, are requesting the Director to lend them the services of a trained Yogic physical culturist. It is the sincere desire of the Director to respond to this call of the Nation. It will take, however, some time before the Ās'rama finds it possible to send out trained Yogic physical culturists for the work required.

SPIRITUAL CULTURE

The sketch that has been attempted up to now of the activities of the Ās'rama during the period under report, refers only to the physical culture and therapeutical sides. Properly speaking Yogic physical culture and therapeutics form only the subordinate ideals of the institution. The principal ideal as stated in the beginning of this report is the co-ordination of the spiritual phenomena of Yoga with the modern science, with a view to evolve a philosophy that would, perhaps, satisfy the majority of mankind. The Director is happy to state that this ideal has been kept before the eye

throughout the growth of the Kaivalyadhāma, ever since its foundation. [For reasons explained in some of the paragraphs in the beginning of this sketch, the work of spiritual and scientific co-ordination had to be postponed up to now and may not be begun in the immediate future. But preparations are being made for that work from the beginning of the Ās'rama. Highly developed spiritual subjects, advanced spiritual culturists as research scholars, and a well-equipped laboratory are the three factors upon which spiritual research depends. Handsome provision of money may make the third factor ready in no time. But spiritually developed subjects and research scholars for spiritual investigation, will always take a long time to develop. The short career the Ās'rama has had up to now has been utilized in developing these two types of spiritual culturists. Although the Director is satisfied with what little progress has been made up to now, he is afraid it will take at least a few years more before people of the necessary qualification are produced in the Ās'rama. Constant efforts are being made to accelerate the spiritual progress of the inmates of the Ās'rama.

Every student admitted to the Kaivalyadhāma is bound to have spiritual evolution through Yoga as the ideal of his life. No one that does not cherish this ideal is allowed to be an integral part of the institution. At present there are some fifteen souls in the Ās'rama trying to be in tune with the Infinite. Every year a few fresh students are admitted. It is only recently that the training facilities at the Kaivalyadhāma have been tolerably complete, as will be seen from this report. When the Indian youth comes to know of these facilities, the Director feels confident that a larger number of students will be available. Whoever happens to read this report is earnestly requested to direct to this Ās'rama earnest soul hankering for spiritual evolution, if he chances to come across them.

S'RĪMAN MĀDHAVA YOGA MANDIRA

or

THE MĀDHAVADĀSA ACADEMY OF SPIRITUAL CULTURE

The type of subjects and scholars required by the Ās'rama for its research work, cannot be available ready-made in the market. Indian universities do not produce this type of graduates. In these universities students have to take courses either in science or in philosophy. The Kaivalyadhāma stands in need of students who have grounding in philosophy as well as sciences. Hence along with practical instruction in Yoga it became necessary to make arrangements for giving intellectual instruction to the graduates and undergraduates admitted to studentships at the Kaivalyadhāma. Again, in order to secure a succession of workers who could co-operate in an organized institution, for research and other things, it became necessary to frame a democratic constitution for the Ās'rama. The institution established for the spiritual and intellectual training of the students is called S'rīman Mādhava Yoga Mandira or the Mādhavadāsa Academy of Spiritual Culture. The organization of spiritual culturists forming an integral part of the Ās'rama,

is named the Kaivalyadhāma Spiritual Service. First the Academy will be taken into account.

Taking advantage of the eighth anniversary of S'rīman Mādhavadāsaji Mahārāja, the revered Gurudeva of the Director, S'rīman Mādhava Yoga Mandira was established on the 6th of January, 1929. S'rīmat Kuvalayānanda instituted himself as the Kulapati of this Academy and Dr. V. D. Merchant, a Retired Civil Surgeon of the Government of Bombay, was made the Superintendent. Dr. Merchant who is a highly evolved soul, after his retirement, has settled in Lonavla and has identified himself with the Ās'rama. Under his able guidance the Academy has worked for more than a year and the progress has been entirely satisfactory.

Only such students as are capable of doing higher spiritual work are admitted to the Academy and are called Probationers under training. The course lasts for four years. Yoga is studied from all points of view; spiritual, physical, therapeutical, scientific and philosophical. These Probationers after completing their course are bound to join the Kaivalyadhāma Spiritual Service if the Director calls upon them to do so. The Ās'rama stands responsible for the boarding and lodging of these Probationers and also bears other expenses legitimately incurred by them as students under training.

To begin with there were six probationers, two graduates and four undergraduates. One undergraduate has since then discontinued his course. In addition to the Kulapati and the Superintendent, the House Surgeon of the Ās'rama, Dr. B. M. Kadkol, M. B., B. S., is one of the tutors at the Academy. S'rīman Raghunatha S'āstrī Kokaje, Tarkatīrtha, is another tutor. He is responsible for the teaching of the Āryan Philosophy. Detailed information about the Academy is to be found on pp. 300 to 304 of Vol. III.

WORKING STUDENTSHIPS

Youths whose intellectual qualifications are so humble as not to secure for them a career at the Academy, are admitted to Working Studentships. This class of students gets practical training in Yoga as a system of spiritual and physical culture. No special attempt is made to improve their intellectual equipment. They are made to work in the Ās'rama for a few hours. These working students also get their boarding and lodging free of charge and their other legitimate expenses are also borne by the Ās'rama. Rules and Regulations for Working Students are given on pp. 297 and 298 of Vol. III.

SPIRITUAL TRAINING FOR OUTSIDERS

For getting spiritual instruction in the Kaivalyadhāma, one need not offer himself to be an integral part of the institution. One may come to the Ās'rama whenever required by the Director for receiving instruction. That much stay is sufficient for being trained in Yoga. These outsiders when they come to the Ās'rama are treated as Visitors. Rules concerning this class of people are given on p. 310 of Vol. III.

If these outsiders so choose, they can stay even outside the Ās'rama in Lonavla; and be available for instruction when needed by the Director. Needless to say that all spiritual instruction is given absolutely free of charge.

THE KAIVALYADHĀMA SPIRITUAL SERVICE

It has been stated above that the Kaivalyadhāma Spiritual Service was instituted on the occasion of the eighth anniversary of S'rīman Mādhavadāsajī Mahārāja, It is mainly the members of this Service that go to form the Ās'rama. They are expected to be spiritual culturists of a fairly high level. It is their duty to perpetuate the traditions and to develop the work of the Kaivalyadhāma. Self-sacrifice and constant anxiety to work for the spiritual uplift of mankind, either through research work or otherwise, are to be the characteristics of these people. It is a body of men who recognize responsibilities without rights. They are expected to live for others, to work for others, and to die for others. They look upon selfless service of humanity as one of the best aids to their spiritual evolution. 'Thyself Last' is to be their motto. At present S'rīmat Kuvalayānanda is the only member of this Service. He has instituted himself to be the First Member of it. Out of the different graduates into which this Service is divided he keeps himself to the last. He expects his successors to be far better equipped both intellectually and spiritually than himself, so that they can befit themselves for the higher grades.

As soon as the Probationers at the Academy complete their course of training, those of them that will be found deserving, will be admitted to the Kaivalyadhāma Spiritual Service.

Outside the Academy one more candidate has been taken up as a Probationer for this Service. It is Mr. Ramadasaji Gulati, who is a Manchester B. Sc. in Engineering. He is to serve a probation of two years before being admitted to the Service.

For detailed information about the Kaivalyadhāma Spiritual Service see pp. 287 to 293 of Vol. III.

THE VILLAGE SERVICE

India is preponderantly a land of villages. The members of the Kaivalyadhāma Spiritual Service are, by their equipment, expected to work in towns and cities. A humbler sort of race has to be evolved spiritually who can work among the villagers and look to the needs of their soul. The Director contemplates instituting a Village Service for this purpose as early as possible. Information given on p. 305 of Vol. III about the intended programme for this sort of service, will show that it can be instituted only if the Ās'rama can make arrangements for instruction in Dairy Farming, Cattle Breeding and Agriculture. It is a costly programme and requires substantial donations to the Ās'rama. The Director is, however, of opinion that the work of the Kaivalyadhāma can never be said to be complete unless and until it prepares

men who can go out and settle in villages and work for the uplift of the rural population at present steeped in ignorance.

THE KAIVALYADHĀMA AS A PARENT INSTITUTE

The Kaivalyadhāma is yet in its infancy. Still the Director is being pressed every day to establish its branches in the different parts of India. There are offers of properties for providing sites for these branches. Gentlemen have come forth to bear the running expenses. All this is very encouraging. It will, however, take some time before any serious work is started by the Ās'rama outside Lonavla.

THE FINANCE

Up to now the Director has made no attempt to collect subscriptions from the public at large. Only a few ruling princes and merchant princes have been approached. The Director is very happy to note that the response from people thus approached has been encouraging, in most of the cases. Some of the personal friends of the Director are responsible for donations far beyond their means. Four occasions have left a deep mark on the economic career of the Ās'rama. The first occasion arose when even before the idea of founding an Ās'rama was entertained, a few friends of S'rīmat Kuvalayānanda came forth to bear the cost of the research work he was then contemplating. The second occasion was marked by a liberal donation of five thousand rupees on the part of S'rīmant Pratapasheth of Amalner. It was this donation which enabled S'rīmat Kuvalayānanda to found and continue the work of the Ās'rama on a decent scale. The third occasion has been made memorable in the history of the Kaivalyadhāma by a generous grant of three thousand rupees a year from His Highness the Maharaja Ranasaheb of Porbandar. This grant gave an immediate impetus to the work of the Ās'rama and enabled the Director to undertake many additional activities. It added to the prestige of the Kaivalyadhāma enormously. The fourth occasion arose when Mr. Lalaji, Gokuldasa, an Advocate of the Bombay High Court, gave in donation to the Ās'rama a decent garden at Borivli, one of the beautiful suburbs of Bombay. This property is worth thirteen thousand rupees ; and is held in trust for the Ās'rama by the Director. It has prepared the Director's way for starting a branch of the Ās'rama for Bombay. People responsible for the donations given on these occasions have earned the eternal gratitude of the members of the Kaivalyadhāma.

There are many others who have also helped the Ās'rama splendidly. Sir Prabhashankar Pattani, very early in the career of the Kaivalyadhāma, placed the Director under obligation by allowing the Ās'rama free use of his beautiful property situated at Lonavla. It is worth twenty thousand rupees. His Highness the Thakorsaheb of Limbdi and his Personal Secretary, Miss Elizabeth Sharpe, deserve the best thanks of the Director for having first introduced him and his work in Kathiawar. Their Highnesses the Thakorsaheb of Morvi and the Maharaja of Bansda were kind enough not

only to give decent donations but also honoured the Ās'rama with their visits. There are other states and other donors who have been equally kind to the Director. S'rīmat Kuvalayānanda takes this opportunity to acknowledge his deep debt of gratitude to the persons referred to above and to others that have helped the Ās'rama to its present position.

Although the amounts given above appear encouraging the ever increasing needs of the Ās'rama require far richer donations to satisfy them. Even after a five years' satisfactory career the Ās'rama is housed in rented buildings. There is no permanent fund nor are the different departments fully developed for want of adequate financial support. Work of this type requires to be placed on a sound economic basis. At a moderate calculation a sum of ten lacs of rupees is needed for the development and satisfactory maintenance of the Kaivalyadhāma.

The Ās'rama is a public institution and is being maintained on the strength of public charities and the extreme sacrifice of its inmates. Whatever property it possesses belongs to none in his individual capacity. The Director himself is a recluse and has absolutely no economic interest in the property of the Kaivalyadhāma.

THE CONCLUSION

Yogic culture is one of the richest legacies the ancient Indian savants have left to the world. The noble spiritual elevation that is seen in India even in her present deplorable condition, is mainly due to the influence of Yoga in one form or another. A revival of this culture is sure to raise her to her former position of glorious dignity. The Ās'rama is trying to bring Yoga in correlation with the present-day culture by attempting a scientific interpretation of its truths. It undertakes to train youths who will stand for whatever is best in the different cultures of the earth, ancient or modern. Under these circumstances the Director humbly begs to suggest that it is the duty of every individual, who cares for the progress and well-being of humanity, to show his active sympathy to the Ās'rama and enable its workers to realize their cherished ideals.

Kaivalyadhāma,
LONAVLA,
April 30, 1930.

Kuvalayananda
(J. G. Guṇe),
Director, KAIVALYADHĀMA.

तदेकोऽवशिष्टः शिवः केवलोऽहम् ।
I alone persist : Blissful : Absolute.

ॐ

सोऽहम् ।

Yoga-Mīmāṁsā

EDITED BY

S'RĪMAT KUVALAYĀNANDA

(J. G. GUṆE)

November, 1930

Vol. IV No. 2

KAIVALYADHĀMA

Post —Lonavla

(BOMBAY-INDIA)

शरीरमाद्यं खलु धर्मसाधनम् ।
Surely Health is the primary requisite of spiritual life.

सर्वं खल्विदं ब्रह्म ।
All this is, indeed, Brahman.

नेह नानास्ति किञ्चन ।
There is nothing here apart from it.

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सदेकोऽवशिष्टः शिवः केवलोऽहम् ।

सोऽहम् ।

YOGA-MĪMĀṆSĀ

VOL. IV NOVEMBER, 1930. NO. 2

Editorial Notes

MAY the Maker of all make this journal a success. Blessed is the name of the Lord. May He bless the workers of the Ās'rama with a happy and prosperous career as servants of the world which is only the Lord Himself objectified. May He, that has created us in His infinite wisdom, lead us to the light that is beyond all darkness.

⚜ ⚜ ⚜

As stated in the Editorial Notes of the first number of this volume, the principal theme of the current volume is Prāṇāyāma. Hence we have included in this issue an article on Kapālabhāti. Technically speaking Kapālabhāti is not Prāṇāyāma; but it is surely a breathing exercise of great cultural value and forms part of the type of Prāṇāyāma called Bhastrikā. In the next issue we shall discuss the technique of Bhastrikā in its different varieties.

⚜ ⚜ ⚜

WE could not include in this number our article 'Ujjāyī Prāṇāyāma Explained'. Our reasons for this exclusion of the article are the same that were given in the last issue. The physiological arguments that are being advanced for explaining Ujjāyī are all based upon the results of our experi-

mental work. The true significance of these arguments will be grasped by our readers, only if they intelligently follow the experiments. Now many of our readers have no grounding in physics and chemistry which is absolutely essential for understanding, not only the experiments, but also their bare results. So for the information of these readers it became necessary to give scientific notes which took up so much of our space.

Our note on the 'Determination of CO_2 and O_2' is so arranged that a reader who does not know even the A, B, C of chemistry, should be able to follow our research work intelligently, provided he tries to digest the note. It is written in the most popular language without sacrificing scientific accuracy as far as possible. However, it cannot be read as a sort of light literature. But we assure our readers that the labour they bestow upon the study of this note will be amply rewarded. Unless the facts discussed in this note are thoroughly digested, the physiological explanations of Prāṇāyāma will merely be empty words. That is why we were so particular about publishing this note in the present number. Again we could not publish it in parts. Because the experiments on the elimination of CO_2, that appear in this issue, would not have been clear to many of our readers without the study of this note taken as a whole.

But the note has taken away all our space. We had even to drop the Miscellaneous Section. There was no choice.

⚜ ⚜ ⚜

THE subsequent part of our article. 'Ujjāyi Prāṇāyāma Explained' will appear in the next issue.

THE SCIENTIFIC SECTION

N. B.—Those of our readers that claim no acquaintance with anatomy and physiology will do well to read The Semi-Scientific Section first.

CO_2 ELIMINATION IN PRĀṆĀYĀMA[1]

INTRODUCTION

ONE of the most important features of a physiological study of Prāṇāyāma, is the consideration of CO_2 elimination in the Pranayamic process. The experimental work published in this issue bears on this consideration of CO_2 elimination. The eight experiments included in this number are only a fraction of our research work in this direction.

The problem of CO_2 elimination in Prāṇāyāma affords many points for examination. We mention here only a few of them.

(i) Whether Prāṇāyāma enables a man to eliminate more CO_2 than the ordinary normal breathing in a particular unit of time ?

(ii) What would be the most advantageous time unit for a round of Prāṇāyāma for the elimination of CO_2 ?

(iii) Whether a larger time unit for a round of Prāṇāyāma leads to a larger elimination of CO_2 ?

(iv) Has Kumbhaka a special value in Prāṇāyāma so far as the elimination of CO_2 is concerned ?

(v) Is it desirable to omit Kumbhaka from the technique of Prāṇāyāma, if only the elimination of CO_2 is aimed at ?

If we were to satisfactorily solve these questions a very large number of experiments will have to be taken into account. As stated above we could not include more than eight experiments in this issue. Hence we must reserve the discussion on the first two points for the next number. We shall briefly examine the results of the eight experiments published here

1. Those of our readers who have no training in physics and chemistry are strongly advised to digest our note on the 'Determination of CO_2 and O_2' published in the Semi-Scientific Section. A very very clear grasp of that note is essential for understanding the experimental work appearing in this Section.

to see what answer we get to the remaining three points raised above. Let us take the third point.

A reference to the last page of this Section where we have published a table summing up the results of the eight experiments, will show that we have used five time units therein. They are: 14″, 21″, 28″, 35″ and 49″. It means that a round of Prāṇāyāma was completed in 14″, 21″, 28″, 35″ and 49″ respectively. Now let us take the first type of round. It took 14″. The result was that 3·97 parts in volume of CO_2 could be eliminated in one hundred parts of the expired air. Supposing now that the total quantity of the expired air was 2800 c.c., the total quantity of CO_2 eliminated comes to 111·16 c.c.

Then let us take the second unit of 21″. Working out the figures as above we find that the total quantity of CO_2 eliminated in 21″ comes to 127·68 c. c. At this rate only 85·12 c.c. would be eliminated during 14″, the length of the first unit. It clearly shows that in choosing a longer unit, not only we do not get any advantage, but we lose heavily, so far as the elimination of CO_2 is concerned. An examination of the other longer units will bear out this very fact. The details will be discussed under different experiments.

Then we come to the consideration of the fourth point. Has Kumbhaka a special value in Prāṇāyāma so far as the elimination of CO_2 is concerned ? For getting a reply to this question we have to examine the last three units, namely, of 28″, 35″ and 49″. Let us take the first unit of 28″. In Experiments III and IV, this same unit is used; but the distribution of time over the component parts of the Pranayamic round is different. In Experiment III we have Kumbhaka of 7″ and Rechaka of 14″, the two together occupying 21″. In Experiment IV, all the 21″ are utilized in Rechaka. There is no Kumbhaka. The time taken for Pūraka is the same in both the experiments. So the total time of the Pranayamic round is the same. The difference is only in the inclusion and exclusion of Kumbhaka. What is the result ? We find that the

percentage of CO_2 eliminated in a Pranayamic round with Kumbhaka is *lower* than the percentage of CO_2 eliminated in a Pranayamic round without Kumbhaka. The same result is shown by a comparison of Experiments V and VI for the unit of 35″.

But the results of the third unit of 49″ are different. Here the percentage of Co₂ eliminated in a Pranayamic round with Kumbhaka is *higher* than the percentage of CO_2 eliminated in Prāṇāyāma without Kumbhaka. Here too, however, the advantage is very small.

Putting together the results of the last six experiments, we come to the conclusion that Kumbhaka has no special value from the point of view of the elimination of CO_2. If Kumbhaka is of a sufficiently long duration, of about half a minute, it does give a slight advantage in this connection over Prāṇāyāma without Kumbhaka. But looking to the total length of time taken up by a Pranayamic round with a tolerably well protracted Kumbhaka, there is a decided disadvantage, so far as the elimination of CO_2 is concerned.

Naturally the answer to the fifth point raised above is in the affirmative. We can safely say that it is desirable to omit Kumbhaka from the technique of Prāṇāyāma, *if the elimination of CO_2 is the only object in view.*

We strongly hope that our readers will not hastily jump to any conclusion regarding the general value of Kumbhaka which depends upon various factors, the elimination of CO_2 being only one of them. It is desirable that they wait and study Kumbhaka from different points of view and then set the right value upon it as an exercise of Yoga.

For the purpose of the eight experiments under consideration, five subjects were examined. Each subject was required to make two attempts at the same type of round in Prāṇāyāma. Thus the final average in every experiment is worked out from ten figures.

No special preparation of subjects was undertaken. It may be argued that the percentage of CO_2 in the expired air depends upon the general metabolism of man; and this general metabolism is largely affected by the type of diet he takes. So for experiments for determining the percentage of CO_2 in the expired air, subjects must be prepared with strict attention to their diet. The argument is valid when the total amount of CO_2 eliminated during a particular period of time, is to be determined. Here our attempt is not to ascertain anything of the type. We simply want to *compare* the percentages of CO_2 in the expired air exhaled under different Pranayamic processes, *these Prāṇāyāmas being done under the same metabolic conditions.* Thus the first attempts in Experiments III and IV were done by every subject at one and the same sitting. Of course, due time was allowed to escape between the two attempts for returning to normal after the little disturbance of the first attempt. The same was done in the case of Experiments V and VI or VII and VIII. In this way wherever a close comparison was necessary, we tried to perform the experiments under the same metabolic conditions. The experimental work, however, had to be carried across a few days. *Ordinary* precautions were taken to secure a tolerably uniform metabolism during these days. As, however, we were not dealing with the absolute quantities of CO_2 eliminated in a particular period of time, we did not think it necessary to do anything more than we did for the preparation of the subjects. We wanted only to determine the comparative efficiency of the different types of Pranayamic processes. We may, however, assure our readers, that even for the calculation of absolute quantities of CO_2 in the expired air, our results may be taken as *tolerably accurate*.

We will describe in detail in the Semi-Scientific Section of this issue, the apparatus we used and the methods we followed in carrying out these experiments. The expired air was collected in a sort of spirometer over water. Its volume at N. T. P. was determined after correcting it for vapour pressure. Then a measured portion of it was examined,

according to the gravimetric method, for estimating the quantity of CO_2 contained in it. The results arrived at gave us the weights of CO_2. From these weights the volume of CO_2 at N. T. P. was worked out and compared with the volume of the expired air originally corrected to N. T. P. Ultimately percentage of CO_2 in the expired air was calculated and the final average determined. On p. 120 will be found a table that shows the results of these experiments at a glance.

We will publish additional experiments on this subject and on the absorption of O_2, in the next number of this journal.

CO_2 ELIMINATION IN PRĀṆĀYĀMA

EXPERIMENT I

OBJECTS OF THE EXPERIMENT:—

One of the objects of this experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka and 7″ Rechaka, with no Kumbhaka between them. The other object was to compare this percentage with other similar percentages secured with Pranayamic rounds of longer time units, with a view to see whether the longer time units had an advantage over this, so far as the elimination of CO_2 was concerned.

PREPARATION OF THE SUBJECTS:—

Five subjects were tried in this experiment. They were young adults of sound constitution, with ages varying from twenty to twenty-nine. No special preparation was undertaken. It was only seen that no excitement either in physical or mental condition was present at the time of experimentation.

THE APPARATUS:—

As stated in the introduction to these experiments, the apparatus has been fully described in the Semi-Scientific Section of this issue at the end of our note on the 'Determination of CO_2 and O_2'.

THE EXPERIMENT PROPER:—

After deep Pūraka of 7″, the air was exhaled into a sort of spirometer in 7″. In the cases of the first two subjects 800 c.c., and in the cases of the last three subjects 700 c.c., of this expired air at 695 mm. of barometric pressure and at 32° C. of temperature, were examined for CO_2 by passing it through a strong solution of caustic potash. From the observed weight of CO_2, its volume at N. T. P. was determined. 800 c.c. and 700 c.c. of the expired air were also reduced to N. T. P. Then the volume of the expired air and

the volume of CO_2 were compared and the percentage of CO_2 was determined. This was done twice in the case of each subject and ultimately the final average was worked out. This came to be 3·97. Detailed percentages are tabulated on the next page.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment I

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of Co_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	0	7	14	4·43	4·11	4·27
B	7	0	7	14	3·56	3·88	3·72
C	7	0	7	14	2·9	3·9	3·4
D	7	0	7	14	4·72	4·72	4·72
E	7	0	7	14	4·04	3·47	3·76

Total, 19·87.

Final Average, 3·97.

EXPERIMENT II

OBJECTS OF THE EXPERIMENT:—

One of the objects of the experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka and 14″ Rechaka, with no Kumbhaka between them. The other object was to compare this percentage with other similar percentages secured with Pranayamic rounds of shorter and longer time units, with a view to see whether the longer time units had an advantage over the shorter units, so far as the elimination of CO_2 was concerned.

PREPARATION OF THE SUBJECTS:—

The same subjects were tried in this experiment as in the last, under the same metabolic conditions.

THE APPARATUS:—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER:—

After deep Pūraka of 7″, the air was exhaled into a sort of spirometer in 14″. As in Experiment I, a measured quantity of the exhaled air was examined under observed conditions and the percentage in volume of CO_2 in it was determined, all the necessary corrections being applied in determining the volumes both of the expired air and CO_2. The final average turned out to be 4·56 per cent. Detailed percentages are tabulated on the next but one page.

REMARKS:—

The time unit of the Pranayamic round was 14″ in the last experiment. It was 21″ in this. If the percentage of CO_2 in the expired air had increased in proportion of the length of time unit, we should have got 5·95 as the result

of the present experiment. But we got only 4·56 as the percentage here. Hence we find that a longer time unit is a decided disadvantage in Prāṇāyāma, so far as the elimination of CO_2 is concerned.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment II

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent. 1st Attempt	2nd Attempt	Average
A	7	0	14	21	4·58	4·35	4·47
B	7	0	14	21	5·23	5·54	5·39
C	7	0	14	21	3·26	4·17	3·72
D	7	0	14	21	5·26	5·17	5·22
E	7	0	14	21	4·27	3·72	4

Total, 22·8.

Final Average, 4·56.

EXPERIMENT III

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentage of Co_2 in the air expired during a Pranayamic round of 7″ Pūraka, 7″ Kumbaka and 14″ Rechaka. The other object was to compare this percentage with a similar percentage secured with a Pranayamic round of the same time unit, but without Kumbhaka, the period of Kumbhaka being added to Rechaka, for lengthening it, with a view to see whether Kumbhaka had a special value so far as the elimination of CO_2 was concerned.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried here as in the last experiment under metabolic conditions, which though not identical with, were tolerably similar to those of the last.

THE APPARATUS :—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER :—

After deep Pūraka of 7″ and Kumbhaka of another 7″, the air was exhaled into a sort of spirometer in 14″. As in the last two experiments a measured quantity of the expired air was examined for the percentage of CO_2. The final average in volume per cent. proved to be 5·02. Detailed percentages are tabulated on the next page.

REMARKS :—

If we compare the time units of the Pranayamic rounds of this and the first exeriment, we find that in this experiment the time unit is exactly double of what it is in Experiment I. Naturally we should expect the percentage of CO_2 in the expired air to be doubled also, that is, to be 7·94. But we find that it is 5·02 only. So this experiment also proves the disadvantage of choosing a longer time unit in Prāṇāyāma, so far as the elimination of CO_2 is concerned.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment III

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	7	14	28	5·39	4·51	4·95
B	7	7	14	28	5·47	5·47	5·47
C	7	7	14	28	4·9	4·36	4·63
D	7	7	14	28	4·9	6·07	5·49
E	7		14	28	4·43	4·67	4·55

Total, 25·09.

Final Average, 5·02.

EXPERIMENT IV

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka and 21″ Rechaka, with no Kumbhaka between them. The other object was the same as the second object of the last experiment.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried here as in the last experiment under the same metabolic conditions.

THE APPARATUS :—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER :—

This was done exactly as the last experiment, with this change only. Instead of 7″ Kumbhaka and 14″ Rechaka, the subjects had 21″ Rechaka only, without any Kumbhaka at all. The final average of CO_2 in volume per cent. in the expired air, worked out at 5·2. Detailed percentages are tabulated on the next page.

REMARKS :—

A comparison between the results of this experiment and the last, clearly shows that Kumbhaka has no special value, so far as the elimination of CO_2 is concerned. Because we had the same time unit in both the experiments, but we got a higher percentage in Prāṇāyāma that was done without Kumbhaka, the difference being of ·18.

N. B. An examination of the detailed percentages of this and the last experiment, shows that the advantage has not uniformly been in favour of Prāṇāyāma without Kumbhaka. Thus the subjects A and C have secured an advantage with Kumbhaka. But the gain is so small, that the conclusion is hardly disturbed. We can still say that Kumbhaka has no *special* value in Prāṇāyāma, so far as the elimination of CO_2 is concerned.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment IV

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	0	21	28	5·39	5·54	5·47
B	7	0	21	28	5·47	6·33	5·9
C	7	0	21	28	4	4·36	4·18
D	7	0	21	28	5·18	5·81	5·5
E	7	0	21	28	5·15	4·75	4·95

Total, 26.

Final Average, 5·2.

EXPERIMENT V

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka, 14″ Kumbhaka and 14″ Rechaka. The other object was to compare this percentage with a similar percentage secured with a Pranayamic round of the same time unit, but without Kumbhaka, the period of Kumbhaka being added to Rechaka for lengthening it, with a view to see whether Kumbhaka had a special value so far as the elimination of CO_2 was concerned.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried here as in the last experiment, under metabolic conditions which though not identical with, were tolerably similar to, those of the last.

THE APPARATUS :—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER :—

After deep Pūraka of 7″ and Kumbhaka of 14″, the air was exhaled into a sort of spirometer in 14″. As in the last experiment, a measured quantity of the expired air was examined for the percentage of CO_2. The final average in volume per cent. proved to be 4·63. Detailed percentages are tabulated on the next but one page.

REMARKS :—

If we compare the time units of this and Experiment III, we find Pūraka and Rechaka are of the same length in both, whereas Kumbhaka has been given double the time in this experiment. Naturally we should expect a higher percentage of CO_2 in the expired air in this experiment. On the

contrary we find that the same is lower by ·39. Although the smaller percentage may partly be due to the irregularity of the elimination process, one thing is clear. Kumbhaka has no special value in Prāṇāyāma, so far as the elimination of CO_2 is concerned.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment V

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	14	14	35	6·02	4·9	5·46
B	7	14	14	35	3·96	4·11	4·04
C	7	14	14	35	4·45	4·08	4·27
D	7	14	14	35	4·54	5·08	4·81
E	7	14	14	35	4·27	4·9	4·59

Total, 23·17.

Final Average, 4·63.

EXPERIMENT VI

OBJECTS OF THE EXPERIMENT :–

One of the objects of this experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka and 28″ Rechaka, with no Kumbhaka between them. The other object was the same as the second object of the last experiment.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried here as in the last experiment under the same metabolic conditions.

THE APPARATUS :—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER :—

This was done exactly as the last experiment with this difference. Instead of 14″ Kumbhaka and 14″ Rechaka, the subjects had 28″ Rechaka only, without any Kumbhaka at all. The final average of CO_2 in volume per cent. in the expired air, worked out at 5·3. Detailed percentages are tabulated on the next page.

REMARKS :—

A comparison between the results of this experiment and the last, clearly confirms the conclusion arrived at in the last experiments. It also proves that Kumbhaka has no special value, so far as the elimination of CO_2 is concerned. Because we had the same time unit in both the experiments, but we got a higher percentage in one that was done without Kumbhaka, the difference being of ·67.

N. B. An examination of the detailed percentages of this and the last experiments, shows that out of the five subjects examined only one— A— had an advantage in Kumbhaka. All others secured a higher percentage from Prāṇāyāma without Kumbhaka.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment VI

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	0	28	35	5·3	4·83	5·07
B	7	0	28	35	5·7	5·23	5·47
C	7	0	28	35	4·72	5·54	5·13
D	7	0	28	35	6·44	5·63	6·04
E	7	0	28	35	4·75	4·83	4·79

Total, 26·5.

Final Average, 5·3.

EXPERIMENT VII

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka, 28″ Kumbhaka and 14″ Rechaka. The other object was to compare this percentage with a similar percentage secured with a Pranayamic round of the same time unit, but without Kumbhaka, the period of Kumbhaka being added to Rechaka for lengthening it, with a view to see whether Kumbhaka had a special value so far as the elimination of CO_2 was concerned.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried here as in the last experiment, under metabolic conditions which, though not identical with, were tolerably similar to those of the last.

THE APPARATUS :—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER :—

After deep Pūraka of 7″ and Kumbhaka of 28″, the air was exhaled into a sort of spirometer in 14″. As in the last experiment a measured quantity of the expired air was examined for the percentage of CO_2. The final average in volume per cent. proved to be 6·01. Detailed percentages are tabulated on the next but one page.

REMARKS :—

Comparing the percentages of this and Experiment V, we find that the higher percentage secured in this experiment, is due to the longer time devoted to Kumbhaka. But this gain is only apparent and not real. This will be clear when we compare the results of this and Experiment II. In both of them the time devoted to Pūraka and Rechaka is the same.

In this experiment 28″ are added by way of Kumbhaka. At the rate of Experiment II, we must get 10·6 as the percentage here. But we get only 6·02, which again proves that Kumbhaka has no special value in the elimination of CO_2.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment VII

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	28	14	49	6·32	5·86	6·09
B	7	28	14	49	5·63	5·47	5·55
C	7	28	14	49	6·52	5·9	6·21
D	7	28	14	49	6·25	6·34	6·3
E	7	28	14	49	5·95	Nil	5·95

Total, 30·1.

Final Average. 6·02.

EXPERIMENT VIII

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentage of CO_2 in the air expired during a Pranayamic round of 7″ Pūraka and 42″ Rechaka, with no Kumbhaka between them. The other object was the same as the second object of the last experiment.

PREPARATION OF THE SUBJECTS :—

The same subjects were tried here as in the last experiment under the same metabolic conditions.

THE APPARATUS :—

The same apparatus was used in this experiment as in the last.

THE EXPERIMENT PROPER :—

This was done exactly as the last experiment with this difference. Instead of 28″ Kumbhaka and 14″ Rechaka, the subjects had 42″ Rechaka only, without any Kumbhaka at all. The final average of CO_2 in volume per cent. in the expired air, worked out at 5·63. Detailed percentages are tabulated on the next page.

REMARKS :—

Up to now we had found that Kumbhaka had no special value in the elimination of CO^2. But a comparison of this and the last experiment shows, that a Pranayamic round with Kumbhaka has an advantage over one without Kumbhaka. We can, therefore, come to the conclusion that a Pranayamic round with *protracted* Kumbaka has some advantage over one without Kumbhaka, when the total time unit of the round is the same in both the cases. As stated in the remarks on the last experiment, however, a longer time unit is always a disadvantage so far as the elimination of CO_2 is concerned.

ELIMINATION OF CO_2 IN VOLUME PER CENT. IN

Experiment VIII

Subject	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total period of Prāṇāyāma in seconds	Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average
A	7	0	42	49	5·69	4·99	5·34
B	7	0	42	49	5·86	5·69	5·78
C	7	0	42	49	4·45	5·63	5·04
D	7	0	42	49	6·8	6·35	6·58
E	7	0	42	49	5·39	Nil	5·39

Total, 28·13.

Final Average, 5·63.

AVERAGE ELIMINATION OF CO_2 IN VOLUME PER CENT. IN DIFFERENT PRĀṆĀYĀMAS

Experiment	Period of Pūraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prāṇāyāma in seconds	Average elimination of CO_2 in volume per cent.
I	7	0	7	14	3·97
II	7	0	14	21	4·56
III	7	7	14	28	5·02
IV	7	0	21	28	5·2
V	7	14	14	35	4·63
VI	7	0	28	35	5·3
VII	7	28	14	49	6·02
VIII	7	0	42	49	5·63

THE SEMI-SCIENTIFIC SECTION

N. B.— The Director of the Kaivalyadhāma entreats every man of means to show his active sympathy for the Āśrama.

DETERMINATION[1] OF CO_2 AND O_2

PART I

SOME BROAD FACTS OF CHEMISTRY

THREE STATES OF MATTER

IF we look around us we find ourselves surrounded by *matter* on all sides. This matter appears to be under three different states. Some of it is *solid*, such as stone, earth, books, the paper on which we write, and the pen that we use in writing. But the ink with which we write is not solid. It is at the time of writing in a different state which we call *liquid*. Matter which is most abundantly found in a liquid state on the face of the earth is water. So far as things that are visible to us are concerned, we find them to be either solid or liquid. There are, however, particular things which we cannot see, but which surely exist. For instance the air we breathe. It positively exists though we are not able to see it with our eyes. It is neither solid nor liquid, but is in a third state called *gaseous*. It mainly[2] consists of two gases, oxygen and nitrogen. As a rule matter in a gaseous condition is not visible to our eye.

Matter, no matter in what state it is, occupies space, such space being called its *volume*. Solids such as stone or a piece of iron, occupies space, so also do liquids such as water. But we find that the two differ in their behaviour. The stone or the piece of iron will not change its shape whatever the shape of the vessel in which it is held. In other words we can say that solids have their *own* shape. But water will occupy the whole length and breadth of the

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1 This note is intended for those general readers who are innocent of any training in physics and chemistry. Only a few broad facts will be stated here, with a view to enable these readers to follow our research work in Prāṇāyāma intelligently. Hence no reference will be made, in this note, to the ultimate nature of matter and such other subtle problems of today's science.

2 We say *mainly* because along with oxygen and nitrogen, ordinary air contains aqueous vapour, carbon dioxide, argon etc.

vessel in which it is contained. It will *not*, however, *necessarily* occupy the whole height. That means that liquids do occupy space, but have not got their own shape. The shape of the interior of the vessel is *partly* the shape of the liquid. In occupying space gaseous matter differs from liquids as well as from solids. A gas such as oxygen, hydrogen or carbon dioxide, will *fully* occupy the vessel in which it is held.[1] Even if part of the gas is removed, the remainder will again occupy the whole space available in the vessel. It means that gases will always have the shape of the interior of the vessel.

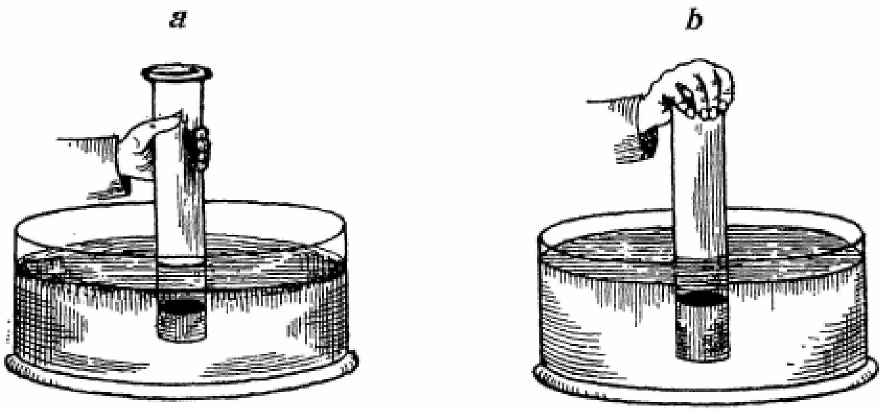
Volume or space occupied by a particular quantity of matter, whether solid, liquid or gaseous, is measured by cubic units, for example, cubic inches, cubic feet, cubic centimeters, cubic millimeters etc.

We have strictly to distinguish between the shape of a substance and its volume. Solids such as a piece of gold, say one cubic inch, have got their own shape as well as their own volume. Liquids such as water have their volume but have not got their own shape. For instance one cubic inch of water will always have the same volume, that is, one cubic inch; but its shape will depend upon the vessel in which it is held. Gases such as oxygen or hydrogen, have neither their own shape nor their own volume. For example if we take one cubic inch of oxygen, this quantity will occupy two, three, four or any number of cubic inches, according to the capacity of the vessel in which it is held. So we see that gases have no volume of their own. Nor have they got their own shape. For this also they depend upon the vessel they occupy. That is why Sir Oliver Lodge has said, 'A solid has volume and shape, a liquid has volume but no shape, a gas has neither volume nor shape.'

With all that has been said above, some of our readers may still doubt the possibility of invisible gases occupying

1 Even an ordinary reader can understand that liquids can be held in open vessels, but for holding gases air-tight vessels are necessary; otherwise gases, having a tendency to diffuse themselves in all directions, will escape through any available opening.

Fig. XVII



Air Occupies Space.

space. For such readers we suggest the following experiments. They are extremely simple.

Experiment I Take a bucket full of water and take an *empty* jug. The ordinary metalic jug of everyday use will do. Now invert this jug and try to sink it into the bucket, taking care to see that the whole surface of the mouth of the jug touches the surface of water at one and the same time. It will be found that the jug refuses to admit water. Why? It is because the jug is *full of air*, although we thought it to be *empty*, and the *space occupied by the air therein*, is not available for water.

If our readers wish to have an ocular demonstration of the facts noted in this experiment, they may take a glass trough instead of a bucket and a glass cylinder instead of a metalic jug. Glass will allow our readers to see the levels of water both in the trough and in the cylinder. If the cylinder is held lightly in water, the inner and outer levels will be nearly the same. (Fig. XVIIa). If, however, the cylinder be pressed forcibly into the water in the trough, as shown in Fig. XVIIb, the inner level will, indeed, rise, as some water will be admitted into the cylinder; but it will be far below the outer level of water. Why? Because the air confined in the cylinder *occupies the inner space* and does not allow more water to come in and raise the inner level.

This experiment not only shows that air occupies space, but also shows that air has no volume of its own. We find the same quantity of air occupies larger space or has a larger volume when the cylinder is held lightly; but when the cylinder is pressed forcibly into water, it occupies smaller space or has a smaller volume. What is true of air is also true of other gaseous substances.

The fact that air occupies space, that is, has volume, can be proved by another simple experiment.

Experiment II Take the same trough filled with water as in the first experiment and also the cylinder. For the

purposes of this experiment, however, the cylinder is to be filled brimful of water. Place your palm on the mouth of the cylinder so as to close it completely. Then invert the cylinder and with the palm fixed on the mouth, with the other hand sink it in the trough. When you find the mouth of the cylinder well under water, remove your palm and continue to sustain the cylinder with the other hand.

You will find that the water in the cylinder does not empty itself into the trough, but stands in a column several inches high above the water level in the trough. Now take a rubber tube, say some three feet in length, and insert one of its ends about four inches into the cylinder. (Vide Fig. XVIIIa). Then hold the other end of the tube in your mouth and blow through the tube slowly but with a little pressure. The air from your lungs will find its way into the cylinder and will appear to rise to the top of it in the form of bubbles. Now if you continue to blow, the air blown into the cylinder will make room for itself by displacing water from the cylinder. Evidently the space vacated by water is occupied by the air from the lungs.

Now if the end of the rubber tube that is inserted into the cylinder is raised some four inches above the water level in the cylinder as shown in Fig. XVIIIb and the cylinder is allowed to sink under its own pressure, the confined air will escape through the rubber tube and can be felt at the other end. Then the space vacated by this will be taken up by water. Thus we see that air does occupy space.

We may elucidate here another point about gaseous substances which may not be clear to some of our readers. Have gases got weight ? If we try to understand some of the things we observed in the last experiment, we will get an answer to this question.

During the last experiment it was seen that the inverted cylinder, though full of water, did not empty itself into the trough. Now the column of water standing in the cylinder

Fig. XVIII-a

Air Occupies Space

Fig. XVIII-b

Air Occupies Space.

has surely got weight. Then why does it not press down ? Or is there any invisible force acting on that water which is counterbalancing its weight ? We have to admit the existence of some force that counteracts the weight of the water column standing in the cylinder. This force is the pressure of the atmosphere which surrounds the earth to the height of several miles. It is called the atmospheric pressure and is calculated to be 14·59 pounds per square inch. The water column in the cylinder is trying to descend, but is kept back by this atmospheric pressure. Scientists have found that this atmospheric pressure is able to support a water column about 33 feet in height. They have also found that this atmospheric pressure can support a column of mercury 760 millimeters in height. What is true of the atmosphere which is only a mixture of gases, is true of all gaseous substances. Thus we see that all gases occupy space and have got their own weight.

In the beginning of this note we have seen that all matter exists in one of the three states: solid, liquid and gaseous. But shall we find the same type of matter always in the same state ? Most certainly not. Take for instance water. We find that at low temperatures, it is turned into ice and becomes solid, whereas at high temperatures it disappears in the form of vapour and becomes gaseous. Thus we see that water can exist in all the three states : solid, liquid and gaseous. A piece of gold or silver under different temperatures will furnish another illustration. Ordinarily it is solid. With heat it will melt into a liquid and if the temperature is raised sufficiently higher, that liquid will be driven into a gaseous state. What is true of water, gold or silver, is true of all other types of matter.

Here an untrained mind might argue as follows. We see a solid piece of gold being melted before our eyes. It can again be returned to its solid condition. That is why we know that the substance in both the states is one and the same. But when the liquid gold is turned into an invisible gas, what is it that enables chemists to say that the resulting gas is gold and nothing else ? First of all the argument

may be answered as popularly, as it is advanced. It may be pointed out that the resulting gas can be collected and again turned into a solid mass of gold, without losing even the smallest particle of the original substance. But the real answer would take the following form.

A solid piece of gold is made of extremely minute particles which were long supposed to be ultimate and indivisible. These particles are called *atoms.*[1] Now scientists have found methods of examining gold even in a gaseous state and they have come to the conclusion that the atoms of gold themselves remain unbroken in a gaseous state and retain all their original properties. So the atoms of gold remain absolutely unchanged whatever the state in which gold exists; and as it is these atoms of which gold is made, gold remains gold whether it is solid, liquid or gaseous.

ATOMS, MOLECULES AND ELEMENTS

In the last paragraph we have talked of the atoms of gold. Are there any other varieties of atoms which retain their original character absolutely unchanged whatever the state of the substance which they go to form? The chemists have up to now found out 90 varieties of atoms. Whatever the variety, all its atoms will be absolutely alike whether they are to be found on the face of the earth or in the sun or in a star a million times more distant from us than the sun. Again all atoms of the same variety will have exactly the same weight and their attitude towards atoms of their own variety or other varieties will be exactly alike.

Now when we find a substance consisting of the atoms of the same variety, we call it an *element.* Naturally there are as many elements[2] as there are varieties of atoms. *Ordinarily* different elements are in a different state. Gold, silver, iron etc., are in a solid state. Mercury and bromine

1 We now know that atoms are not the ultimate particles that go to form matter, nor are they indivisible. But for the purposes of this note, they can be looked upon as ultimate units of matter.

2 For an exhaustive list of elements readers are referred to some text-book of chemistry.

are in a liquid state. Oxygen, hydrogen, nitrogen etc., are in a gaseous state. As explained above, however, it is possible for these elements to change their state, without making any change in the original character of their respective atoms.

We have seen that there are ninety varieties of atoms giving us ninety different elements. But have all these atoms of different varieties got the same weight or are the atoms of a particular variety heavier than those of some other variety? Although all the atoms of the same variety have got the same weight, atoms of different varieties have got different weights. Naturally some atoms are heavier than others. Scientists have found that the atoms of uranium are the heaviest and the atoms of hydrogen are the lightest. Hydrogen being the lightest of all elements, its atomic weight has been taken as a standard[1] and the atomic weights of other elements are estimated in terms of this unit. Thus the atomic weight of hydrogen is taken as one; and as an atom of oxygen is sixteen times heavier than an atom of hydrogen, the atomic weight of oxygen is put down as sixteen. So when we say that the atomic weight of mercury is 200, it only means that an atom of mercury is 200 times heavier than an atom of hydrogen. We need not add that an atom of mercury will retain this weight in relation to the hydrogen atom whatever the state in which the two elements are found.

The atoms of an element have the greatest freedom to move when that element is in a gaseous state. It is desirable to know, therefore, whether these atoms move all alone or whether they prefer to be associated with others, when they enjoy the greatest freedom. In this connection chemists have found that there are some elements such as mercury and zinc which give the greatest liberty to their atoms and allow them to move about in single blessedness. But in the case of many elements the atoms have to find one companion. For instance the atoms of oxygen have to move about in pairs. This companionship of atoms is not, however, limited

1 This was originally the case. But now scientists take the atomic weight of oxygen as the standard and evaluate other atomic weights accordingly.

to two members only. Atoms of phosphorus always form *fours*, whereas every atom of sulphur will require at least five more companions. Thus we see that most of the elements when in a free state do not exist in the form of single atoms, but they exist in the form of groups of atoms of different numerical strength. As these groups form little masses of those elements, chemists call them *molecules*. They will say that oxygen has two atoms to the molecule, phosphorus has four atoms to the molecule, and so on. What we have particularly to note here is this. Whatever the number of atoms that go to form a molecule of an *element*, all those atoms will be exactly similar.

COMPOUNDS AND MIXTURES

Here we might ask ourselves the following question. Can atoms form association with their own kind to build up molecules, or are they free to associate with atoms of a different kind also? The answer to this question is in the affirmative. Although every kind of atom is not free to associate itself with every other kind of atom to form a molecule, different kinds of atoms do associate themselves with other kinds of atoms to build up molecules. For instance two atoms of hydrogen will associate themselves with one atom of oxygen and build up a molecule of three atoms. Similarly one atom of sodium will associate itself with one atom of chlorine to form a molecule of two atoms. In the same way it is possible to build molecules with atoms of three, four, five or even six kinds of atoms, the total number of atoms in the molecule being as big as 2,876 and the molecule being 8,334 times heavier than the molecule of hydrogen.

We must, however, learn to distinguish between molecules that are formed of atoms exactly similar to one another and molecules that are formed of atoms that are not of the same kind. Molecules of the first type constitute *elements*, whereas molecules of the second type constitute *compounds*. Thus every molecule of phosphorus will consist of four atoms that are exactly similar and will go to form the *element* called phosphorus. But a molecule formed of two atoms of hydrogen

and one atom of oxygen, which are not of the same kind, will give us the *compound* called water. Similarly one atom of carbon and two atoms of oxygen will combine into a molecule which will give us the *compound* carbonic acid gas. So whenever there is a substance the molecules of which consist of atoms of the same kind, it is called an *element*. And whenever there is a substance the molecules of which consist of atoms of different kinds, it is called a *compound*.

Again every molecule of the compound called water will ever consist of the three atoms, two of hydrogen and one of oxygen, so long as water remains water, whether it is in a solid, liquid or a gaseous state. The moment, however, these molecules are broken up, water will disappear, giving rise to two types of molecules which will be entirely different from the molecules of water. Some of these new molecules will be of the element hydrogen, consisting of two exactly similar atoms ; whereas others will be of the element oxygen, again, consisting of two exactly similar atoms, though dissimilar from the atoms of hydrogen. Thus we see that when a compound is formed, all its molecules are of an entirely different character from the molecules of the different original elements that combine to form that compound.

Now suppose that the two gases oxygen and hydrogen obtained by breaking up the molecules of a drop of water, are held in a closed vessel. Immediately the molecules of the two gases will intermingle. What shall we call this quantity of intermingling molecules ? Shall we call it a compound or shall we give it a different name ? Chemists do not call it a compound, because no new molecules are formed therein, differing from the molecules of the original gases. The name they give to such a quantity is *mixture*. According to this nomenclature, the air we breathe is a mixture. It mainly consists of two gases, oxygen and nitrogen. The molecules of these two gases do intermingle to form the air, but they never change their original characteristics. So when two or more elements come together to form a substance giving rise to a new type of molecules, that substance is

called a *compound.* But when two or more elements come together to form a substance while their respective molecules retain their original characteristics, that substance is called a *mixture.* It is possible for mixtures to be made not only of elements but of compounds, provided the compounds do not give rise to a new compound.

SYMBOLIC REPRESENTATION IN CHEMISTRY

Chemists have got a very short and sweet way of expressing elements, compounds and their molecules, not omitting to mention the number of atoms that go to form these molecules. The method they follow may be described as a symbolic representation in chemistry. They start by choosing a symbol for every element. Generally these symbols are only the first letters of the names of those elements. Thus instead of using the word hydrogen they will simply say H; instead of oxygen, O; instead of nitrogen, N, and so on. But at times there are more elements than one that have got the same initial letter. When this is the case one of these elements is represented by the initial letter and the remaining are represented by adding to the initial one more letter from the name of the element concerned. For instance carbon, calcium and chlorine, all begin with C. So carbon is represented by C, calcium by Ca and chlorine by Cl, all initial letters being written capital. At times, however, the symbols are not taken from the current names of the elements, but from their Latin names. Thus the symbol of copper is Cu, being taken from its Latin name *cuprum*, of iron it is Fe from *ferrum* and of gold it is Au from *aurum*.

Next we want to see how chemists express an elementary or a compound molecule and the number of atoms that the molecule contains. For expressing an elementary molecule, chemists write down the symbol of the element followed by the number of the atoms of which the molecule is made. Thus when they want to say one molecule of oxygen, they will simply say O_2, meaning thereby that every molecule of oxygen is made up of two atoms. If a molecule of phosphorus is to be expressed, they will say P_4, showing that four atoms of

phosphorus make up its molecule. If, however, a molecule is formed of one atom only as in the case of mercury or sodium, no number will be mentioned after the symbol of the element, the number one being left understood. Thus one molecule of mercury is written as Hg, and not Hg_1, and of sodium as Na, and not Na_1. For expressing the number of molecules, they will prefix the necessary figure to the symbol of the molecule. For instance if chemists want to say six molecules of oxygen, they will write $6O_2$. So we see that the figure prefixed to the symbol of an element indicates the *number of molecules*, whereas the figure affixed to the symbol expresses the *number of atoms* contained in each molecule.

Compound molecules are expressed by chemists just as they express elementary molecules. Our readers know that water is a compound formed from two atoms of hydrogen combined with one atom of oxygen. So chemists' symbol of water is H_2O. Again as common salt is a compound of one atom of sodium and one atom of chlorine, it is written as NaCl. It is possible for a compound to contain three or more elements. Even then the same method of expression is followed. Thus sulphuric acid is H_2SO_4 which means that every molecule of this acid is formed by a combination of two atoms of hydrogen, one atom of sulphur and four atoms of oxygen.

Our readers may note here that every element and every compound in the world is made up of infinite molecules that are exactly similar in nature. Thus hydrogen is made up of countless molecules but they are all alike. Similarly water or sulphuric acid is made up of an infinite number of respective molecules which are exactly similar in nature. This being the case, the symbol which expresses a molecule also appropriately expresses the element or compound to which the molecule belongs. Thus H_2O is water, NaCl is common salt, and so on.

CHEMICAL REACTIONS AND EQUATIONS

When two or more substances combine so as to change themselves into one or more substances of an entirely differ-

ent molecular constitution, the action which takes place is called a *chemical change.* These changes are termed *chemical reactions*, and are expressed by what are called *chemical equations*. The substances as they are originally taken are symbolically expressed on the left side of the equation and the new substances as they are produced by the chemical reaction are similarly expressed on the right. Thus we may have the following equation.

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

What the equation means is this. If we put together one molecule of zinc (Zn) and a molecule of sulphuric acid (H_2SO_4), a chemical reaction will take place ; and the chemical reaction will yield from these molecules, one molecule of zinc sulphate ($ZnSO_4$), and will liberate one molecule of hydrogen (H_2). Thus a chemical equation *shows the quality* of the substances which chemically react and also the quality of the substances that are produced as a result of the chemical reaction. We know what substances we have put together and also what substances we could get from them.

Now let us also see whether we lose anything in such a business or we recover everything that we put in. For this examination we must see that we could recover all the atoms that we put in. So let us count the atoms on both the sides of the equation. On the left hand side we have one atom of zinc, two of hydrogen, one of sulphur and four of oxygen, altogether eight in number. On the right hand side we have one atom of zinc, one of sulphur, four of oxygen and two of hydrogen, again altogether eight. So we see that we get back all the atoms that we put in. Further it will be clear that we get back not only the total number of atoms, but every atom of every *element*. Thus on both the sides, there is only one atom of zinc and only one of sulphur. So also on both the sides, there are two atoms of hydrogen and four of oxygen. The only difference that we see between the two sides is a difference in the grouping of these atoms and this leads to a difference in the *quality* of the four substances. Thus it is clear that a chemical equation is

a very short and sweet way of expressing the *quality* of the substances that chemically react and also the *quality* of the substances that are produced as a result of this reaction. Such an equation also shows the exact number of molecules and atoms on both the sides.

Does a chemical equation say anything as to the *quantity* of the substances taking part in a chemical reaction? On further study of these equations, we shall find that they are useful in telling us also the *quantities* of the substances concerned.

Let us recall a few facts that we have learnt in some of the foregoing paragraphs. We have already seen that atoms and molecules have weights and that these weights have been determined in terms of a unit offered by the hydrogen atom. This determination of weights of individual atoms and molecules, should enable us to know the quantities of the substances taking part in a chemical equation. Let us return to the equation that we have already studied.

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

We know the atomic weights of all the substances[1] that are used here and we can at once write down the equation with the atomic weights written below each of the substances.[2]

$$\begin{gathered} Zn + H_2SO_4 = ZnSO_4 + H_2 \\ 65 + 2 + 32 + 64 = 65 + 32 + 64 + 2 \\ 163 = 163 \end{gathered}$$

What does it mean? It means as follows: If we put together zinc weighing 65 times as much as one atom of hydrogen and sulphuric acid, weighing 98 times as much as

1 The atomic weight of zinc is 65 and of sulphur 32.

2 When the weight of an elementary molecule is to be determined, we have simply to *multiply* the atomic weight of the element by the number of atoms which go to form the molecule. Thus molecular weight of oxygen would be 16×2, where 16 is the atomic weight and 2 is the number of atoms forming an oxygen molecule. When we wish to find the weight of a compound molecule, we have to *add* the weights of the different atoms of which it is formed. Thus the weight of H_2SO_4 is 2 (for H_2) + 32 (for S) + 64 (for O_4 or 16×4) = 98.

the same unit, we can produce zinc sulphate weighing as much as 161 times that unit and liberate hydrogen weighing twice the same unit. That is to say, we have put in 65 units of zinc and 98 units of sulphuric acid and produced 161 units of zinc sulphate and two units of hydrogen, our unit all the while being the weight of an atom of hydrogen. Here our readers may very pertinently ask us to state the weight of a hydrogen atom in terms of weights that are generally known to us such as ratis, grains, grammes, ounces etc. We must admit that the question is very valuable and yet we must say that the question need not detain us here. We can put the equation to a practical use, if we simply know that we can substitute any unit we like for the unit referred to up to now. So instead of taking the weight of a hydrogen atom as our unit, we can take grains as our unit and yet the equation must hold good, if only our units are all weighing units. The reason is obvious. All the figures that we have written below the substances as showing their atomic weights, in the equation under discussion, are merely multiples of a particular unit and their mutual relations will stand so long as one and the same unit underlies the whole calculation. Whether that unit is a grain, a gramme or the weight of an atom of hydrogen is immaterial. So let us have the grain as our unit and let us see what the equation means, when we use this new unit of weight. Now the equation tells us that if we put together 65 grains of zinc and 98 grains of sulphuric acid, we shall get 161 grains of zinc sulphate and two grains of hydrogen. Thus it is clear that a chemical equation can express not only the *qualities* of the substances concerned, but also their respective *quantities.*

We shall take two more examples to make the subject clearer still.

Our readers must be familiar with the substance called red oxide of mercury (हिंगुल Sanskṛita). Chemically it is a compound of mercury[1] and oxygen. When it is heated it is

[1] The symbol for mercury is Hg. Atomic weight 200.

decomposed into the two elements which combine to form it. This chemical change can be expressed in the form of an equation.

$$2HgO = 2Hg + O_2$$

Expressed in terms of weights the equation would read as:
2 (200 + 16) red oxide of mercury = 2 × 200 of mercury + 16 × 2 of oxygen.
that is,
432 units red oxide of mercury = 400 unit of mercury + 32 units of oxygen.

which means that we can get 400 grains of mercury and 32 grains of oxygen, if we heat 432 grains of red oxide of mercury.

Another example may be furnished by the action of hydrochloric acid upon chalk.[1] We can express the same by the following equation.

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$$

100 units of calcium carbonate + 73 units of hydrochloric acid = 111 units of calcium chloride + 18 units of water + 44 units of carbon dioxide.

Again if we take the gramme as our unit, we can say that 100 grammes of calcium carbonate when subjected to the action of 73 grammes of hydrochloric acid, will yield 111 grammes of calcium chloride, 18 grammes of water and 44 grammes of carbonic acid gas.

Before we close the topic of chemical equations, we wish to refer to one point which would be suggested by a study of the equations just discussed and which would be useful to us in understanding the principal question before us, namely, the estimation of O_2 and CO_2. In all the three equations we see that a particular gas is found to be *fixed* in one of the substances represented on the left hand side of the equation. Thus in the first equation hydrogen is found fixed in sulphuric acid; in the second, oxygen is found fixed in red

1 Chemically chalk is calcium carbonate or $CaCO_3$. The symbol of calcium is Ca and its atomic weight 40. Chlorine in hydrochloric acid, has for its symbol Cl with atomic weight 35·5.

oxide of mercury; and in the third, carbon dioxide is found fixed in calcium carbonate. Again we learn that these *fixed* gases can be set *free* by means of a chemical reaction. Thus we could get free hydrogen in the first equation, free oxygen in the second and free carbonic acid gas in the third.

Again if we study the right hand sides of these equations, we find that the exact quantities of these free gases have been mentioned. Thus we have referred to two grains of hydrogen, 32 grains of oxygen and 44 grammes of carbon dioxide. Here the question arises, and that is the principal question before us, as to how scientists determine the exact quantities of these gases. Having studied thus far some of the broad facts of elementary chemistry, our readers are now in a position to understand the methods which scientists follow in this connection. In the second part of this note, we shall try to describe these methods briefly with special reference to O_2 and CO_2.

PART II

VOLUMETRIC AND GRAVIMETRIC ESTIMATION OF CO_2 AND O_2

Scientists have developed two methods of determining the exact quantities of gases. One is called the *volumetric method* and the other is called the *gravimetric method.*[1] We shall first study the volumetric method.

THE VOLUMETRIC METHOD

According to this method the quantity of a gas is determined by measuring its volume. Thus if the quantity of CO_2 in the expired air is to be determined, its volume is measured and thus the quantity of that gas is estimated. Now this would sound quite strange to our readers, because

1 We use both the methods in our everyday life. For instance when we estimate the quantity of a stock of milk we use the volumetric method and when we determine the quantity of a stock of butter, we use the gravimetric method. The means we employ are rough whereas scientists' means are accurate.

they have been told that gas has no volume of its own. but it assumes the volume of the vessel in which it is contained. Thus a particular quantity of gas, say of CO_2, can be made to have 2 c.c. as its volume or 4 c.c. or even ·5 c.c. How is then the volume of a gas going to help us in determining its quantity? The question raised by our readers is perfectly right; and yet we shall find that the quantity of a gas can be determined by measuring its volume. We shall now proceed to see how this becomes possible.

Let us take an elastic rubber bag. A football bladder will do. Let us fill it very moderately with air by means of an air pump, and close its mouth air-tight. Ordinary air is only a mixture of gases and what we shall find true of air, will hold good in the case of any other gaseous substance. We find that the bladder is a little bit inflated with the particular quantity of air that it holds. Let us now place the bladder horizontally on a table and let us press it down with our palm. We find that the air confined in the bladder is putting forth counter pressure. Now let us fold half the bladder at one end in such a way that the folded part will be empty and the whole quantity of air will be held in the remaining half. Let us again press the inflated part of the bladder with our palm. What do we feel? We find that the counter pressure offered by the confined air has considerably increased. If we roll up the bladder still further, the confined air will offer a still higher counter pressure. Now throughout these operations the quantity of air in the bladder has remained the same. The volume of it, however, has become smaller and smaller as the bladder continued to be folded. And we have found that the smaller the volume the air assumed, the greater was the counter pressure offered by it. Now this counter pressure is merely the pressure at which the air inside the bladder stands. So we come to the conclusion that the pressure of a quantity of gas is increased, if its volume is reduced.[1] Now scientists have found that this

1 The other factor which influences the volume of a gas is temperature. We shall refer to this presently. Till then we are taking it for granted that there is no change in temperature, but it is constant.

variation in pressure of a gas is exactly in the inverse proportion of its volume. Thus if the volume is doubled the pressure will become half; and if the volume is made four-fold, the pressure will be reduced to its quarter. From this it is clear that a particular quantity of gas will always have the same volume if the pressure is maintained uniform. We have already said that all gases as well as their mixtures, behave in the same way so far as the relation between their volume and pressure is concerned. Thus CO_2, O_2 or H, all will have the same volume for the same quantity, if they are at the same pressure. Now if we reverse this position, we can say that two gases, if they are at the same pressure and have the same volume, must be equal in quantity.

We may note here that everything on this earth is under the atmospheric pressure which is equal to 760 milli-meters Hg. This atmospheric pressure is looked upon as the standard pressure. Now suppose that a particular quantity of CO_2 under this pressure has a volume of 4 c.c. and a particular quantity of O_2 under that very pressure has a volume of 16 c.c., we can at once come to the conclusion that the quantity of O_2 is four times that of CO_2. Our readers may note here that the quantity of O_2 which measures 16 c.c. will measure only 8 c.c. if the pressure is doubled, that is, is made equal to 1,520 mm. Hg.

Thus far we have studied the relation existing between the pressure of a gas and its volume. Now we have to take into consideration another factor which influences the volume of a gaseous substance. This facter is *temperature*.[1]

1 The instrument which measures temperature is called the *thermometer*. There are different scales of thermometers, but we shall say something here only about two scales. One of these is the *fahrenheit* scale and the other the *centigrade*. The former is very much in the popular use in England and the latter is universally used in scientific circles. According to fahrenheit scale water boils at 212° (212 degrees each of which has an equal value), and according to the centigrade scale it boils at 100° (100 degrees each of which also has an equal value). Descending along the scales, we find the freezing point of water to be at 32° F. and 0° C. Thus we see that the range of temperature between the boiling point of water and its freezing point is divided into 100 parts accordng to the centigrade scale and into 180 parts according to fahrenheit scale, each part in both the scales being called a *degree* which is symbolically indicated by °

Heat expands and cold contracts is a scientific proposition applicable to all substances whether they are solid, liquid or gaseous. The degree of expansion in the case of solids and liquids is not the same. Different solids and different liquids will have each its own degree of expansion. Gases stand on a different footing in this connection. All gases will expand uniformly for the same degree of heat. Thus if we have 273 c.c. of CO_2, O_2 or air, or any other gaseous substance at 0° C., and if we raise this temperature by 1° C., that is, if we raise it to 1° C., the volume of each gas will have increased by 1 c.c., that means, each gas will measure 274 c.c.[1] If we raise it by 2° C., each gas will measure 275 c.c. and so on. If we, however, lower the temperature by 1° C., the volume of each gas will shrink by 1 c.c. Thus at – 1° C., the quantity of gas taken above will measure 272 c.c., and at – 2° C., 271 c.c. only.

If we were to deduce a general proposition from the statements made in the last paragraph, we can say that the volume of a gas at 0° C. increases or decreases according as its temperature rises above or falls below that level, the variation being 1 in 273 units for every degree of heat of the centigrade scale. Here it is clear that in our calculations of expansion or shrinkage of the volume of a gaseous substance, we have to start with 0° C. Hence this temperature is looked upon as the standard temperature. At this standard temperature a particular quantity of any gas will have the same volume,[2] and this volume will uniformly vary according to temperatures higher or lower.

Continued—]
placed on the top of the number. It must be noted here that hundred degrees of centigrade are equal to hundred and eighty degrees of fahrenheit. Therefore 1° of centigrade is equal to 1·8° of fahrenheit. With the help of this proportion it is possible to convert the degrees of fahrenheit into the degrees of centigrade and *vice versa*. Thus 10° C. is equal to (32 + 18 =) 50° F. and 30° C. is equal to 86° F. Temperatures below the freezing point of water are read as *minus* on the C. scale. Fahrenheit records 32° according to its own scale below the freezing point as *plus*, lower temperatures being recorded as *minus*. The clinical thermometers used by doctors are according to the F. scale.

1 How this volume is measured will be seen later on.

2 Pressure being constant.

Up to now in our discussion on the volume of a gas we referred to pressure and temperature separately. When we considered the effects of pressure on the volume, we neglected the temperature of the gas; and when we took into consideration the temperature, we neglected the pressure of the gas. Now pressure can be neglected, if it is constant and the volume is changing according to temperature alone. For instance suppose that we have a quantity of gas 40 c.c. in volume, at a pressure of 760 mm. Hg., and at a temperature of 30° C. Further suppose that the pressure does not change, but the temperature changes from 30° to 40° C. Under these circumstances it is clear that the change in the volume will be due only to temperature and not to pressure which does not change, but remains constant. Hence in calculating the change in volume of a gas under such circumstances, temperature alone is to be taken into account and pressure can be neglected. Again temperature can be neglected if it is constant and the volume is changing according to pressure alone. It is possible, however, that both pressure and temperature may change and conjointly influence the volume of a gas. But even under these circumstances, we can work out the volume by calculating the influence of temperature and the influence of pressure separately. Let us take a concrete example. Suppose we have 626 c.c. of CO_2 at 40° C. and at a pressure equal to 380 mm. Hg. and we want to find the volume of this gas at the standard pressure and standard temperature. First we start with the consideration of the influence of pressure. The gas is at a pressure of 380 mm. Hg. This is only half of 760 mm. Hg. It means that the gas is at half the atmospheric pressure. Hence the present volume is double of what it would have been at the atmospheric pressure. So in order to find its volume at the standard pressure, we have to divide the present volume by 2. $\frac{626}{2}$ c.c. $= 313$ c.c. So we find that the present quantity of CO_2, would have a volume of 313 c.c. at the standard pressure. Up to now temperature has not been taken into account. It has been allowed to be constant. Now let us take that into consideration. It is 40° C. The standard temperature is 0° C.

So we have to reduce the volume 313 c.c. at 40° C. to what it would be at 0° C. By simple algebraic calculation[1] we find it to be 273 c.c. What all this means is this. A quantity of CO_2 which at 40° C. and at a pressure equal to half the atmosphere, has a volume of 626 c.c., will have a volume of 273 c.c. at the standard pressure and standard temperature. In this way all gases can be reduced to the standard pressure and temperature. And as everyone of them obeys the same rules of expansion under different pressures and at different temperatures, when they are reduced to the same standard of pressure and temperature, they become comparable in volume. A gas when reduced to the standard temperature and pressure is said to be at normal temperature and pressure or at N. T. P.

As the same quantity of any gas whatsoever, at N. T. P. will always have the same volume, the same volume of any gas at N. T. P., will indicate the same quantity. If the volume is doubled at N. T. P., the quantity must be doubled. If the volume at N. T. P. is halved, the quantity must also be halved. Thus we find that the volume of any gas at N. T. P. increases or decreases according as its quantity increases or decreases. Hence the volume of a gas at N. T. P. is a measure of its quantity. Thus if we have 100 c.c. of CO_2 at N. T. P. and 200 c.c. of O_2 at N. T. P., we

1 We have seen above that for every degree of variation above or below zero degree of temperature according to the centigrade scale the volume of gas varies by one in 273 parts, pressure being constant. If we take V to be the volume of gas at zero degree centigrade for every degree of variation in temperature it will vary by $\frac{V}{273}$. Now in the case of the present example, the gas stands at 40° C. and we have to find its volume at 0° C. Now we have supposed V to be its volume at 0° C. Evidently at 40° C. its volume will be $V + 40 \times \frac{V}{273}$. Now as we know its volume at 40° C. to be 313 c.c., we can calculate the value of V which will give the volume of the gas at 0° C.

$$\text{We have } V + \frac{40\,V}{273} = 313 \text{ c. c.}$$
$$\therefore 273\,V + 40V = 273 \times 213 \text{ c. c.}$$
$$\therefore 313\,V = 273 \times 313 \text{ c. c.}$$
$$\therefore V = 273 \text{ c. c.}$$

that means the present gas will have a volume of 273 c.c. at 0° C.

can conclude that the quantity of O_2 is double the quantity of CO_2. In this way by measuring the volume of a gas we can measure its quantity, the method being called the *volumetric estimation* of gas.

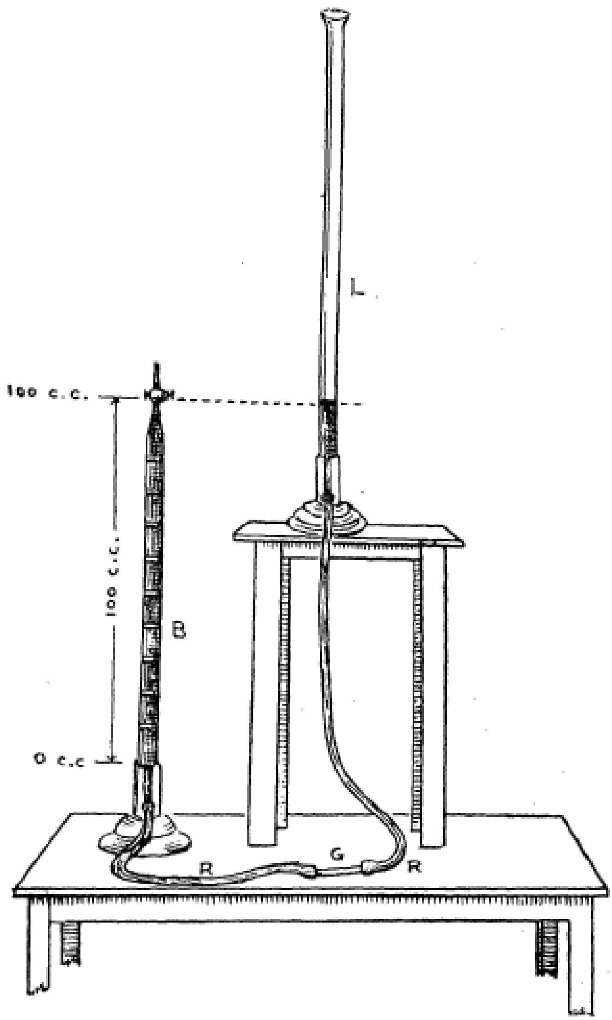
We shall now give a brief account of the practical way in which the percentages of CO_2 and O_2 in the expired air are estimated according to the volumetric method.

The apparatus which plays the most important part in the volumetric estimation of gases is called the *gas burette*. In Fig. XIX, *B* illustrates such a burette. It consists of a glass tube graduated to 100 c.c. in $\frac{1}{5}$ c.c. and is set on a wooden foot. If necessary both the ends of the burette are provided with taps for conveniently establishing or cutting off its connection with the outside. The burette shown in the present illustration is fitted with the upper tap only. There is another glass tube called either the *pressure tube* or the *levelling tube*. *L* represents this levelling tube in Fig. XIX. This is also set on a wooden foot. The lower ends of both these tubes are connected with each other by means of two pieces of a rubber tube which are in their turn joined in the middle by a short length of a glass tube as shown in the illustration.

At the time of the experiment, the tap of the burette is opened and the two tubes are filled with water and their levels adjusted as illustrated in Fig XIX. The burette and the rubber tube are completely filled with water. The levelling tube is filled with water up to the dotted line. Our readers must have seen that the level of water in *B* and *L* must be the same, because both of them are exposed to the same atmospheric pressure, the upper ends of both being open.

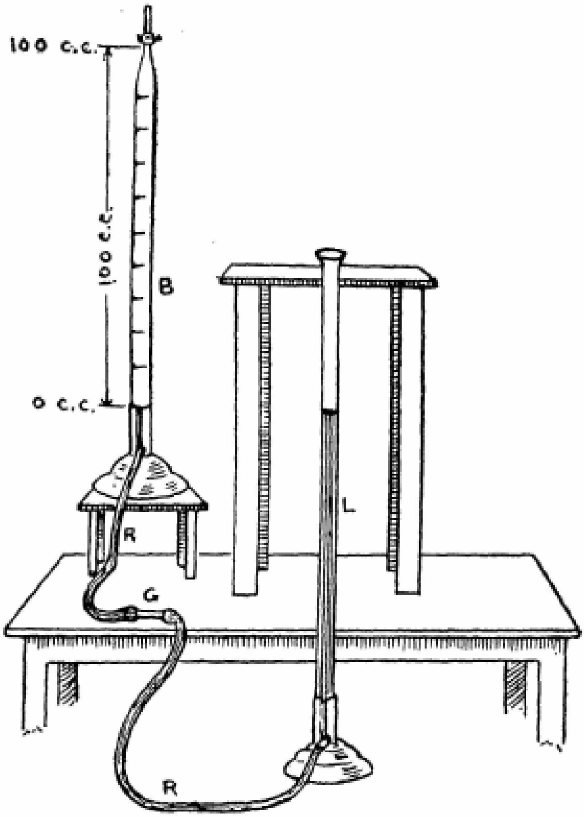
The stock of the expired air which is to be examined for finding out percentages of CO_2 and O_2, is generally held in a rubber bag or some other convenient vessel. That source is now connected with the upper end of the burette. The levelling tube is lowered, so that the water level in it rises in relation to itself, but sinks in relation to the burette. The

Fig. XIX



The Gas Burette in Working.

Fig. XX



The Gas Burette in Working.

result is that the water level in the burette also sinks and the place of this water is taken by the air from the rubber bag. Only as much air is admitted into the burette as would keep the water level exactly at 0 c.c. when the tap of the burette is turned off. (Vide Fig. XX).

Our readers will see that the quantity of the expired air that we admitted into the burette now measures 100 c.c., that is, has a volume of 100 c.c. We cannot, however, understand the real value of this volume, unless we know the pressure and temperature at which the expired air in the burette stands. Because this very quantity of the expired air may measure more than 100 c.c. or even less than 100 c.c. according as its pressure or temperature will vary. Let us, therefore, try to note its present pressure and temperature and also try to see what volume this quantity of air will have at N. T. P.

Let us first know the pressure. The water in *L* is under the atmospheric pressure. The level of this water and the level of water in *B* is the same. Hence we conclude that water in *B* is also under the same pressure as water in *L*. Now let us understand exactly the pressure that is exerted on the water in *L*.

We have already seen that the water in *L* is under the atmospheric pressure. In order, however, to know the exact value of this pressure, we have to take into account one point which we have not taken notice of up to now. The atmospheric pressure changes according to the altitude of a place and the weather conditions. 760 mm. of mercury is the value of the atmospheric pressure at the sea-level and under particular weather conditions only. As we rise higher this value of the atmospheric pressure will fall.[1] Again at a given altitude fair weather will have a value different from a cloudy atmosphere. The instrument which records the exact pressure in

1 Because the column of air that stands above the higher place is shorter than the column of air standing above the sea-level. Hence its weight will be smaller, so also its pressure.

terms of mercury for all these conditions is called the *barometer*.[1] Now suppose that the barometer indicates only 605 mm. as the atmospheric pressure at the time of our measuring the volume of the expired air in the burrette. We, then, conclude that the water in *L* is under pressure equal to 605 mm. Hg. and as the water in *B* is also under an equal pressure, the water in *B* is also under pressure equal to 605 mm. Hg.

Can we say that this pressure, 605 mm. Hg., exerted on the water in *B* is all due to the pressure of the expired air confined in the burette ? We would have been justified in saying so, had there been nothing else present in the burette except the confined air. But scientists have found that aqueous vapour is invariably present in gases when they are confined over water in a burette. Our air is confined over water. Hence vapour must be present in the air that is held in the burette. Now this aqueous vapour exerts its own pressure along with the air. Hence the pressure exerted on the water in *B* is due not only to the air but also to the vapour present.

So if we want to know the pressure of the expired air alone, we have to deduct the vapour pressure from the total pressure exerted on the water in *B*. We know the total pressure on the water in B to be 605 mm. Hg. or equal to the barometric pressure. So if we can determine the vapour pressure, and deduct it from the barometric pressure, we can at once know the correct air pressure.

In order to determine the vapour pressure, we have to know the temperature[2] of the air we are examining, because this pressure varies as temperature. Let us suppose our air to be at 32° C. Now ready-made tables are available that record the vapour pressure at different temperatures in terms of mercury. From these tables we can find that the vapour pressure at 32° C. is 35 mm. Hg.

1 We have already noted in the first part of this note that the atmospheric pressure is equal to 760 millimeters of mercury. These millimeters are indicated on the barometer.

2 How to determine this temperature will be seen presently.

Deducting this vapour pressure of 35 mm. Hg. from the barometric pressure of 605 mm. Hg., we get 570 mm. Hg. as the pressure that is exerted by the expired air alone on the water in *B*. That is to say the real pressure of the air under examination is 570 mm. Hg. and not 605 mm. Hg. Pressure thus corrected is said to be corrected for vapour. The correction may be called *vapour correction*.

Thus we find that the quantity of air admitted into the burette measures 100 c.c. at 570 mm. Hg. and at 32° C. Now if we want to find the volume of this quantity at N. T. P. we have to further correct this volume of 100 c.c. to both pressure and temperature. We have already applied the vapour correction. We also know how to correct a volume for pressure and reduce it to the normal pressure of 760 mm. Hg. The present volume is 100 c.c. at 570 mm. Hg. Therefore the volume at 760 mm. Hg. would be 75 c.c.

Again the temperature of the volume of the expired air that we have confined over water in the burette has to be taken into account. This is determined by finding the temperature of water in the levelling tube by means of a thermometer. Now suppose this temperature to be 32° C. We at once see that the volume of the expired air we are examining has again to be corrected to temperature before we can know its volume at N. T. P. This correction too we know how to do. Calculating accordingly we get 67·1 c.c. to be the volume of our sample at N. T. P. 100 c.c. is its volume at the barometric pressure of 605 mm. Hg. and at 32° C. of temperature.

Having corrected[1] the volume to N. T. P., we now proceed to examine what percentage of it is made of CO_2. For this purpose a *pipette* is necessary. Fig. XXI illustrates what is called a *simple absorption pipette*. It consists of a glass tube with convenient bents and two bulbs blown in it at suitable places. It is mounted on a wooden stand. This pipette

1 These corrections need not be worked out. Only the barometric pressure and temperature may be noted down in order to understand the exact value of 100 c.c. of the expired air taken up for the examination.

is filled with a strong solution of caustic potash as shown in Fig. XXI. Both the ends X and Y are open. The tube ending in X has a very fine bore.

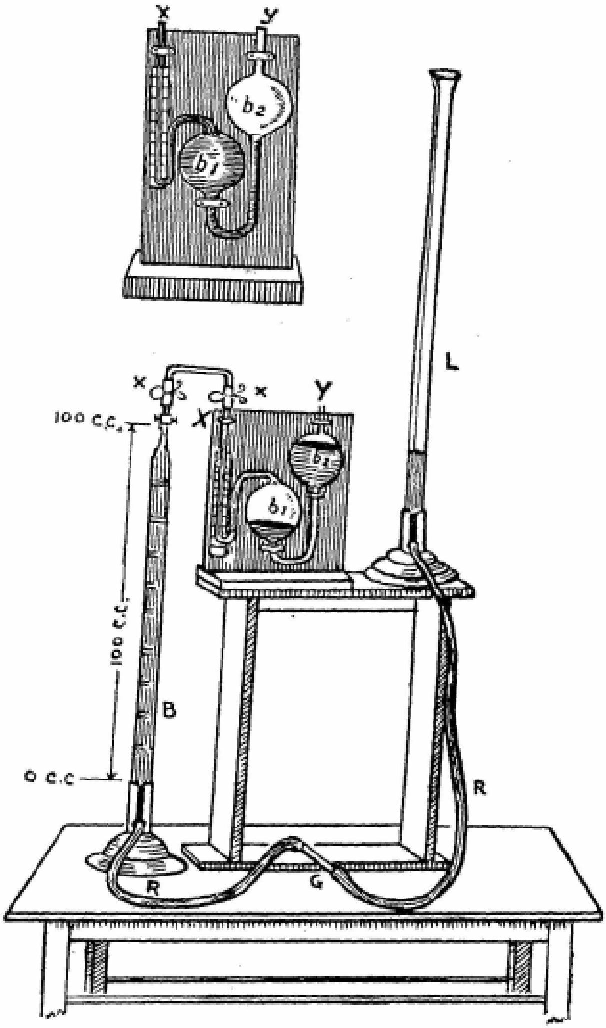
Now the end X is connected with the burette by means of a capillary tube as shown in Fig. XXII. Then the tap of the burette is opened and the levelling tube is raised, till at last the water level in the burette reaches the graduation 100 c.c. While the levelling tube is being raised, the burette begins to be filled with water and the air from it is driven into the pipette. By the time the water level reaches the graduation 100 c.c. the whole volume of the confined air is driven into the pipette. When this is done the tap of the burette is closed. The air pushed into the pipette partly fills the bulb b_1 displacing a quantity of the potash solution which finds its way into the bulb b_2.

Now the strong potash solution comes in direct contact with CO_2 of the expired air. It also comes in contact with the nitrogen and oxygen of the air, but for these two gases it has no affinity. Hence they are left out, whereas CO_2 is absorbed and becomes *fixed*. With a view to promote this absorption the pipette is gently shaken in its own place. In about five minutes carbon dioxide becomes fully absorbed. Hence after five minutes the shaking business is stopped.

Then the tap of the burette is opened and the levelling tube is lowered. The water level in the burette begins to sink and draws into the burette air from b_1 of the pipette. The water level in the burette is allowed to sink till the potash solution reaches the end X of the pipette, because then we can be sure that the whole quantity of air is returned to the burette and none is left in the pipette. Water levels both in the burette and the levelling tube are allowed to settle themselves till they are brought in the same line. For comparing the water levels, the two tubes may be brought together as shown in Fig. XXV.

It will be seen that the water level in the burette is not now at the graduation 0 c.c., but is slightly above it.

Fig. XXI & Fig. XXII



The Simple Absorption Pipette in Working.

Why? Because the quantity of CO_2 which was absorbed by the potash solution is absent and hence the volume of the air has become reduced by that much quantity. If the water level stands at 5 c.c. we can come to the conclusion that 5 c.c. of CO_2 were present in 100 c.c. of air and that they were absorbed by the potash solution.

This result, however, is not looked upon as final. The air is again driven into the pipette and the whole experiment repeated. It is possible that some CO_2 may have been left unabsorbed in the first experiment. If the second experiment gives the same result as the first, the result of the first experiment is confirmed. But if the second experiment shows a larger quantity of CO_2 absorbed, say 5·2 c.c., then the experiment has to be repeated till the results of the last two experiments are the same. In our experiment let us say that the first result is confirmed by the second and that only 5 c.c. of CO_2 were present in 100 c.c. of the exhaled air.

The result arrived at in the last paragraph would be correct, if at the time of reading off the volume for CO_2, the atmospheric pressure and temperature have remained the same as those when we measured the volume of the air taken up for examination to be 100 c.c. If the atmospheric pressure or temperature has changed, the value of 5 c.c. of CO_2 under the changed circumstances will have to be determined. Our original atmospheric pressure was 605 mm. Hg. and temperature 32° C. Suppose now that the atmospheric pressure has become 609·5 and the temperature 34° C. Then volume of CO_2 which measured 5 c.c. at this pressure and temperature will have to be corrected[1] before it can be compared with the volume of the original stock of air. Now the original stock measured 100 c.c. at 605 mm. Hg. of atmospheric pressure and at 32° C. of temperature or it measured 67·1 at N. T. P. So the present volume of CO_2, namely 5 c.c., will have to be corrected

1 In the improved apparatus used for gas estimation, arrangements are made for automatic corrections to pressure and temperature.

either to the pressure 605 at 32° C. or to N. T. P. Let us correct it to N. T. P. We get 4·2 as the volume. Now this is to be compared with 67·1 c.c. which is the volume of the original stock of air at N. T. P. Then we get 6·2 as the percentage of CO_2 present in the sample of the expired air. This percentage is by volume.

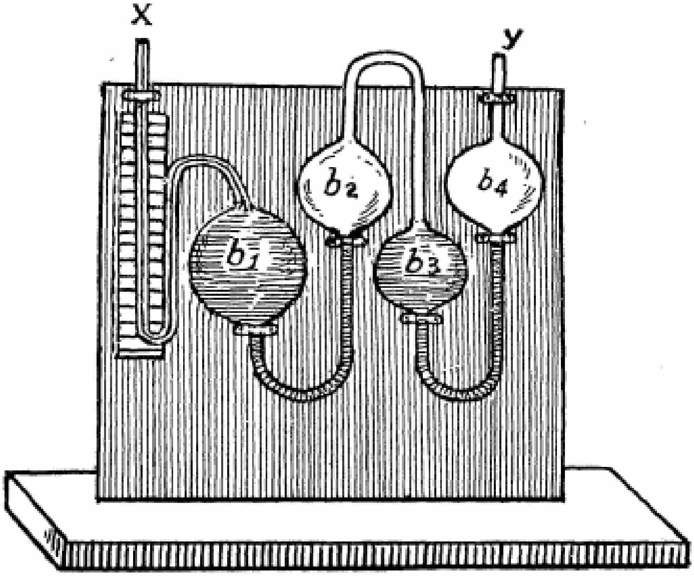
It is needless to point out that we would have got this very percentage, if we had corrected the volume of CO_2 to 605 mm. Hg. at 32° C. Because then, the corrected volume of CO_2 would have been compared with 100 c.c. and not with 67·1 c.c.

Again if at the time of reading off the volume for CO_2, the barometric pressure and temperature would have been the same as at the time of determining the volume of the air taken for examination, no correction would have been necessary for the volume of CO_2, for finding its percentage in the expired air. For both the volumes, being at the same pressure and temperature, would have been comparable. Then the percentage by volume would have been 5.

It must have been clear to our readers that every time we wish to compare the volumes of gases, we have to reduce them to the same pressure and temperature, because the same volume at different pressures or temperatures will show different quantities.

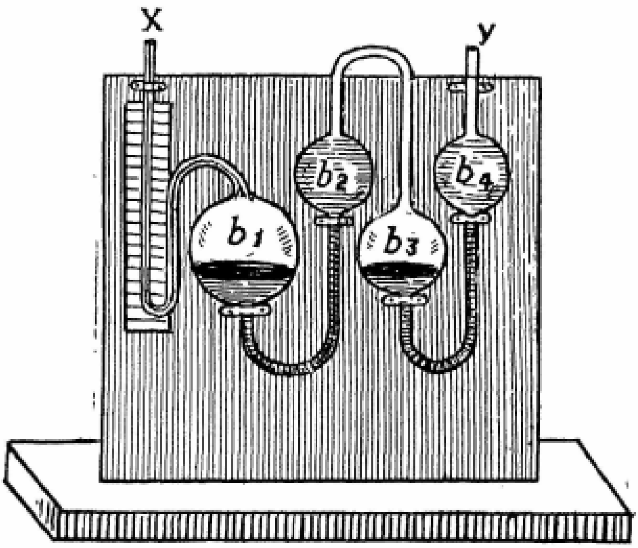
Having determined by the volumetric method the percentage of CO_2 we now proceed to ascertain the percentage of O_2. The same type of experiment is to be repeated. The stock of air left with us after the elimination of CO_2 is held in the burette. By adjustments of the levelling tube this stock is to be driven into the pipette and after shaking it for absorption, the remaining air is to be returned to the burette and its volume to be read off as previously. It will be found to be much smaller than the stock left after the absorption of CO_2. Let us suppose the volume left to be 80 c.c. It means that we have lost 20 c.c. of air because of the absorption of CO_2 and O_2. Suppose now that in the

Fig. XXIII



The Double Absorption Pipette.

Fig. XXIV



The Double Absorption Pipette in Working.

last experiment we lost 5 per cent. by way of CO_2. Then it is clear that we lost 15 c.c. of O_2 in this experiment. Let us again suppose that at the time of taking the reading of the present experiment, the atmospheric pressure and temperature have remained the same as previously. Then the conclusion would be that we had 15 per cent. by volume of O_2 in the expired air. Of course we must repeat this O_2 experiment and check the results obtained as in the case of CO_2.

Again if there are any changes of pressure or temperature the results must be corrected as shown in the CO_2 experiment, and then the percentage determined.

Our readers must note that in conducting this experiment with O_2, we have to use a different type of pipette and also a different kind of absorbent. The strong solution of caustic potash that we used in the case of CO_2, has no affinity for O_2 and did not absorb it when we conducted the first experiment. So we must change this absorbent and substitute one that will absorb O_2 only, and leave out nitrogen. Such an absorbent is the potassium pyrogallate solution. Now in the use of this solution there is one difficulty. The ordinary air contains a lot of oxygen or O_2 and as soon as this solution comes in contact with the air it begins to absorb O_2. The capacity of this potassium pyrogallate solution for the absorption of O_2 is, however, limited. So it is just possible for the quantity of the absorbent, we may take for an experiment, to have reached the limit of its absorbing capacity very soon, and thus become useless. In order to avoid this difficulty, scientists use what they call the *double absorption pipette* under such circumstances. Such a pipette is shown in Fig. XXIII. It has four bulbs instead of two. b_1 is filled with potassium pyrogallate solution, b_2 is empty, b_3 is filled with water and b_4 is empty. The stock of water in b_3 cuts off the connection of the solution with the outer air through the end Y. The end X is kept closed except when the pipette is connected with the burette. Fig. XXIV illustrates the position of the liquids, when the stock of air from the burette is driven into the pipette.

A change in the pipette and the absorbent is the only change required to be done in conducting experiments on CO_2 and O_2 for determining their volumes in a given quantity of air.

The air returned to the burette after the absorption of O_2, consists mainly[1] of nitrogen. If we suppose that the atmospheric pressure and temperature have remained constant through out our experimentation, we can conclude that the 100 c.c. of expired air that we examined, contained 5 c.c. of CO_2, 15 c.c. of O_2 and 80 c.c. of N. To put it in the form of percentage we might say that the expired air tested, contained 5 per cent. of CO_2, 15 per cent. of O_2 and 80 per cent. of N, these percentages being according to the volume.

Our readers will remember that the whole stock of the expired air was held in a rubber bag. We took out only 100 c.c. from it and examined the percentage of CO_2 and O_2 that it contained. If the volume of the whole stock is measured[2] and this percentage applied, we can know the total volume of CO_2 and O_2 contained in one expiration. Thus if the total volume of expiration is 800 c.c. which is possible if the expiration is a little deeper than the normal, the total volumes of CO_2 and O_2 would be 40 c.c. and 120 c.c. respectively.

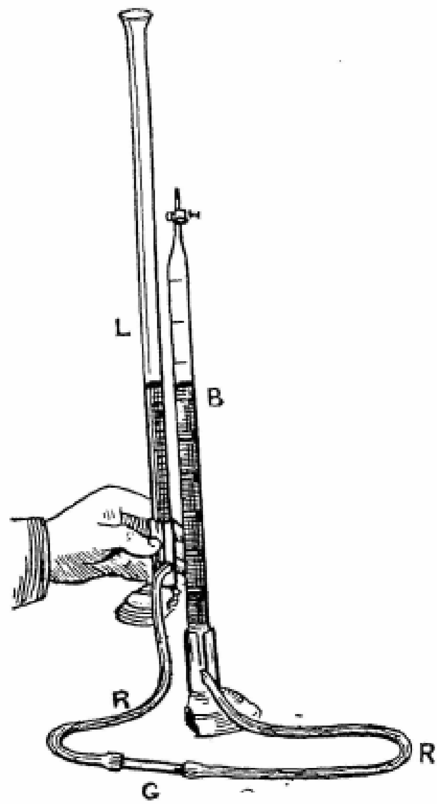
Now just as we examined the expired air volumetrically for CO_2 and O_2, we can examine the air we inspire and compare the volumes of CO_2 and O_2 present in both the types of air. We can then at once see how much O_2 has been absorbed into our system and CO_2 eliminated from it in a single breath.

In the volumetric experimental work that we shall publish in the next issue, we have determined the *percentage* of CO_2 eliminated and O_2 absorbed in the different types of Prāṇāyāma, because when the percentage is determined it is applicable to all volumes. Thus if the total volume of the expired air is 500 c.c., and the percentage in it of CO_2 is 5,

1 We say *mainly* because expired air is likely to contain some organic matter. This is neglected in our present calculations.

2 The instruments generally used to measure the volume of expired air are called *spirometers*.

Fig. XXV



The Gas Burette and Levelling Tube Brought Together for Comparison of Water-Levels.

we can conclude that the total volume of CO_2 eliminated is 25 c.c. But if the expired air is 800 c.c. the total volume of CO_2 would be 40 c.c. Thus we see that once the percentage is fixed, we can examine different volumes with its help. Again for comparison percentages afford ready-made figures.

Up to now we have measured gases according to their volumes, and we have found that all gases will have the same volume under the same pressure and temperature conditions. Thus at N. T. P. or under any other condition, equal quantities of CO_2, O_2 or N, or any other gas, will have the same volume. But our readers may ask us whether the same volume of different gases at the same pressure and temperature will have the same weight. We have been told in the first part of this note that different gases have got different weights. Thus oxygen is heavier than hydrogen and so on. Does it mean that 1 c.c. of oxygen at N. T. P. is heavier than 1 c.c. of hydrogen at N. T. P.? Yes, it does, because the number of molecules contained in 1 c.c. of any gas is the same, provided the gases are at the same pressure and temperature and the molecules of oxygen are heavier than the molecules of hydrogen. Thus we see that although all gases will have the same volume at the same pressure and temperature, the same volume of different gases will have different weights.

Scientists have prepared tables in which are given the respective weights of 1 c.c. at N. T. P. of different gases. Thus 1 c.c. at N. T. P. of O_2 weighs 1·43 milligrammes; of CO_2, 1·97 milligrammes; of N, 1·25 milligrammes and so on.

We have already studied methods by which we can find the volume at N. T. P. of a particular quantity of a given gas. Thus we found in the first experiment that the quantity of CO_2 measured 5 c.c. at 32° C. of temperature and 605 mm. Hg. of atmospheric pressure. From this measure we could at once calculate that its volume at N. T. P. would be 4·2 c.c. Now from the tables we find that 1 c.c. of CO_2 at N. T. P. weighs 1·97 milligrammes. Hence we can see that 5 c.c. of CO_2 at 605 mm. Hg. of atmospheric pressure and at 32° C. temperature

weigh 8·3 milligrammes. Similarly we can find the weights of other gases and find out the proportion of these gases *by weight*. Generally in the discussions on the proportion of different gases in the inspired and expired air, percentages are mentioned in volumes and not in weights. In our tables giving the results of our experiments, we have followed the general practice and given percentages in volumes.

THE GRAVIMETRIC METHOD

In the last few paragraphs we have found that the weight of a given quantity of a gas can be found, by first determining the volume of that quantity at N. T. P. and then by calculating the weight from the ready-made tables. There is, however, a direct method by which the weight of a quantity of gas can be determined. This is called the *gravimetric method.* Let us see how we can determine the weight of CO_2 in a given quantity of the expired air, according to the gravimetric method. The chemical fact that CO_2 is absorbed by a solution of caustic potash, as we saw in our study of the volumetric method, is taken advantage of by scientists in the gravimetric method also. The stock of expired air containing the quantity of CO_2 which is to be weighed, is passed through a strong solution of caustic potash. Now while the air is passing through this solution, caustic potash combines with CO_2 and allows the remaining constituents to pass over. The absorbed CO_2 which thus becomes fixed naturally adds to the weight of the potash solution. This solution is weighed before and after absorption and the difference is noted down. This difference denotes the weight of CO_2 contained in the quantity of air passed through the potash solution.

In the volumetric determination of CO_2, we used pipettes for the purpose of absorption. These pipettes are too heavy and clumsy to be weighed in the sensitive balance[1] which is necessary for detecting small differences in weight. Hence in

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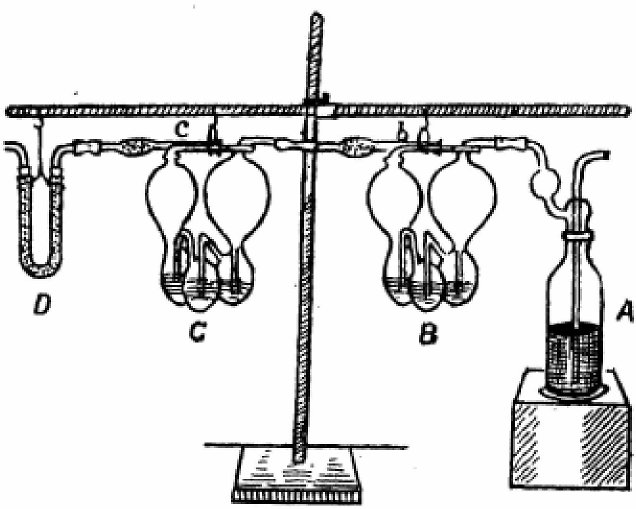
1 The balance of average sensitiveness used in ordinary laboratories for gravimetric work, is able to weigh one-tenth part of a milligramme, that is, $\frac{1}{10,000}$ of a gramme.

Fig. XXVI



Apparatus for Gravimetrically Determining CO_2.

the gravimetric method light bulbs of glass called the potash bulbs are used to hold the caustic potash solution. In Fig. XXVI and XXVII, *C* and *B* illustrate these bulbs. To one end of these bulbs are fitted small tubes filled with calcium chloride. During the experiment the bubbles of air pass from one bulb to another. This air is likely to carry moisture with it and thus reduce the weight of the solution in one bulb and increase the weight of it in the other. Calcium chloride tubes fitted to the end of each bulb hold up this moisture. So when the potash solution is weighed originally and after absorption, it is weighed with the bulb in which it is held along with the calcium chloride tube attached to it.

Just as it is desirable that the moisture from one bulb is not transferred to another, so it is necessary that the moisture, if any, from the expired air is removed before this air comes in contact with potash solution. Otherwise that moisture will increase the weight of the solution and spoil the calculation of CO_2. Hence the stock of air is first passed through sulphuric acid which is held in a tower. In Fig. XXVI, *A* represents such a tower. The apparatus is arranged as shown in Fig XXVI. The tower of sulphuric acid is connected with the potash bulb *B* by means of a rubber tube, this bulb *B* being connected with the bulb *C* in its turn in a similar fashion. The current of the expired air passes through *A*, *B* and *C*. In order to complete the apparatus, however, it is necessary to connect the bulb *C* with one more tube *D* which is filled with both soda lime and calcium chloride. We know that the ordinary air contains moisture and also a quantity of CO_2, although very small. It is desirable to see that the moisture and CO_2 of the ordinary air do not affect the bulb C. The tube *D* serves this purpose. Soda lime arrests the traces of CO_2 and calcium chloride absorbs moisture.

It has already been stated that the stock of expired air which is to be examined for determining the quantity of CO_2 is held in a vessel. This vessel is now connected with *A*. It is then pressed so that the expired air passes through *A*, *B*, *C*

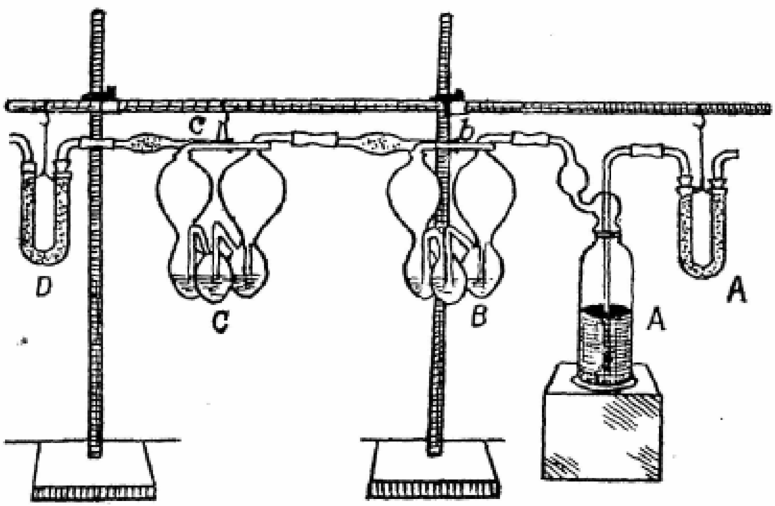
and D and escapes from the free end of D. Or an aspirator[1] is used at the free end of D which sucks up the stock of the expired air. When a measured quantity of the expired air is aspirated, the vessel that held the expired air is disconnected. Our readers will see, however, that although the necessary measure of the expired air has been removed from the vessel, the whole of that measure has not passed through the potash solution. A small quantity must have been left in the tower A, which must contain some CO_2. In order, therefore, to get this CO_2 absorbed into the solution, some quantity of ordinary air is sucked up. But here one difficulty arises. The very small amount of CO_2 contained in the ordinary air may get mixed up with the CO_2 of the expired air which we are experimenting upon. So with a view to eliminate this CO_2, a tube similar to D filled with soda lime is attached also to this end before the ordinary air is aspirated. (Vide Fig. XXVII) This current of ordinary air in passing through A sweeps off the little CO_2 from A into the bulbs.

As stated above, the bulbs B and C are weighed after absorption. They were already weighed before absorption The difference between these two types of weights is noted down to show the weight of CO_2.

We have used two potash bulbs instead of one. The bulb C is only a guard bulb. Its purpose is to show whether the bulb B has fully absorbed the whole quantity of CO_2 or some of it has been allowed to escape. This can be known by comparing the weights of C taken before and after absorption. If there is no difference in the weights of C, it means it has received no CO_2, the whole of it being absorbed in B. But if the bulb C shows an increase we cannot be sure that CO_2 has not escaped from both the bulbs. In such a case it is necessary to repeat the experiment with three bulbs instead of two and make sure that the last bulb shows no increase, assuring us that the whole quantity of CO_2 is

1 *Aspirator* is an apparatus which, because of the negative pressure created in it, sucks up gaseous matter from vessels that may be connected with it.

Fig. XXVII



Apparatus for Gravimetrically Determining CO_2.

absorbed in the remaining bulbs. Then the total increase in the weights of all the bulbs indicates the weight of CO_2.

When the weight of a particular quantity of CO_2 is determined gravimetrically, we can know the volume of the same at N. T. P. by using the tables to which we have already referred. Suppose the weight of a quantity of CO_2 is found to be 80 milligrammes. Then we can find its volume at N. T. P. to be 40·5 c.c. Now if the expired air containing this quantity of CO_2 measures 664 c.c. at N. T. P., we can know the percentage of CO_2 in it to be 6·09.

In the experimental work that we have published in the present issue, the percentages of CO_2 are given in volume, although the quantities of CO_2 were determined gravimetrically. This has been done with a view to enable our readers to compare these percentages with those that will be published in the subsequent issues both for CO_2 and O_2 and that have been determined by the volumetric method directly.

We have not discussed here the gravimetric determination of O_2, because we do not intend publishing any experiments of this nature in the immediate future.

N. B.—Instruction in Yogic culture higher as well as lower will be given gratis at the Āśrama to everyone that earnestly seeks it.

THE POPULAR SECTION

The Director of the Kaivalyadhāma is ever willing to help those who are in earnest about their spiritual advancement, as he confidently feels that this help will in a way help his cause.

KAPĀLABHĀTI

THE NAME:—

The word Kapālabhāti is a compound consisting of two members: Kapāla and Bhāti. In Saṅskṛita Kapāla means the skull, and Bhāti is derived from a Saṅskṛita root meaning to shine. Hence Kapālabhāti means an exercise that makes the skull shining. Kapālabhāti is one of the six cleansing processes, known in Haṭha Yoga as Shat Kriyās,[1] and is intended to clear the nasal passages *contained in the skull*, along with the remaining parts of the respiratory system. As the exercise necessarily cleanses a part[2] of the skull, the name Kapālabhāti is appropriately given to it.

In Yoga S'āstra[3] three different varieties of Kapālabhāti have been mentioned. All these varieties are characterized in common by their capacity to cleanse the nasal passages contained in the skull. Here, however, we are going to notice the most popular variety of the lot. As will be seen from its technique, this variety is a type of breathing[4] exercise.

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1 The following verse from *Hatha-Pradīpikā* enumerates the six cleansing processes : धौतिर्बस्तिस्तथा नेतिस्त्राटकं नौलिकं तथा ।
कपालभातिश्चैतानि षट् कर्माणि प्रचक्षते ॥ H. P. II 22.
Out of these six, धौति (Vol. II, pp. 170–177) ; बस्ति (Vol. I, pp. 101–104), and नौलि (Vol. I, pp. 25–26) have already been treated in this journal.

2 We are studying the physiology of Kapālabhāti in our laboratory. The research work is yet far too incomplete to enable us to make a definite statement. But the little work that has already been done in this connection, has led us to think that the exercise is capable of cleansing not only the respiratory system but also the different parts of human anatomy connected with the skull. We have also reasons to believe that Kapālabhāti is capable of cleansing even the capillaries of the remotest parts of the human body.

3 Vide *Gheraṇḍa-Saṃhitā*, I 55.

4 The other two varieties are performed with the help of water and constitute what we may call the Yogic nasal douches. We shall make a passing reference to their technique in the next issue. In this connection it is to be noted that the technique of the variety discussed in the present article as described here is different from the technique as it is given by the author of Gheraṇḍa-Saṃhitā. In writing this article, we have followed the author of Haṭha-Pradīpikā.

THE TECHNIQUE:—[1]

Although Kapālabhāti is not[2] a Prāṇāyāma in the strictly technical sense of the word, it is surely a breathing exercise and as such all that is said about the place, the seat, the time etc., in our article on Prāṇāyāma in the last volume[3] applies as much to this exercise as to Prāṇāyāma proper. So the student should select his place, arrange his seat and fix his time according to the general instructions given in that article. The next question to be considered is about the posture appropriate to this exercise. A student of physical culture can assume any sitting posture that is convenient to him. We do not think that Kapālabhāti can be advantageously practised in standing. As will be seen later on, this breathing exercise requires a very free movement of the abdominal muscles. Now the front abdominal muscles are not fully relaxed while one is standing, and as such cannot be freely manipulated. But while one is sitting these abdominal muscles can undergo complete relaxation and their movement can be thoroughly controlled in this position. Hence even a physical culturist will do well to practise Kapālabhāti in a sitting posture.

The question of a spiritual culturist stands on a different footing. He is very strongly recommended the Lotus Pose[4] (पद्मासन) for the practice of Kapālabhāti. The reason is this: Kapālabhāti to be of any spiritual advantage, has to be practised vigorously and across a good length of time. A vigorous practice of Kapālabhāti, even for a few minutes, makes almost every

1 Readers wishing to practise Kapālabhāti according to the technique given here, are earnestly requested to study carefully our 'Note on Respiration' given in the third volume. This will enable them not only to grasp intelligently the different points of the present technique, but will help them to eliminate all possible errors from their practice of the exercise.

2 We will discuss this point later on in this very article.

3 Pp. 271-274.

4 For the technique of this pose see Y. M., Vol. II, pp. 227-228.

tissue in the human body vibrate. These vibrations become more and more violent if the exercise is pushed further with the original vigour, till at last it becomes very difficult to control the pose that one may have assumed. Now out of the meditative[1] poses that we have recommended to students of spiritual culture, Padmāsana is the only sitting pose that can keep the limbs of the student in their proper place under such circumstances. The principal question is of the lower extremities. The foot-lock which forms part of the Padmāsana technique is so arranged that no amount of violence done to the legs can unlock it. In other meditative poses, the legs are loose, and the violent jerks which the body begins to receive through vigorous Kapālabhāti, soon throw them out of order. As it is essential that the pose once assumed is maintained intact throughout the exercise, Padmāsana is the only meditative pose available for the practice of Kapālabhāti.

This traditional and rational teaching of Kapālabhāti being practised in Padmāsana only, is supported by the author of Haṭha-Pradīpikā. We must admit that Svātmārāma Sūri does not say in so many words that Padmāsana is obligatory for the practice of Kapālabhāti ; but we can know what he means from what he says in connection with Bhastrikā. Whereas in the case of other Kumbhakas, Svātmārāma does not mention any particular pose, in his technique of the Bhastrikā Kumbhaka he makes a special mention of Padmāsana[2]. This means that according to him the Bhastrikā Kumbhaka *must* be practised in the Lotus Pose.[3] Now the exercise of

1 Siddha, Svastika and Sama are the other meditative poses recommended to a student of spiritual culture. For the physiology of these meditative poses read our article on the subject in Vol. III, pp. 245–250.

2 His description of the technique of Bhastrikā opens as follows :
सम्यक् पद्मासनं बद्ध्वा ... H. P. II 59. [Having satisfactorily taken the Lotus Pose...]

3 This very conclusion has been drawn by Svātmārāma's commentator Brahmānanda. The latter, says—भस्त्राकुंभकस्य पद्मासनपूर्वकमेवानुष्ठानात्तदादौ पद्मासनमाह । [The author describes the Lotus Pose before giving the technique of the Bhastrā (the same as Bhastrikā) Kumbhaka, because that pose is obligatory for that type of Kumbhaka.]

Kapālabhāti is so akin to Bhastrikā, that we can safely say that Bhastrikā[1] is equal to Kapālabhāti plus a Kumbhaka of the Ujjāyī type. That being the case we can logically conclude that the Āsana which is obligatory for Bhastrikā is also obligatory for Kapālabhāti.[2]

It is to be remembered in this connection that the Lotus Pose to be assumed for Kapālabhāti mainly consists of the foot-lock.[3] The position of the hands may, as usual, be either on the knees forming Jn'āna-Mudrā,[4] or they may be arranged[5] in front of the abdomen as required in Padmāsana. Regarding the two Bandhas, namely, Jālandhara and Mūla,[6] which ordinarily form part of Padmāsana, the following instructions may be attended to.

In breathing exercises Jālandhara-Bandha has to be practised during the period of Kumbhaka.[7] Kapālabhāti is

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1 Our readers will better understand this statement when they will have read our article which discusses the technique of Bhastrikā in the next issue.

2 For the guidance of the practical students of Yoga we may mention here that even for spiritual purposes Kapālabhāti may be practised in some other meditative pose, provided it is not done so vigorously nor for so long a time as to induce violent jerks. There are many people who find it very difficult, if not altogether impossible, to have the foot-lock folded. These need not forego the practice of Kapālabhāti simply because they cannot carry out this part of its techniqe. They may assume any comfortable sitting posture for this exercise.

3 What we say will be clear when we read Svātmārāma's description of Padmāsana when it is taken for Bhastrikā. He talks there of the foot-lock and nothing else.

ऊर्वोरुपरि संस्थाप्य शुभे पादतले उभे ।
पद्मासनं भवेदेतत् ... ... ॥ H. P. II 58.

[The Lotus Pose is secured when the feet with their clean soles upturned are arranged on the thighs....]

4 Vide Y. M., Vol. III, pp. 272-273.

5 Vide Y. M., Vol. II, p. 226.

6 Vide Y. M., Vol. II, p. 225.

7 There is only one exception to this general rule. That exception is to be found in the technique of the Mūrchhā Kumbhaka (Kumbhaka for rendering the mind passive). This Kumbhikā (feminine of Kumbhaka), requires the expulsion of breath to be done with a Chin-Lock.

Cf. पूरकान्ते गाढतरं बद्ध्वा जालंधरं शनैः ।
रेचयेन्मूर्च्छनाख्येयं ... ... ॥ H. P. II 68.

[In the Kumbhikā called Mūrchhanā (the same as Murchhā), one should expire slowly while the Chin-Lock is very firmly secured after the completion of inspiration....]

indeed a breathing exercise: but consisting as it does of; incessant respiration exclusively, it does not include Kumbhaka. Hence the practice of Jālandhara is not needed in the Lotus Pose when it is taken for Kapālabhāti.

The other, namely, Mūla-Bandha is to be treated in a different way. Students of Yoga peculiarly susceptible to the vibrations set up by Kapālabhāti, *involuntarily* form this Bandha, as the vibrations become more and more violent. The whole pelvic region is *automatically* contracted resulting in the vigorous contraction of the anal sphincters. Hence it is desirable that in the initial stage of the practice, the intentional formation of Mūla-Bandha is avoided. If it is found that the Kapālabhāti vibrations do not automatically secure this Bandha, even when a Yogic student is well established in this exercise, Mūla-Bandha may be voluntarily introduced in the technique of this Kriyā.

What has been said about the erect spine in the case of Ujjāyī equally applies to Kapālabhāti.

Having dealt with the Āsana necessary for Kapālabhāti, we now proceed to discuss the technique of the exercise proper.

Broadly speaking Kapālabhāti is a breathing exercise of the abdominal[1] or diaphragmatic type in which sudden expulsions of breath follow one another in quick succession and which is characterized by the absence of any pause in the movement of breath so long as the exercise continues. So this exercise consists of Rechaka and Pūraka only, Kumbhaka being done away with entirely. Again between Rechaka and Pūraka, Rechaka is the principal part of the practice, Pūraka, being only supplementary. In the case of Kapālabhāti there is one more feature which deserves to be borne in mind. In other breathing exercises in Yoga, one Pūraka, one

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1 For information on this point read our 'Note on Respiration', Vol. III, p. 239.

Kumbhaka and one Rechaka complete one round. But in Kapālabhāti one round consists of as many expulsions of breath as one likes or is capable of performing. Thus one may have several hundred expulsions in a single round of Kapālabhāti.

Let us now come to details and let us start with Rechaka which constitutes the main feature of the exercise.

RECHAKA :—

As in Ujjāyī so in any other breathing exercise, whether Eastern or Western, Rechaka and Pūraka are invariably advised to be very deep. In fact Rechaka is expected to be so complete that no additional c.c. of air could be further extracted from the lungs. So also Pūraka is expected to be so complete that no additional c.c. of air could be further introduced into the lungs. Kapālabhāti, however, stands on a different level. It is the only[1] exercise which does not require very deep expiration or very deep inspiration. Then what is the volume of air that is to be expelled from the lungs in an expiratory attempt in Kapālabhāti? In every Rechaka in Kapālabhāti only as much air is to be exhaled as can be driven out of the lungs by a sudden and vigorous inward stroke of the front abdominal muscles. Naturally this amount of air will be different for different individuals. We have conducted experiments in our laboratory to measure these amounts for different subjects and also to compare these with the respective amounts of their normally exhaled air. On the strength of this evidence[2] we can say that in Kapālabhāti the exhalation should be a little deeper than in ordinary breathing. For example, if the volume of the normally expired air in the

1 Also that part of Bhastrikā which corresponds to Kapālabhāti. It is to be noted, however, that Bhastrikā as a Kumbhaka does require deepest possible Rechaka and Pūraka.

2 We hope to publish this evidence on some future occasion.

case of an individual, is 480 c.c., he is expected to exhale about 600 c.c. in an expulsion in Kapālabhāti.[1]

The essence of Rechaka, however, does not consist in regulating the volume of the expired air, but it lies in a definite arrangement of the different anatomical parts especially those that are directly involved in breathing. It has already been stated above that Kapālabhāti is an exercise in abdominal breathing. Hence in this exercise exhalation is effected more by the movements of the front abdominal muscles and the diaphragm than by the movements of muscles acting on and between the ribs. In fact the muscles that act on and between the ribs are kept contracted as long as a particular round of Kapālabhāti lasts, whatever the number of expulsions that go to form that round. In other types of breathing exercises in Yoga, these muscles remain contracted only in Pūraka and Kumbhaka. As soon as Rechaka begins they are relaxed, the relaxation being complete when Rechaka is the deepest. But in Kapālabhāti, owing to its peculiar character, the muscles acting on and between the ribs, once contracted, remain in the same condition, keeping the ribs raised even during expulsions of breath. The only muscles that freely move throughout the exercise, undergoing alternate contraction and relaxation, are the diaphragm and the front abdominal muscles. This should not be interpreted to mean, that the ribs do not sink *at all* during exhalation in Kapālabhāti. As a matter of fact it is impossible to exhale without a little lowering of the ribs. But the falling of the ribs is so little in a well conducted exercise of Kapālabhāti that it is almost negligible. This can be verified by the external appearance of the thorax. It neither rises nor falls appreciably

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1 We know that these mathematical values of the expired air are of little help to a practical student of Yoga. In everyday practice the following rule of thumb will be sufficient. Let the abdominal stroke be complete and let the breath flow out easily. When this is done the volume of the expired air will take care of itself.

throughout a round of Kapālabhāti. [For the position of the thorax and the abdomen compare Figs. XXIV and XXVIII].

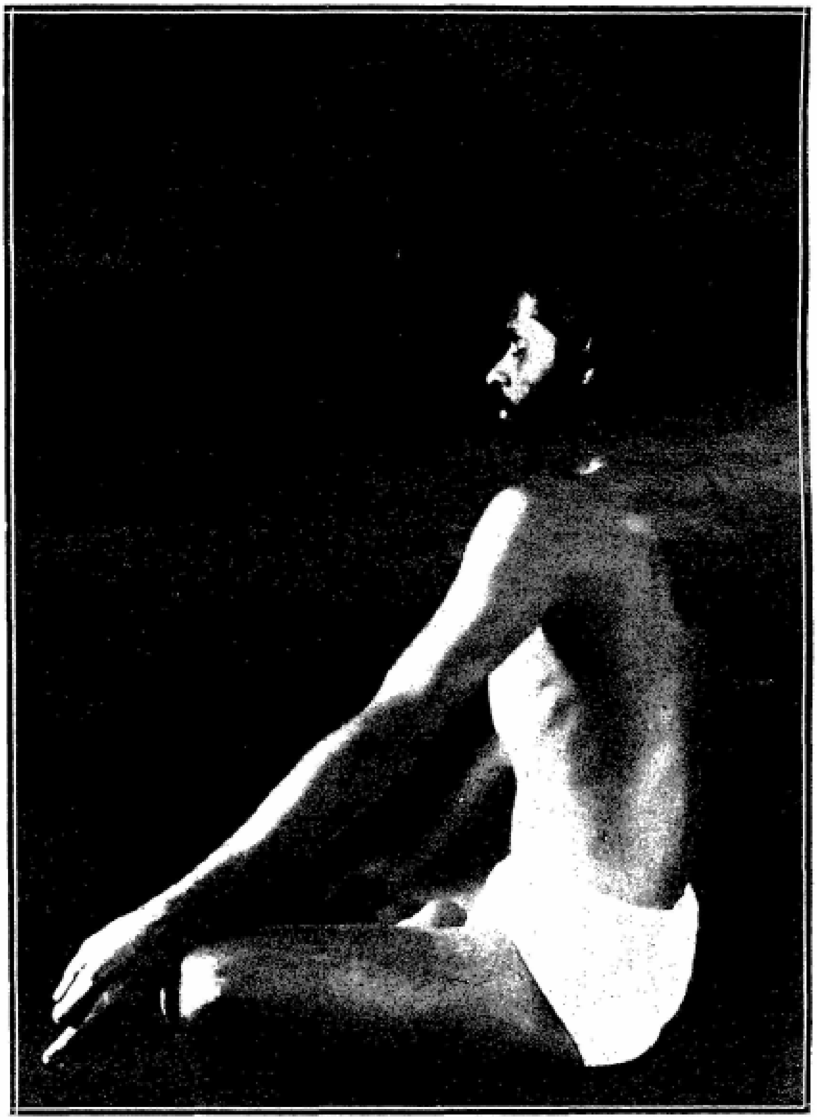
The exercise of Kapālabhāti, as stated above, is a play of the abdominal muscles and the diaphragm. These must be thoroughly supple and capable of undergoing sudden and vigorous contractions. In the Rechaka of Kapālabhāti, the front abdominal muscles are suddenly and vigorously contracted giving an inward push to the abdominal viscera which in their turn move upward pushing up the relaxing diaphragm that recedes into the thorax expelling a volume of air from the lungs. As the retracting lungs are not allowed to contract the thorax, expiration in Kapālabhāti is not as deep as in Ujjāyī. The speed with which the diaphragm and the abdominal muscles can be manipulated will depend upon one's practice. It is not desirable, however, to develop speed at the cost of thoroughness.

Up to now we have discussed the work to be done with the abdomen and the thorax in Kapālabhāti. We now proceed to see how the respiratory passage outside the thorax is to be worked.

In Ujjāyī we are required to close the glottis partially. In the present exercise this is to be avoided. The reason is clear. The volume of air exhaled in a single Rechaka of Kapālabhāti is so suddenly expelled, that a partially closed glottis would afford serious obstruction to the passage of the air and would render the expiration incomplete. There is one tradition,[1] however, which would wish very slight narrowing of the glottis even in Kapālabhāti. But the extent to which this is to be done is so small that the expelled air is not likely to be held back to any appreciable extent.

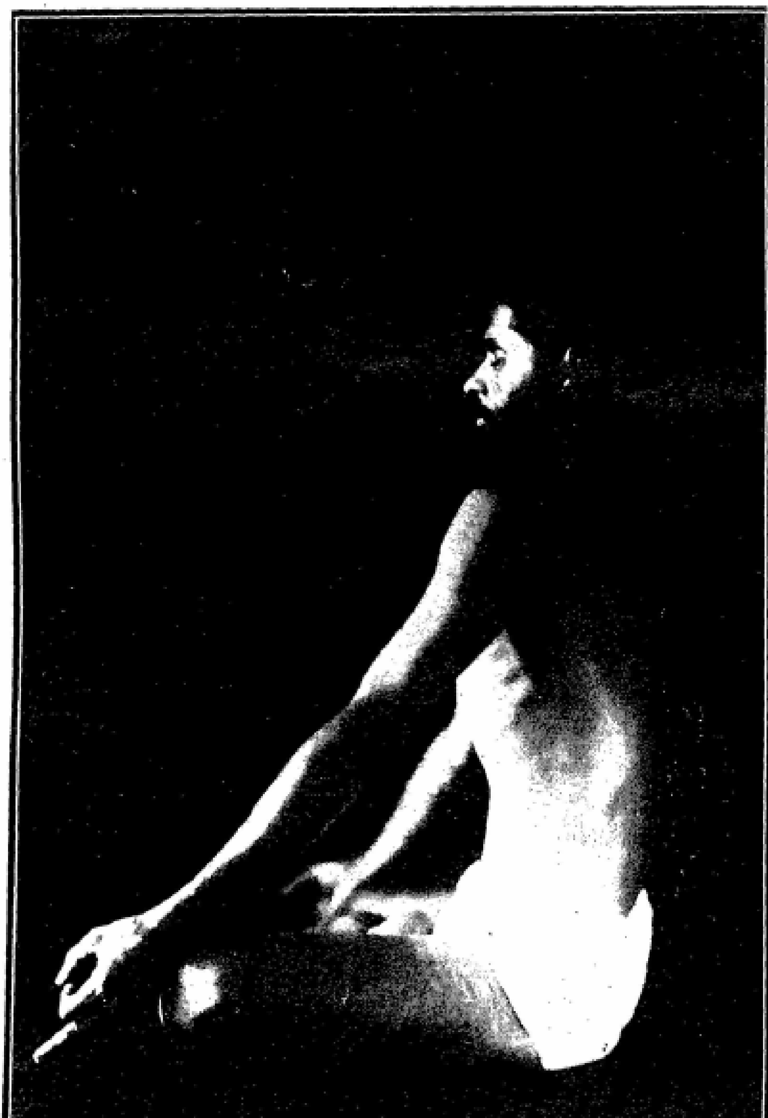
1 This is the tradition followed by the author of Haṭha-Pradīpikā.

Fig. XXVIII



Abdomen and Thorax at the End of Pûraka in Kapâlabhâti.
(Side View)

Fig. XXIX



Abdomen and Thorax at the End of Rechaka in Kapâlabhâti.
(Side View)

When the expelled air is allowed to escape freely through the glottis, it has a smooth though rapid passage to the end of the nostrils. If permitted to do their work automatically, the nostrils will open out voluntarily to facilitate the flow of the expired air. So the student of Yoga should not try to manage either his nostrils or his facial muscles at this stage. Very often people are in the habit of having all sorts of ugly contortions of their face when they are practising Kapālabhāti. This is far from being desirable. The air should be permitted to have a very smooth escape which it would surely have if allowed to go its own way.

It is to be remembered, however, that the rapid expulsion of a volume of air will surely cause some friction at the lower end of the nostrils. But this does not matter. As our readers know this part of the internal nose is covered with thick skin and any friction there is not likely to lead to any untoward results. What is to be cautiously avoided is the friction of the air with any of the delicate parts of the mucous membrane that lines the interior of the nasal passages.

PŪRAKA :—

In order to get a clear grasp of the process of Pūraka in Kapālabhāti, it is desirable for our readers to refresh their memory regarding a few facts about normal respiration. Normally the process of inhalation is active whereas the process of exhalation is passive. In normal inspiration the thorax is to be opened out for increasing its internal capacity, so that its lowered internal pressure might draw in air from outside. Thus the muscles that act on and between the ribs, so also the diaphragm, are put into action and contracted, raising the former and lowering the latter. But normal expiration is only a passive process. The muscles referred to just now are relaxed. Consequently the ribs sink down of themselves and the diaphragm is drawn up by

the retracting lungs that voluntarily shrink owing to their elastic recoil. It is only on the side of the anterior abdominal muscles that things are a little different. These muscles are active in normal expiration and passive in normal inspiration, because during expiration they contract and during inspiration they stand relaxed. Thus their role in respiration is just the opposite of the one played by the thoracic muscles.

Now let us return to the process of Pūraka in Kapālabhāti.

As noted above the exercise of Kapālabhāti is a play of the abdominal muscles. The muscles of the thorax are kept contracted throughout the exercise whether it is inhalation that is being practised or exhalation. The thoracic muscles are relaxed only when the exercise is over. It is only the front abdominal muscles that keep on moving to and fro, according as they are contracted for exhalation or relaxed for inhalation. We shall presently consider the case of the diaphragm.

Thus Kapālabhāti being markedly an exercise in abdominal breathing, one has to pay attention only to his abdominal muscles. At the end of Rechaka these muscles stand contracted. So in Pūraka one has simply to withdraw his control of these muscles and they will relax of themselves. Relaxation of muscles is a passive act. So when the abdominal muscles are let go at the end of Rechaka, they will voluntarily relax.

Up to now we have left out of consideration one important muscle, the diaphragm. Up to a particular extent the manipulation of this muscle is entirely under the control of our will. But this muscle does not require the exercise of our will for its ordinary movements, just as the other respiratory muscles go on doing their ordinary work, without any attention on our part. While we are deeply absorbed in some work, these

respiratory muscles are functioning even without entering into our consciousness.

Now at the end of Rechaka the diaphragm stands relaxed, but ready for another contraction. The stimulus from the inspiratory centre brings about this contraction and the descent of the diaphragm is allowed by the relaxing abdominal muscles. The lowering of the diaphragm increases the vertical diameter of the thorax, the internal pulmonary capacity is increased, and the internal pressure being lowered, the external air moves in, till the air expelled in Rechaka is replaced, raising the intra-pulmonic pressure to one atmosphere.

Thus it will be clear that in Pūraka no wilful contraction of muscles is necessary. One has simply to relax his abdominal muscles and Pūraka is performed. That is why we have said that Pūraka in Kapālabhāti is a passive act.

There is a sharp contrast between the Rechaka process and the Pūraka process in Kapālabhāti. The former is sudden and vigorous, the latter smooth and quiet. In fact Pūraka in Kapālabhāti is there only to provide air for the next expulsion which alone forms the real part of the exercise.

The volume of air inhaled in a single Pūraka must be for all practical purposes equal to the volume of air exhaled in the previous expulsion. The student of Kapālabhāti has, however, to remember that the time taken for one Pūraka is not the same as the time taken for one Rechaka. If we suppose that one Rechaka and one Pūraka taken together require half a second, it may be roughly stated, that Rechaka would occupy only one-fourth of this total time, Pūraka occupying the remaining three-fourths. In Pūraka the whole respiratory passage is kept fully open, there being no narrowing of it either at the glottis or any other part. Hence air

glides smoothly into the lungs, we might say *almost*[1] as smoothly as in normal inspiration.

Rechaka and Pūraka are performed in a quick succession, no time being allowed to go by in between any two acts till a round is completed. Pūraka follows Rechaka and Rechaka follows Pūraka without a break. All the while the noisy and sudden Rechaka is so much in evidence that the smooth and quiet Pūraka sinks into nothingness. So in practice, Kapālabhāti appears to be an exercise of successive and sudden expulsions only. Each expulsion is preceded by a relaxation of the abdomen and is accompanied by a sudden and vigorous inward stroke of it. The incessant blowing at the nose accompanied by the alternate rise and fall of the abdomen, give the exercise an appearance of the bellows of a village smith. In fact that is the simile given by the author of *Haṭha-Pradīpikā* to illustrate the action of Kapālabhāti.[2]

A SINGLE ROUND IN KAPĀLABHĀTI :—

Up to this time we have considered the technique of an individual exhalation and an individual inhalation in Kapālabhāti. Now we wish to discuss the measure of

1 The minimum time taken up by an ordinary inspiration is nearly *a second and a half*, whereas inspiration in Kapālabhāti, at an average speed of 120 expulsions per minute, requires only *three-eighths* of a second. Again the volume of air inhaled in Kapālabhāti is slightly larger than that inhaled in ordinary inspiration. Hence we find that the volume of air passing through the respiratory passage *during a particular unit of time* is far larger in Kapālabhāti than in ordinary inspiration. Hence inhalation in Kapālabhāti cannot be as smooth as normal inhalation. Still experience will show that Pūraka in Kapālabhāti is smooth enough, and there is no roughness about it, corresponding to one evidenced in Rechaka.

2 Svātmārāma Sūri says—

भस्त्रावल्लोहकारस्य रेचपूरौ ससंभ्रमौ ।
कपालभातिर्विख्याता ... ... ॥ H. P. II 35.

[Hurried exhalations and inhalations after the fashion of an iron-smith's bellows, constitute the famous exercise of Kapālabhāti ...]

It is interesting to note here that Kapālabhāti plays such a prominent part in the Bhastrā or Bhastrikā Kumbhaka, that Kumbhaka gets the very name of bellows. Bhastrā or Bhastrikā means bellows in Saṅskṛita.

a single round of Kapālabhāti and also to see how that round should begin and end.

In determining the measure of a round, we have to determine the number of expulsions that go to form one round and the speed with which these expulsions are performed. The question of speed we shall take up later on. Here we shall say something about the number of expulsions. In this connection we can follow the golden rule laid down by an old Sanskṛita proverb[1] according to which a humble beginning is always free from danger. The number of expulsions which we prescribe to our patients[2] and even to students of physical or spiritual[3] culture is eleven to begin with. Generally three rounds are given at each sitting, two sittings being advised per day, one in the morning and the other in the evening. In normal cases eleven expulsions are added to each round every week, till at last each round consists of one hundred and twenty-one expulsions.

Every round should begin with an exhalation and should end with an inhalation. In between any two successive rounds normal respiration should be allowed to intervene. It will be found that this respiration is unusually slow and smooth.[4] This period affords the rest necessary for the respiratory system in general and the abdominal muscles in particular. The length of this period should be settled according to one's own convenience. Generally speaking half a minute to one minute should be sufficient for preparing one for the next round. The dose of Kapālabhāti prescribed in the last two para-

1 अल्पारम्भः क्षेमकरः ।

2 Whether Kapālabhāti can be prescribed to a particular patient and whether a change in this measure is indicated by the condition of his health, are questions which cannot be detailed here. The discussion offered in this article is from the point of view of an average man of health.

3 Although Kapālabhāti is not a Pranayamic exercise, it is of considerable spiritual value.

4 A detailed explanation of this circumstance will be offered in a physiological examination of this exercise in some future issue of this journal. A general explanation will be found in this very article under *General Hints*.

graphs is perfectly general. It is intended for an average man of health and is sufficiently strong for bringing about the *physiological* results expected of this exercise. Those who feel themselves above the average, may have a larger measure of Kapālabhāti in their daily practice. For the purposes of physical culture, we might recommend double the average dose as the maximum. This doubling may be secured either by doubling the expulsions in each round, keeping the number of rounds constant; or by doubling the number of rounds, keeping the number of expulsions in each round constant. Needless to say that the latter course will put less strain on the system than the former. The need of a spiritual culturist is greater. He may have, for his maximum dose, three rounds of three minutes each, at a sitting. It is *absolutely necessary, however, that in reaching this maximum no undue strain is put upon the system.* To be spiritually useful, the practice should set up the vibrations to which we have made reference in discussing the propriety of the Lotus Pose in this exercise.[1] These vibrations are set up only after *prolonged* rounds. Hence a spiritual culturist should distribute his total measure of the Kapālabhāti exercise in as small a number of rounds as possible. Even in doing this the question of undue strain should never be lost sight of.

CONCENTRATION :—

The question of concentration is of supreme importance to a student of spiritual culture in his practice of Kapālabhāti. With every expulsion of breath, he is delivering inward strokes upon the abdominal viscera. He is to think that these strokes are being delivered against a centre in the lower abdomen in which spiritual energy[2]

1 Vide p. 163.

2 According to Yogic teachings Kuṇḍalinī which represents spiritual energy is coiled up in the lower abdomen. The concentration being prescribed is calculated to wake up this Kuṇḍalinī. We have purposely avoided any modern anatomical terms here, simply because we cannot venture any speculative theory in connection with Kuṇḍalinī.

is stored up. This concentration, if maintained throughout the exercise, will enable a student[1] to make some centre of his nervous system spiritually active.[2] Even during the period of rest that is taken in between two successive rounds, the spiritual culturist should entertain no other thought except the working up of the desired centre.[3]

The question of a physical culturist is comparatively simple. He should concentrate upon the expulsions, all the while realizing that he is eliminating very large quantities[4] of carbon dioxide and absorbing into his system similarly[5] large quantities of oxygen. This is rendering his blood richer in quality and consequently he is rebuilding the tissues all over his body. These thoughts should accompany not only his expulsions but also his period of rest.

GENERAL HINTS :—

As an exercise of very great oxygen value, Kapālabhāti has no parallel. Its nerve culture value is also very great. Its effects upon the circulatory and digestive systems are of considerable physiological importance.

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1 We do not wish to raise false hopes. So we request every student of spiritual culture to remember constantly the following fact. The ability to awaken nerve centres of spiritual value, varies very widely with different individuals. One person may get a response from one of these centres with less than six months' active work, whereas another person may fail to get it even after six years' labour. So when one wants to embark on a voyage that leads to the land that is beyond all darkness, one should consider himself to be the least qualified of the spiritual aspirants and be prepared for the arduous task before him. This will avoid frequent disappointments and early clamouring for results, provided always that the aspirant has undying faith in the immortal teaching of Bhagavāna S'rīkṛishṇa that no spiritual aspirant ever comes to grief.

2 This activity is experienced first in the form of *throbbing* and then in the form of *serene light* glowing at the particular centre.

3 The concentration described in this paragraph is only one of the different concentrations available for Kapālabhāti in spiritual culture. We cannot notice the other concentrations in this article for want of space. The subject will be taken in the system for treatment on some future occasion.

4 The exact quantities of carbon dioxide eliminated and oxygen absorbed in Kapālabhāti will be published in some future issue. Much experimental work has already been done in this connection in our laboratory. Experiments on the elimination of carbon dioxide in Ujjāyaī will be found in the Scientific Section of this number.

5 Generally slightly larger than those of carbon dioxide eliminated.

The massage of the abdominal viscera which the exercise effects is obvious. The massage of other anatomical parts though not so clear to an untrained eye, is not of lesser consequence. Even this bare[1] statement of the physiological importance of this exercise should be sufficient to prove that the exercise deserves a definite place in the daily physical culture programme of every man that cares for his health.

All the physiological advantages enumerated in the last paragraph accrue also to a student of spiritual culture. But he practises Kapālabhāti for these advantages only up to a particular stage[2] of development. Afterwards Kapālabhāti is practised by him for nerve culture and especially for awakening particular nerve centres of spiritual significance.

There is, however, another way in which a spiritual culturist takes advantage of Kapālabhāti for his higher development. He uses Kapālabhāti for enabling him to practise his Prāṇāyāma more efficiently. We shall now state briefly how this is done. The exercise of Kapālabhāti leads to the elimination of carbon dioxide from the system on a very large scale. The absorption of oxygen into the system is also abnormally large. This extraordinarily heavy exchange of gases in the lungs brought about by Kapālabhāti, soon leads to get the blood saturated with oxygen. The result is that the chemical stimulus to the respiratory centre[3] becomes weak and that centre becomes quiet.

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1 A detailed examination of the physiology of Kapālabhāti will appear shortly in this journal. Our readers will find some interesting information in this connection in Vol. III, pp. 45–47. What is said there of Bhastrikā equally applies to Kapālabhāti.

2 As stated in the beginning of this article Kapālabhāti is one of the six cleansing processes advised in Yoga for securing what is technically called Nāḍīs'uddhi, that is, the physiological balance necessary for spiritual development. Nāḍīs'uddhi literally means the purification of nerves. This attainment of Nāḍīs'uddhi indicates the stage where Kapālabhāti ceases to be practised for physiological advantages by a spiritual culturist.

3 For information on this point read our 'Note on Respiration', Vol. III, pp. 240–244.

It is a common experience of the students of Prāṇāyāma, that their attempts to control the lungs are seriously interfered with by the respiratory centre. A strong stimulus coming from this centre, makes hasty inspiration or expiration obligatory. If, however, the respiratory centre could be so quieted as to send out feeble impulses, if at all, the interference of this centre with our Pranayamic exercises would be the least, and we could manage the measure of our Pūraka, Kumbhaka and Rechaka as we pleased. This quieting of the respiratory centre is brought about by Kapālabhāti in the manner explained in the last paragraph. That is why students of Prāṇāyāma are able to perform their Pranayamic exercises more efficiently, if they are prefixed by a few rounds of Kapālabhāti. That is also why Yogic tradition requires a student of Yoga to practise Kapālabhāti before starting with Prāṇāyāma proper,[1] in his daily course of exercises.

We cannot close this article without discussing the question of speed with which the exercise is to be gone through.

As a cautious measure one can start at the rate of one expulsion per second. This may be developed into two expulsions per second in due course of time. One hundred and twenty expulsions per minute should be considered to be a fairly good speed for an average man of health. Those that feel themselves to be above the average may develop two hundred expulsions per minute. To exceed this limit would be physically impossible, because then the expirations begin to be so shallow that the exercise would lose all its efficacy. A tolerably good speed is essential for Kapālabhāti to be spiritually useful.

1 It is to be remembered that students of spiritual culture practise Prāṇāyāma for the culture of their nerves. This is done by the manipulation of particular muscles, especially the diaphragm. Therefore these students want to be free to manage their diaphragm as they please. This they are able to do when interference from the respiratory centre is *largely* eliminated.

The vigour of expulsions is a thing to be constantly attended to. Any attempt to develop speed at the cost of vigour is in the wrong direction.

The degree of vigour and speed, the measure of a single round, the number of rounds to be done at one sitting and the total amount of exercise to be done in a day, are things which should be cautiously and judicially determined. Kapālabhāti is a vigorous exercise and therefore less innocent than Ujjāyī. Hence the necessity of being very careful in getting the right sort of dose. We shall close this article by repeating here what we have said in our article on Ujjāyī.

The whole treatment accorded to the subject here, is from the point of view of an average man of health. People not suffering from any serious trouble either of the heart or of the lungs, can also follow these instructions with suitable changes. But any one suffering from a pulmonary or cardiac disorder, is strictly warned against taking to these practices on his own responsibility. He must consult an expert.

तदेकोऽवशिष्टः शिवः केवलोऽहम् ।
I alone persist : Blissful : Absolute.

ॐ

सोऽहम् ।

Yoga-Mîmâṅsâ

EDITED BY

S'RÎMAT KUVALAYÂNANDA

(J. G. Guṇe)

सर्वं खल्विदं ब्रह्म ।
All this is, indeed, Brahman.

नेह नानास्ति किञ्चन ।
There is nothing here apart from it.

July, 1933

Vol. IV No. 3

KAIVALYADHÂMA

Post-Lonavla

(Bombay-India)

शरीरमाद्यं खलु धर्मसाधनम् ।
Surely Health is the primary requisite of spiritual life.

Printed by Y. K. Padwal at 'The Tatva-Vivechaka Press', Byculla, Bombay No. 8;
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सोऽहम् ।

YOGA-MÎMÂṄSÂ

VOL. IV JULY, 1933 NO. 3

Editorial Notes

MAY the Maker of all make this journal a success. Blessed is the name of the Lord. May He bless the workers of the Âśrama with a happy and prosperous career as servants of the world which is only the Lord Himself objectified. May He, that has created us in His infinite wisdom, lead us to the light that is beyond all darkness.

◆ ◆ ◆

IT is after two years and a half that a fresh number of *Yoga-Mîmâṅsâ* is being issued to our readers. Although the journal has been irregular in its publication from its very birth, there was never such a long break in its career up to now. We deeply regret these extreme irregularities of our editorial work, but humbly crave to be forgiven by the generous public and sincerely request them not to discontinue their patronage to our journal.

◆ ◆ ◆

OUR warmest thanks are due to the present subscribers of *Yoga-Mîmâṅsâ*. Inspite of more than two years' suspension of its publication, these subscribers have shown utmost patience and in their inquiries about the issue of the present number they have not said anything that cannot be called polite.

◆ ◆ ◆

The following few paragraphs are written with a view to keep our readers acquainted with the developments of the Âśrama. It is not an attempt to defend ourselves against the charge of editorial irregularity. We frankly plead guilty to that charge.

◆ ◆ ◆

Publication of *Yoga-Mîmâṅsâ* journal is, indeed, a very important activity of the Âśrama. But there are other activities which are, perhaps, more important than this ; and have to be given prior attention, if the cause for which the *Kaivalya-dhâma* stands is to prosper as a whole. In the beginning of 1931, it became vividly clear to us that the progress of the Âśrama would come to a standstill, if we did not immediately enter upon some new activities in addition to the work that was then being turned out by the *Kaivalyadhâma*. The following were the new activities that claimed our immediate attention : (*i*) Opening of a branch of the Âśrama in Bombay. (*ii*) Publication of popular handbooks of Yoga. (*iii*) Adaptation of Yogic exercises to the needs of educational institutions. (*iv*) Creation of an exclusive Spiritual Centre. We are happy to see that we could, by the grace of the Lord, start all these activities during the last two years, and make them at least a humble success.

◆ ◆ ◆

The circulation of *Yoga-Mîmâṅsâ* throughout the length and breadth of India had, even before 1931, attracted the attention of many educated Indians to *Yogic Physical Culture* and *Yogic Therapy*. But going over to the Âśrama at Lonavla for cultural and therapeutical work was possible only for a lucky few, because such a thing required the absence of the intending physical culturist or patient from his home and from his post of duty for a considerably long time, besides incurring the heavy expenses of travelling, at times across hundreds of miles ! It was, therefore, clear that *Yogic Physical Culture* and

Yogic Therapy, if they were to command a wider popularity, must be introduced into the big cities of India by establishing branches of the Âśrama there. Bombay happened to be so near and so many citizens of Bombay had taken genuine interest in the affairs of the Âśrama, that it was decided to open the first branch in this premier city of India. Immediately work was undertaken in that direction and in January, 1932, the *Bombay Branch* was established, with its headquarters at Borivli, one of the most beautiful and healthy suburbs of Bombay, and a Health Centre at Santa Cruz, another suburb nearer the city.

The *Kaivalyadhâma Health Centre* at Santa Cruz proved to be very attractive. A summary of the Medical Officer's report on the working of that Centre, will be found in the *Miscellaneous Section.* People of different castes and creeds took advantage of the facilities offered by this Centre and vastly improved their health. Attendance at Santa Cruz was, however, being found inconvenient by the public coming from Bombay proper. Hence the Health Centre was shifted to the heart of the city last March, and is now working opposite the Charni Road Railway Station in a building ideally situated for this work. The successful working of our Health Centre in Bombay has clearly demonstrated the need of such a centre in every city of our Motherland. Visitors from different parts of our country were so much impressed with the efficacy of Yogic exercises as they are systematized and scientifically administered to patients and physical culturists by the Âśrama, that we have been already asked by responsible people to put in schemes for running similar centres in two other important cities. We feel sure that in the fulness of time, the *Kaivalyadhâma* will have to manage a network of such centres spreading over the whole of India.

◆ ◆ ◆

EVEN before starting the *Bombay Branch*, there were persistent demands from all over India for popular handbooks

of Yoga. *Yoga-Mîmâṅsâ*, no doubt, makes an excellent text-book in Yogic exercises. In fact it is very largely used as such by thousands. But its price is beyond the reach of many. Again there is so much of theory discussed in the pages of this journal and the practical lessons are so widely scattered over its different issues, that the reader has to turn over several numbers for getting practical information on a particular subject. Hence the want of popular and cheap handbooks devoted to the practical treatment of the different types of Yogic exercises, such as Âsanas, Prâṇâyâma, Shat Kriyâs, etc., was very keenly felt. The same want began to be felt much more keenly when hundreds of educated people began to take lessons in Yogic culture in the city of Bombay. We, therefore, instituted the *Popular Yoga Series* and brought out two handbooks, one of *Prâṇâyâma* and the other of *Âsanas.* Others are to follow in due course of time.

Here we wish to draw our readers' attention to what we have said about the *Popular Yoga Series* in the preface to the handbook of Prâṇâyâma. "The Popular Yoga Series is no substitute of Yoga-Mîmâṅsâ. Whoever wishes to understand Yoga from the modern point of view and cares to learn thoroughly and intelligently the anatomy and physiology of different Yogic exercises, must study Yoga-Mîmâṅsâ." On the contrary it may be pointed out that readers of *Yoga-Mîmâṅsâ* need not study these handbooks. Most of the matter appearing therein is to be merely a reprint of the articles in the *Yoga-Mîmâṅsâ* journal. Some chapters contained in the *Popular Yoga Series* thus far published, are, indeed, written afresh and present *a new angle of vision* to the students of Yogic culture. We are, therefore, including in this and the next number of this journal all such new things as have appeared in the *Popular Yoga Series.* Nay, we hereby assure our readers once for all that everything concerning Yoga that will be published from the *Kaivalyadhâma* will ever find its place

in *Yoga-Mîmâṅsâ* and that the readers of this journal will never be required to incur double expenses, first for *Yoga-Mîmâṅsâ* and then for the other publications.

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THE establishment of Âśrama branches in the cities, and the publication of popular handbooks of Yoga will, no doubt, very largely facilitate the spread of Yogic culture. But the influence of even these activities is bound to be limited. If Yogic culture is to permeate through the life of every household, and that is the ideal set by the members of the *Kaivalyadhâma* before themselves, it must be introduced in the educational institutions of the land. Endeavours of the Âśrama in this direction have also borne some fruit. Early in 1932, the Government of the United Provinces called us to Lucknow, and with a view to introduce Yogic exercises in their educational institutions, got a few teachers trained in *Yogic Physical Culture.* In this connection a letter containing the remarks of the Director of Public Instruction, U. P., which is printed in the *Miscellaneous Section,* will be found interesting. We feel confident that this laudable example of the U. P. Government will be followed by other provincial governments in due course of time, and in less than two decades, Yogic exercises will form a part of the physical instruction given to each school-going boy and girl in India.

In order to introduce these exercises in the educational institutions, we had to adapt them to mass movement. This has been very successfully done and a handbook written on the subject with the approval of the U. P. Government, will soon be in the hands of the general public.

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THE three activities referred to above concern themselves with the lower or physical side of Yoga. As must have been clear by this time to the readers of the *Yoga-Mîmâṅsâ* journal, the interest of the *Kaivalyadhâma* is centred round the higher

or spiritual side of Yoga on a far larger scale than round the physical side. All the Sâdhakas that have joined the Âśrama, forming an integral part thereof, have come together for their spiritual uplift, although the service of humanity through the physical side of Yoga has all along been an important consideration with them. Our physical and curative activities, however, have developed to such an extent that the whole atmosphere of the Âśrama, both at Lonavla and in Bombay, is unduly influenced by the physical side of Yoga, rendering higher spiritual work seriously difficult. Hence an exclusive Spiritual Centre for the use of the advanced Sâdhakas of the Âśrama, has long since become a sore need of the *Kaivalyadhâma.* We are greatly pleased to mention here that the Âśrama has already secured a sacred and beautiful site for its Spiritual Centre. But more of this in the next number.

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As stated in one of the foregoing *notes* the Âśrama has not only started these four important activities during the last two years, but has also achieved some degree of success in them. Hence we could now find time for the resumption of the editorial work and with the deepest pleasure we are presenting this third number of Volume IV to our readers. May we not hope to be forgiven all our faults and be getting the same patronage at the hands of our readers that has been accorded to us up to now?

◆ ◆ ◆

In this number we have included everything new that has appeared in the handbook of *Âsanas.* Fresh information appearing in the handbook of *Prâṇâyâma* will be supplied to our readers in the next number which will contain, besides this, valuable original articles shedding new light on the subject of Prâṇâyâma.

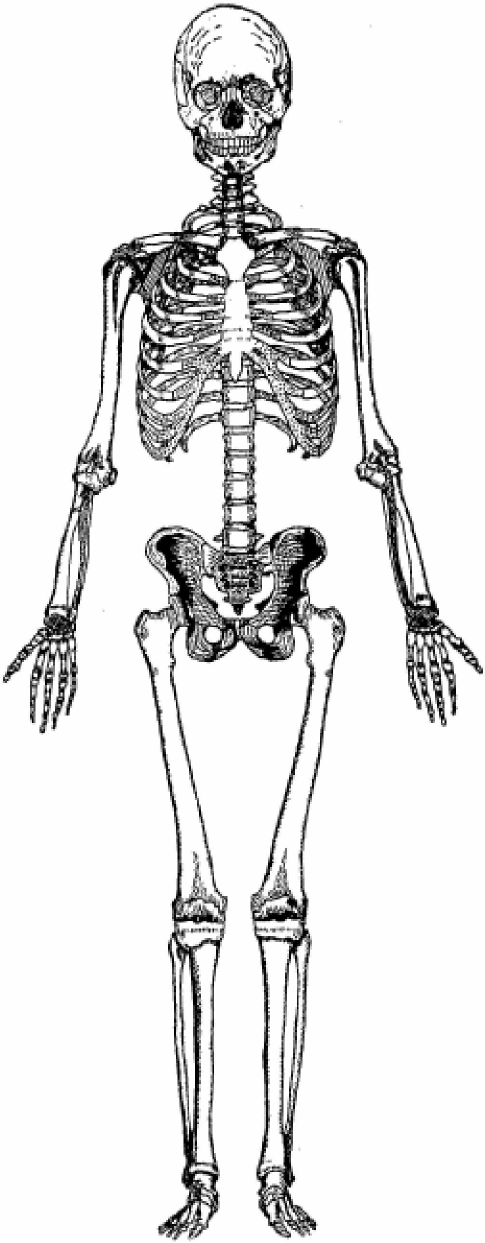
◆ ◆ ◆

May the Lord that enabled us to found the Âśrama, give us strength enough to carry on its work! May He ever widen the circle of our sympathizers and thus allow us to serve Him and His children to the best of our ability!

The Semi-Scientific Section

N. B.—The Director of the Kaivalyadhâma entreats every man of means to show his active sympathy for the Âśrama.

Fig. XXX



The Skeleton.

Fig. XXXI

The Muscles.

HUMAN BODY

INTRODUCTION

BROADLY speaking the human body consists of two central parts called the trunk and the head. Attached to the trunk at its upper corners are the arms and at its lower corners are the legs. The arms are termed the upper extremities and the legs are known as the lower extremities. Bones are the hardest parts of the human body, and form the framework of the physical structure. (Vide Fig. XXX). This framework of bones supports the softer parts of the body such as muscles which are attached to them. It also offers effective protection to some other parts of the human organism. For instance, some of the bones are arranged in such a way that they give wonderful protection to the brain, the spinal cord, the heart and the lungs. The brain is held securely in the bony case of the skull, and the spinal cord is safely lodged in the hollow of the backbone. Similarly the heart and the lungs are located within the cage of the ribs. A very important group of organs such as the stomach, the intestines, the liver, the spleen, the pancreas, and the kidneys, is situated inside the belly. These organs are ably protected there by means of very strong muscles that go to form the walls of the belly and are attached to the bones at the two ends. Thus we find that the bony framework of the human body protects directly or indirectly all the organs of vital importance and also supports human flesh in the form of muscles in which it is clothed. These muscles, however, would have given a very uneven surface to the human body (vide Fig. XXXI), had it not been for the fat which fills up the depressions in the muscles and gives a rounded appearance to the different parts. What little roughness would still be persisting, is smoothed down by the skin forming the outermost coat of the human body.

THE CELL

In the foregoing paragraph we have referred to several parts of the human body. Thus there are references to bones, to the muscles, to the brain, to the liver, to the spleen and also to the skin. Now when a man dies, all these parts of his body also die. But in the case of living persons we often find that all these parts are not necessarily alive. Some of them may be attacked by disease and decay while the remaining body is sound and healthy. The above circumstance clearly shows that the different parts of the human body have no doubt a life which they share with the body as a whole, but they have also their individual life which must end with the whole body, but which may end even when the other parts of the body are living. Take, for instance, the case of a man who gets a serious burn in which not only his skin, but even some inner parts of his fingers are involved. What has become to the skin and the fleshy parts of his fingers? They are dead! They must be removed by a surgeon, so that fresh skin and flesh may take their place. During treatment we can clearly observe that living flesh and skin are slowly growing and taking the place of the dead parts that were previously scraped off.

Now the question arises as to what is the smallest unit in the human body which while sharing the life of the body as a whole, has its own independent life also? The answer to this question is the *cell* according to the science of biology. This science looks upon the human body as a republic of cells. Just as in a republic every person while sharing the life of the whole republic, leads his own individual life, so in the human body every cell while partaking of the life of the whole body, has also its own individual life. The cell is the ultimate organic unit of the human body. In fact it is with the cells that the body is constructed. It is the cells that undergo wear

and tear when the human body is working. It is the cells that are repaired when the human body is resting. It is the cells that receive nourishment when the human body is being treated with food and drink. It is the cells that are crying for oxygen while the human body is gasping for breath.

Naturally it is the cells that must be studied, if one wants to understand the structure and functions of the human body.

These cells are extremely minute things and are densely packed in every part of the human body. They differ, however, very widely in size. Thus within the space of a cubic millimeter we can hold several millions of them, if they are of the smallest variety ; but within the same space we cannot hold more than a thousand, if they happen to be of the biggest size. It is calculated that we carry more than 5,000,000 of these cells in a tiny drop of blood, that is only as big as one cubic millimeter.

What is the stuff of which the cells are made? They are made of a substance that is known as *protoplasm*. It resembles the white of an egg and is considered by the biologist to be the physical basis of all life. Biologists have come to the conclusion that there is no life apart from protoplasm. It is because of this protoplasm that the cell can become an independent organic unit so much so that it can live, it can take nourishment, it can grow and it can even reproduce its own kind.

The process of cell reproduction is very interesting. Each cell has a highly specialized central part called the *nucleus*. This nucleus is as it were the very soul of the cell. So when the process of reproduction starts, the nucleus first divides itself into two. The two parts begin to work independently and develop themselves into two full-fledged cells. When the development is completed, they separate themselves into two cells either of which can in its turn become a mother and

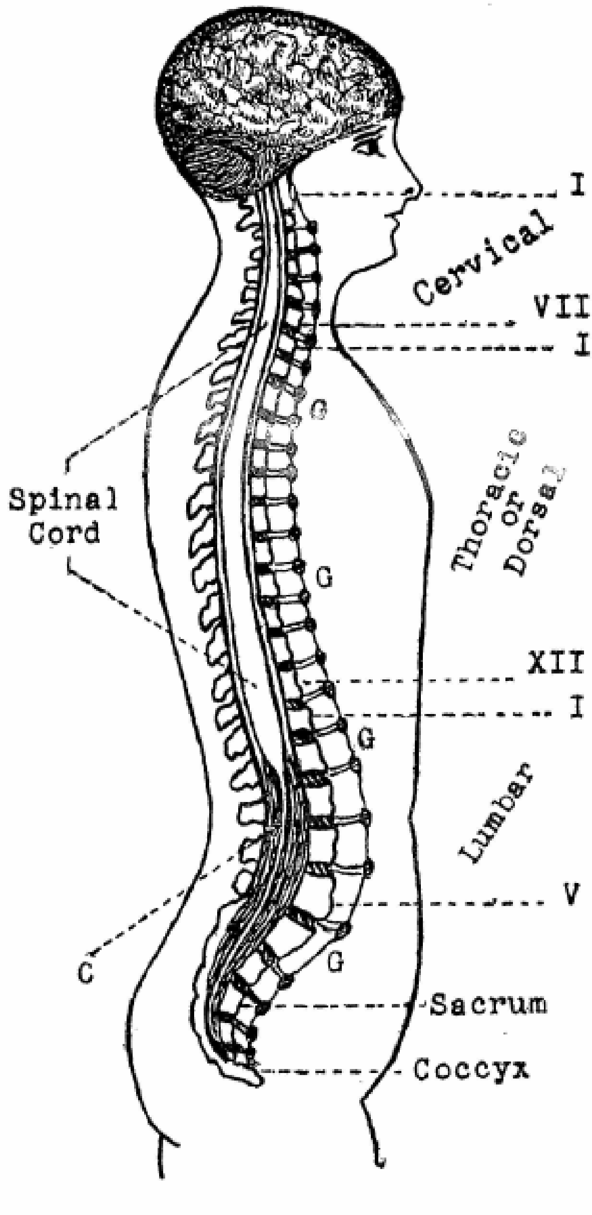
reproduce two cells from itself. This process of cell-multiplication can best be observed in a rapidly healing wound where a large number of these cells is reproduced every day.

Although all cells are uniformly made of protoplasm, they mutually differ in form according to the form of the organs to which they belong. For instance, muscle-cells are spindle-shaped, but gland-cells are cubical in form.

Several cells combine to form what are called *tissues* in anatomy. Broadly speaking, in some of the tissues of the human body the original cells are changed into fibres. Thus the fibres of the nerves and of the skeletal muscles are only modifications of the cells. Every tissue has got not only its distinctive form but also its specialized function to perform. Organs all over the body are made of these tissues, every one of which is characterized by the functional activity of the organ to which it belongs. The activity of the muscles is characterized by their contraction, so every muscular tissue will be found to contract when stimulated to action. If a tissue belongs to a gland, it will be found to secrete juices when active. Similarly a nervous tissue will be found capable of transmitting impulses.

Thus we have seen that the ultimate organic units of the human body are cells. These cells combine themselves into tissues each of which has its characteristic form and function according to the form and function of the organ to which it belongs. But what is it that enables the cells to live and function ? As these cells work, they must undergo wear and tear. What is it that enables them to repair themselves ? The answer to this question is nourishment. Every one of these cells is constantly being supplied with nourishment in the form of oxygen, water, proteins, fats, sugars and salts. This nourishment is derived from the air we breathe, the liquids we drink, and the solids we eat. Out of this nourishment

Fig. XXXII



The Vertebral Column, the Brain, the Spinal Cord and the Sympathetic Ganglia.

C— Spinal Canal, *G*— Sympathetic Ganglia.

cells are able to manufacture protoplasm which enables them to live and function and even to multiply.

We shall now proceed first to study the arrangements made in the human body for carrying its nourishment to every cell and then to see how the nourishing elements are prepared out of the food and drink that we take by the mouth, and the air we take in by the nose. But even before we do this, we shall take a short notice of the bones and muscles that go to form the bulk of the human body.

BONES

There are about two hundred bones in a human adult. As stated in the introduction of this article they form the framework of the human body and support the softer part thereof. Fig. XXX illustrates the human skeleton. This illustration will make it clear that not only our trunk, legs and arms, but even our toes and fingers have these hard bones running through them. Bones are joined together by means of joints most of which allow them movements within particular limits. These movements are brought about by muscles which connect the two bones joined together. In order that the movements of the joints may be smooth not only soft pads of cartilages are inserted between the joining bones, but also a sort of lubrication is made available there in the form of secretions.

The most wonderful structure containing a series of joints is the *backbone* or the *vertebral column*. This column originally consists of 32 separate pieces of bones, each piece being called a *vertebra*. In Fig. XXXII these vertebræ can be distinctly seen. It will be discovered that they are only 26 because several of them have become fused together as they do in the case of an adult. The first seven vertebræ are situated in the neck and hence are called *cervical*, from cervix: the neck. The twelve that follow are located in the region of the back and are therefore named *dorsal*. The next five are called

lumbar because they support the loins. Below these is the *sacrum*, originally consisting of five bones but afterwards of one continuous piece, the separate parts being united. The last piece is the *coccyx*.

These vertebræ are arranged one on the top of the other, so that every one of them fits in with the one immediately above it and also with the one immediately below it, through partially movable joints. Between these vertebræ soft bony substances are placed to serve as cushions. They are called *cartilages*, and allow free movements to the vertebræ. Strong fibrous bands called *ligaments* bind together these 26 separate pieces of the vertebral column. Each vertebra has a hollow ring inside it. The column is so arranged as to keep these rings one above the other, forming a canal for the spinal cord to lie in. It is, therefore, called the spinal canal. In Fig. XXXII this canal is indicated by *C*.

Very strong muscles surround this vertebral column and enable it to move in almost all directions. Thus it can bend backwards and forwards, to the right and to the left, so also it can have considerable right and left twists. 31 pairs of spinal nerves exit through the spaces left between every two adjoining vertebræ and spread themselves to the different parts of the body.

THE MUSCULAR SYSTEM

The muscular system consists of muscles about five hundred in number. They constitute what is popularly known as flesh. They not only cover the skeleton, but also occupy the deeper parts of the human body. The skeletal muscles are made up of small, elongated thread-like structures called muscular fibres. The muscular coats of the stomach, the intestines etc., are made up of cells. When a muscle is working these fibres and cells contract and consequently become

shorter. The result is that the whole muscle is contracted and becomes shorter. When a muscle composed of fibres is at work, it not only becomes shorter but also thicker in the middle. This thickening of the muscle in the middle can best be felt and seen in the case of our biceps. This muscle crosses our upper arms in the front and its work is responsible for bending our forearm in the elbow. If we grasp our right arm with the left hand while the right elbow is straight and then if we bend the right forearm in the elbow, we find a muscle bulging out under our hand. This muscle is the biceps and its bulging out is due to its thickening in the middle because of its activity.

All the movements of our body are brought about by muscles that cover the skeleton. We can bring about any one of these movements at our will, simply because the muscles connected with these movements are under the control of our will. Hence these muscles are called *voluntary*. There are other muscles, however, which we cannot contract at our will. Their work is being done independent of our will-power. Such muscles are called *involuntary*. The best examples of involuntary muscles are the stomach, the intestines and the heart. The walls of arteries are also made of involuntary muscles.

We shall understand the working of the involuntary muscles when we come to the study of the different systems to which they belong. At present, we shall take into consideration a few voluntary muscles of importance.

The *diaphragm* is perhaps the most important voluntary muscle in the human body. Being strongly built it divides the thorax from the abdomen, serving as a partition between the two. The diaphragm is a dome-shaped muscle, the convex surface of it being turned towards the chest. It moves up and down several times a minute. When it descends the vertical capacity of the chest is increased, which leads to the

act of inspiration. On the side of the abdomen this descent of the diaphragm exerts a gentle pressure upon the abdominal viscera and gives them a sort of massage, which helps them considerably in maintaining their health.

The diaphragm is not, however, the only muscle that brings about respiration. There are others situated between the ribs. These muscles are called *intercostal.* They help the ribs to move up and down.

On the side of the belly there are a number of strong muscles which hold together the abdominal viscera. We might here take notice of only two of them, the two straight muscles that vertically cross the front wall of the abdomen. They are called *abdominal recti.* On the upper side they are attached to the ribs and on the lower side to the pubic bone. When they contract they give a forward bend to the body. During respiration they move in co-operation with the diaphragm, and just like it massage the different organs held in the abdominal cavity and promote their health.

Having studied a few facts about the bones and muscles which form the bulk of the human body, we come to the nourishment of the cells of which the whole body is made.

THE CIRCULATORY SYSTEM

The duty of carrying the nutrient material to every cell in the human body is assigned to a fluid called the blood. This is something with which every one of us is familiar. It consists of a liquid called the *liquor sanguinis* or *plasma* and minute solid particles called *corpuscles.* The corpuscles are of two varieties : red and white. Red corpuscles are smaller in size but far too numerous than the white ones. The average size of a red corpuscle may be about $\frac{1}{3200}$ of an inch in diameter. Hence a cubic inch of the blood will contain millions and millions of these corpuscles.

The total quantity of the blood in a healthy adult human body has been estimated to be equal to one-thirteenth of its total weight. According to this proportion a man weighing 156 pounds will have 12 pounds of the blood in him.

This quantity of the blood is constantly being circulated throughout the body and is being brought to every cell therein. When coming to the cell, the blood brings oxygen, proteins, fats, sugars, and salts to them which they pick up for their nutrition. While going away from the cell, the blood is loaded with carbon dioxide, urea etc., which the cells throw into it as waste products. These waste products are ultimately eliminated from the system through the lungs, the skin and the kidneys to which they are brought by the blood in its ceaseless flow. In this way the necessary purity of the blood is constantly preserved. The cells are perpetually depriving the blood of the nutrient material it carries with it. Hence the blood has constantly to borrow this material from the lungs and the digestive system, and thus to satisfy the needs of the cells.

The work of carrying oxygen to the cells falls upon the red corpuscles of the blood. They contain a solid substance called *hæmoglobin* which has a great friendship for the oxygen gas. This hæmoglobin picks up oxygen from the lungs and brings it to the cells.

We have to note here the following characteristics of hæmoglobin. When this substance combines with oxygen it becomes scarlet red in appearance, but when deprived of oxygen it becomes purple in colour. Further if hæmoglobin combines with carbon dioxide, its colour becomes entirely dark. These characteristics of hæmoglobin will help us to understand the difference between the colour of the blood coming to the cells and the colour of the blood going away from them. Let us see how. When the blood is flowing to the cells, the hæmoglobin in its red corpuscles is combined

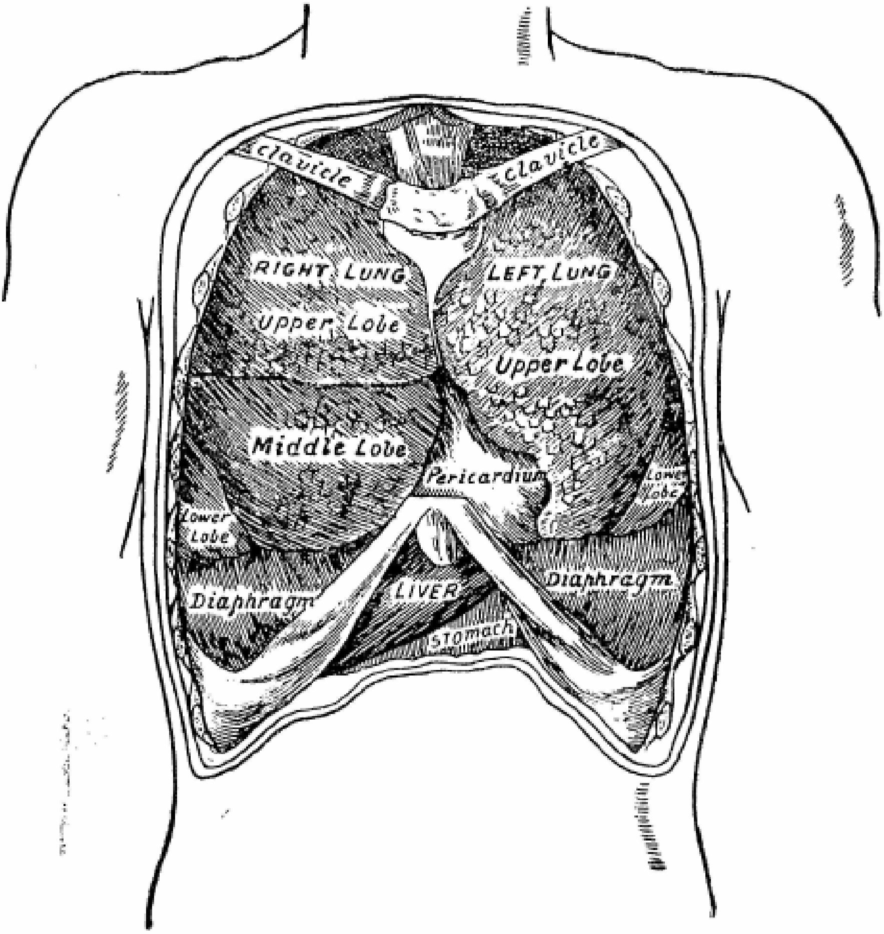
with oxygen, and has a bright red appearance which it lends to the whole quantity of the blood to which it belongs. But when the blood is flowing away from the cells, the hæmoglobin of the red corpuscles becomes deprived of its oxygen. Not only that but it becomes combined with the carbonic acid gas which the cells pass into the blood. Now the hæmoglobin of the blood thus combined with carbon dioxide becomes dark in colour and lends a darkish appearance to the whole blood.

Up to now we have studied the nature of the blood and also the work it has to do in the human body. We shall now proceed to see what apparatus has been set up to keep the blood going on its ceaseless round.

This apparatus consists of the heart, the arteries, the capillaries and the veins. The heart is the central pumping station from which the fluid of the blood circulates in the body. A big tube starts from the heart which divides and subdivides itself several times till at last its branches reach every organ in the human body. This big tube is called the aorta, and its branches leading to the different organs have their individual names, the aorta and its ramifications being called *arteries.* These arteries after reaching the respective organs become distributed into countless minute tubes the smallest of them having a diameter hardly bigger than $\frac{1}{3200}$ of an inch. These hair-like tubes are called *capillaries.* These capillaries penetrate every organ so thoroughly that every cell of the organ is surrounded by them in every part of the human organism. This network of capillaries after penetrating every organ through and through, reunites to form bigger and bigger tubes, till at last two very big tubes are formed which completing the round of tubes open into the heart. The tubes which join the capillaries with the heart are called *veins.*

We shall now try to see something more of this apparatus which goes by the name of the circulatory system. The

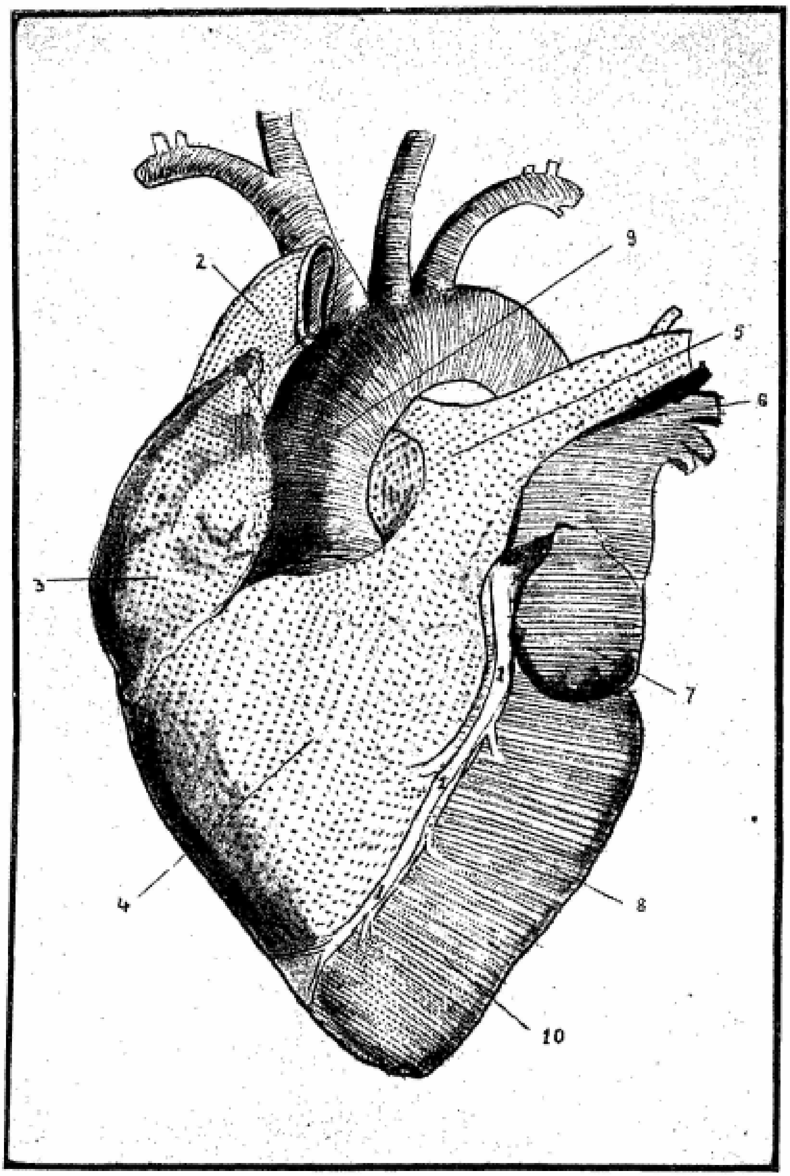
Fig. XXXIII



The Lungs, the Heart, the Diaphragm, the Stomach and the Liver.

(The Pericardium shows the position of the Heart)

Fig. XXXIV



The Heart.

1 The Groove indicating the Septum. 2 The Superior Vena Cava. 3 The Right Auricle. 4 The Right Ventricle. 5 The Pulmonary Artery. 6 The Pulmonary Vein. 7 The Left Auricle. 8 The Left Ventricle. 9 The Aorta. 10 The Apex.

(Parts containing Arterial Blood are marked with lines, whereas parts containing Venous Blood are marked with dots)

heart is a pear-shaped hollow organ whose walls are made up of an involuntary muscle. It is placed in the chest between the two lungs. (Vide Fig. XXXIII). The cavity of the heart is divided by a septum into two parts, the right and the left, the place of the septum being indicated by a groove which crosses the outer surface of the heart muscle. (Vide Fig. XXXIV). Again each of these two parts, the right and the left is further divided into two chambers, the upper and the lower. The upper chambers are called *atria* or *auricles* and the lower chambers are called *ventricles.* Thus there are four chambers: the right auricle, the right ventricle, the left auricle, and the left ventricle. Between each auricle and the corresponding ventricle there is a valve which allows the blood to pass from the auricle to the ventricle, but does not allow any blood to pass back from the ventricle to the auricle. Tubes in the form of arteries and veins stand connected with the heart.

We have already seen that the heart is an involuntary muscle. It contracts and relaxes something like 70 times a minute in a healthy individual. Its contraction is called systole while its relaxation is known as diastole. *Systole is the time of action* for the heart whereas *diastole is the time of rest.* It is to be noted that the heart does not contract as a whole at once, but the contraction takes place in parts, first in the two auricles and immediately thereafter in the two ventricles. Both auricles and ventricles relax after their respective periods of contraction when the whole heart is at rest. It is observed that diastole of the heart lasts a little longer than its systole. Hence they say that the heart sleeps for thirteen hours and works for eleven hours every day. The sleeping heart passively receives the blood from the body and the waking heart actively propels it into the body.

Let us now follow the current of the blood that is kept going round by the circulatory system. Two big veins, the

superior vena cava and the *inferior vena cava* (Fig. XXXIV), pour the blood into the right auricle of the heart. The superior vena cava drains those parts of the body that are situated above the level of the heart, whereas the other vein drains the other parts. During this time the right auricle is in diastole. When full this auricle contracts and squeezes its contents into the right ventricle which receives them passively, itself being in a relaxed condition. Now it is the turn of the right ventricle to contract and to force out the blood it contains into the *pulmonary artery* for being taken to the lungs. The blood received from the two cavæ is full of carbon dioxide which is to be eliminated. Hence the heart sends this blood to the lungs. There that gas is got rid of and fresh oxygen is picked up. When this is done the blood becomes charged with oxygen. It gets also its colour changed from purple to red scarlet. Now this oxygenated blood is to be distributed to the different cells in the body. For this purpose it is brought from the lungs to the heart by the *pulmonary vein.* The blood is first poured into the left auricle when it is in diastole. Thereafter that auricle contracts and forces the blood into the left ventricle. The left ventricle then contracts and pushes out the blood into the aorta and its various branching arteries.

The left ventricle contracts with such a vigour that the blood forced out into the aorta is sent throughout its ramifications with a jerky motion. It is this jerk that constitutes the pulse which medical men feel in the patient's wrist. An idea of the vigour with which the left ventricle works can also be had by the feeling of the heart beat in the chest. This beat is the result of the left ventricle dashing itself against the chest wall while undergoing its forceful contraction.

During each contraction the heart propels about four ounces of the blood into the arteries. We have seen that the heart contracts 70 times in a minute. Thus we find that every

minute the heart pushes into the arteries as much as 280 ounces of the blood or in other words as much quantity of it as is sufficient to fill half a tin of kerosine oil !

From the arteries the blood passes into the capillaries and from the capillaries into the veins. Ultimately the two cavæ gather the blood from all the veins and pour it into the right auricle.

The blood pushed into the arteries feels the propelling force of the heart every time. This force is the strongest just near the heart, but it becomes weaker and weaker as the blood gets further away. In the capillaries the propelling force becomes so weak that the blood loses the jerky motion which it has in the arteries. Hence the blood flow in the capillaries is smooth. In the veins the propelling force continues to weaken increasingly till it is entirely lost when the blood returns near the heart. In fact the heart has to suck up the blood from the veins that unite with it.

As stated above the blood squeezed out of the heart flows through the blood-vessels, namely, the arteries, the capillaries and the veins. The arteries and the veins are made up of the same types of tissues. In some parts the elastic tissue predominates, in others, the contractile. But the arteries are far stronger in their structure than the veins. Hence when empty, veins will collapse, whereas arteries will maintain their tubular form. Even the weakest veins, however, do not allow the blood flowing through them to exchange its contents with anything outside their walls. It is only in the capillaries that this exchange takes place, because the walls of the capillaries are extremely thin. Thus the blood while going through the capillaries of the lungs exchanges its carbon dioxide with the oxygen of the air in the air-cells ; and while passing through the capillaries of the other parts of the human body, it exchanges its nutrient material including oxygen with the waste

products of the cells, these waste products consisting of the carbonic acid gas, etc.

THE RESPIRATORY SYSTEM

In our study of the circulatory system we have seen that the blood when flowing through the capillaries of the lungs exchanges its carbonic acid gas with the oxygen of the air that is contained in the air-cells of the lungs. This exchange of gases becomes possible only because quantities of fresh air are being constantly brought to the pulmonary area. We shall now proceed to see how these fresh quantities of air are made available for the gaseous exchange in the lungs.

If we take an elastic rubber ball having one opening and if we press the ball, we find that a part of the air contained in the ball is squeezed out. Again if we remove the pressure from the ball, it resumes its original size and while doing so it sucks up some air from outside. We shall now try to understand why this happens. The air outside the ball like the free air everywhere, is always under the pressure of *one atmosphere* or pressure equal to 760 mm. of mercury.[1] Under normal conditions the air inside the ball also remains under an equal pressure, because through the opening it communicates freely with the air outside. Now when the ball is pressed, its internal capacity diminishes and the pressure on the air inside the ball increases. Hence a part of that air is expelled, so that the pressure inside the ball and the pressure outside it becomes equal. Again when the pressure is removed from the ball, it resumes its original size and regains its original capacity which is bigger than its capacity in the compressed condition. A part of the original air remains driven out. Hence when the ball returns to its normal size, it has in it much less air than it can hold. That is the air inside the ball

1 This is the pressure of the atmosphere at the sea-level. As one rises higher up this pressure goes on decreasing proportionately.

is at a lower pressure than the air outside. Hence some air from the atmosphere gets into the ball and equalizes its internal and external pressure.

Now instead of one if we take two balls and if the opening of each ball were to end in a tube, the two tubes afterwards uniting into one, and if we fill up the balls with very elastic pieces of sponge through which air can penetrate, these balls will exactly illustrate the lungs. Let us see how.

There are two lungs, the right and the left. Both of them are made up of a spongy substance. This substance is divided into three parts in the right lung and into two parts in the left, each of the parts being called a *lobe.* (Vide Fig. XXXIII). The spongy substance of each lung is held in an air-tight bag having two coverings in close contact with each other, so that the two coverings make one coat only. These coverings are called the *pleuræ.*

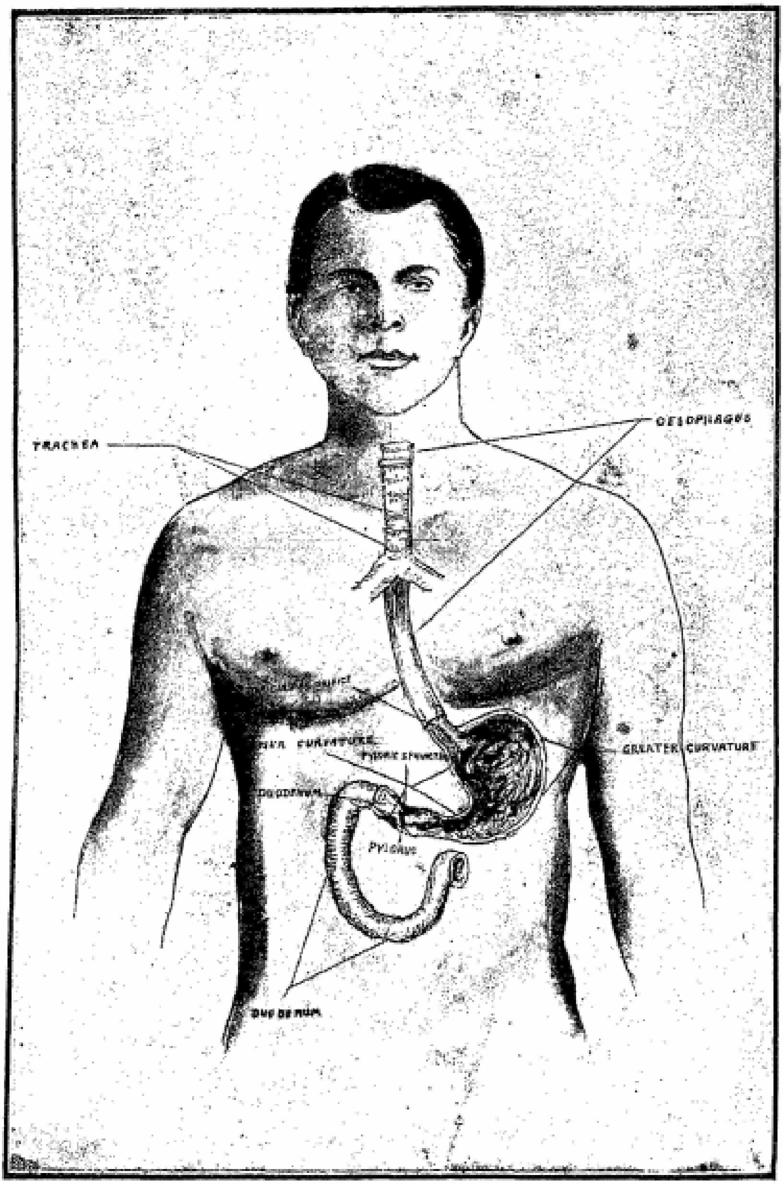
The coat of each lung has only one opening. It is in the form of a tube called the *bronchus.* The tube connected with the left lung is known as the left bronchus whereas the tube connected with the right lung is known as the right bronchus. The two bronchi unite to form the *trachea* which opens into the throat, which throat in its turn communicates with the nose. It is through the bronchi, the trachea, the throat and the nose that the lungs keep communication with the outside atmosphere.

The two lungs are held in an air-tight cage called the chest. The sides of this cage are made up of the flexible ribs and its bottom is made up of a very stout muscle called the diaphragm. The ribs are moved up and down by means of the intercostals. Because of the action of the diaphragm and the intercostals, the chest expands and contracts, several times in a minute. Now when the chest contracts the lungs inside

are pressed and the air contained in them is forced out, just as the air from the elastic rubber ball referred to in the last but one paragraph, is forced out under pressure. This going out of the air from the lungs is called *exhalation.* Again when the chest expands, the pressure in the lungs is lowered. Hence they suck up some air from the atmosphere. This sucking up of the external air into the lungs is called *inhalation.* Both inhalation and exhalation constitute the act of *respiration* and the apparatus used in this act is called the respiratory system.

In the foregoing paragraph we have seen how air is drawn into the lungs. We shall now see how it is brought close to the blood circulating through the lungs for an exchange of gases. We have referred to the bronchi which enable the lungs to communicate with the atmosphere. These bronchi after entering the lungs, divide and subdivide themselves into numerous smaller and still smaller branches till their diameter measures hardly more than $\frac{1}{40}$ of an inch. Here these fine bronchial tubes stop subdividing themselves further, but form very tiny air-cells roundabout them. When the air drawn into the lungs comes as far as these air-cells, it finds that the walls of the air-cells are so thin that it can easily leak out if it is wanted outside the air-cells. Now forming a sort of network with the air-cells in the lungs are distributed the blood capillaries bringing from the heart quantities of the blood full of carbonic acid gas. This gas the blood is anxious to get rid of and obtain oxygen instead for the nourishment of the cells all over the body. The walls of these capillaries also are so thin that they can allow carbon dioxide to escape and oxygen to come in its exchange. Even the combined thickness of the walls of the air-cells and capillaries is not sufficient to stop this exchange of gases. So the air from the lungs takes up carbon dioxide from the capillaries and lends its oxygen to the blood instead.

Fig. XXXV



The Trachea, the Bronchi and the Digestive Tube
up to the End of the Duodenum Exposed.

In every inhalation we take about 500 c.c. of air into the lungs. This contains little less than 105 c.c. of oxygen. All this oxygen is not, however, taken up by the blood. The blood takes up only about 24 c.c. of it and returns nearly an equal quantity of the carbonic acid gas. So when the air comes out of the lungs, it contains all the carbonic acid gas taken from the blood and also a large quantity of oxygen that remains unabsorbed by the blood. The rate of respiration in a healthy adult is from 14 to 18 per minute.

THE DIGESTIVE SYSTEM

In our study of cells we have seen that they require oxygen, proteins, fats, sugars and salts for their life and growth. Out of these oxygen is supplied to the cells by the respiratory system. The system which is responsible for getting the other nutritive material ready for them is the digestive system. We shall now proceed to study the different parts of which this system is made up and the way in which it feeds the cells.

The digestive system consists mainly of a continuous tube known as the *alimentary canal*, that is, the passage along which food passes through the body. This tube is something like 30 feet in length and starting from the mouth ends at the anus. Only a small part of it is situated in the chest, most of the tube being held in the abdomen. The part next to the mouth is the *pharynx* which descends down the throat and ends in the *œsophagus* or the gullet. Passing behind the trachea the œsophagus crosses the chest almost vertically, till it pierces the diaphragm and enters the abdomen. (Vide Fig. XXXV). The œsophagus is something like 9 inches in length. After coming into the abdomen in the form of the œsophagus, the digestive tube becomes greatly dilated to form the *stomach*. So the stomach is only a dilated part of the alimentary canal. The stomach, however, is not a straight tube,

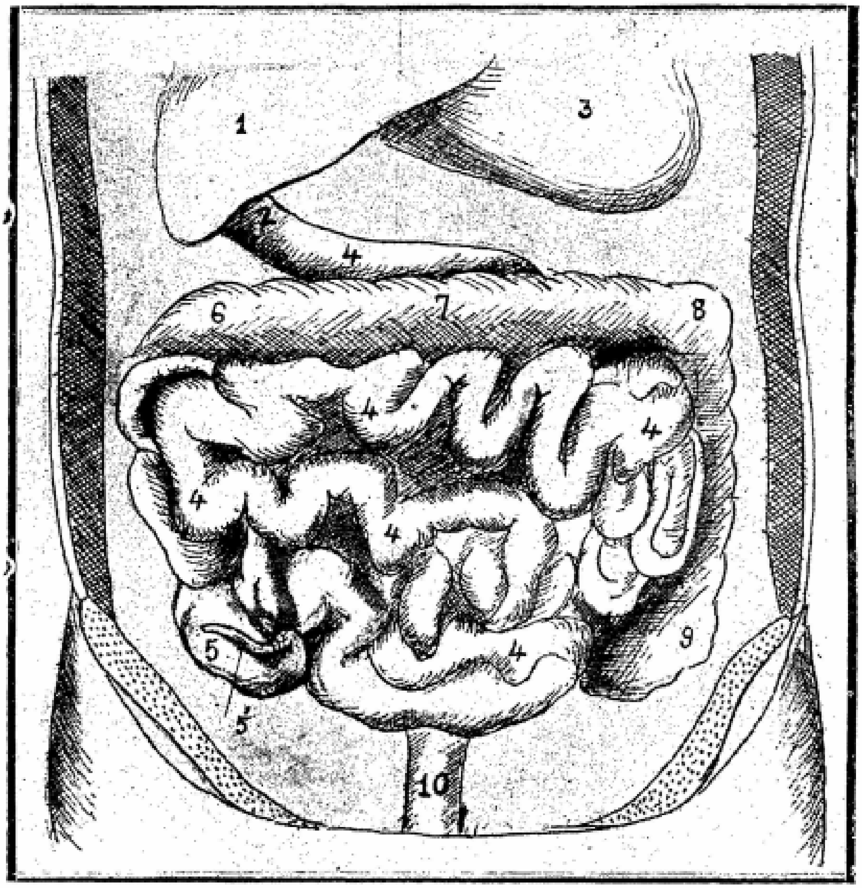
It is curved. Fig. XXXV illustrates the inner or the lesser curve and also the outer or the greater curve. The stomach lies just below the diaphragm and crosses the abdomen from left to right. It ends in the small intestine. The stomach has two openings. The upper opening connects it with the œsophagus and the lower one joins it with the small intestine. Both these openings are formed of strong muscular rings which remain closed ordinarily, but which open when necessary. The upper opening is called the *cardiac orifice* and the lower one the *pyloric orifice*.

The *small intestine* is so named because it is small in calibre. It is, however, 22 feet in length. This whole length is admirably held inside the abdomen in several coils as illustrated in Fig. XXXVI. The small intestine is divided into three parts, these successive parts being named as the *duodenum*, the *jejunum* and the *ileum*.

The ileum opens into the *large intestine* or the *colon* by means of a valve called the *ileo-cecal valve*. The colon is called the large intestine because of its big calibre which varies from 1·5 to 3 inches in diameter. The length of the colon is only 5 feet. In the abdomen it passes in a curve round the coils of the small intestine and gets different names for its different parts. That part of it which is below the ileo-cecal valve is called the *cecum*. To this cecum is attached externally a small organ called the *appendix*. This organ when inflamed gives rise to the disease appendicitis.

The colon ends in the *rectum* which is only some 6 inches in length. The last part of the colon, hence also of the digestive tube, is called the *anal canal*. It is only an inch in length. The rectum and the anal canal are continuous. The opening by which the digestive tube terminates is called the *anus*. It is guarded by a strong muscular ring which opens at the time of defecation, but otherwise remains contracted and closed.

Fig. XXXVI



The Abdominal Viscera.

1 The Liver.
2 The Gall-Bladder.
3 The Stomach.
4 The Small Intestine.
5 The Cecum.
5' The Appendix.
6, 7, 8, 9 } The Colon.
10 The Rectum.

(The Cecum has been drawn upwards and backwards so as to expose the Appendix)

The digestive tube is made of strong muscular coats. A wave of contraction travels down the tube and pushes forth the food contents. Such a wave is called *peristalsis.* If the wave travels in the opposite direction, it takes the contents backwards. The backward wave is called *anti-peristalsis.* The action of vomitting is brought about by anti-peristalsis.

The inner surface of the whole of the digestive tube is lined with the mucous membrane, the same fine delicate thing that covers the cavity of the mouth. Several glands are situated in this tube and pour their secretions into it for helping the digestive process. The *salivary glands* are located in the mouth, the *gastric* or *peptic glands* in the mucous membrane of the stomach and the *intestinal glands* in the mucous membrane lining the intestines.

No description of the digestive apparatus can be complete without taking into account two accessory glands, the liver and the pancreas.

The *liver* is the biggest gland in the human body. It weighs as many as 55 ounces. It is situated on the right side of the abdomen just below the diaphragm. (Vide Fig. XXXVI). Its left part extends a little even beyond the breastbone. The liver plays a very important part in the digestive system. The venous blood carrying with it nourishing material collected from the stomach and the intestines has to pass through this gland and be worked upon by it. If the liver does not function satisfactorily this nourishing material suffers in quality and leads to various disorders. The liver is responsible for an important product called the *bile.* This product is generally first stored up in a vessel called the *gall-bladder* (Fig. XXXVI), and then poured into the duodenum through the *bile-duct.*

The *pancreas* is much smaller than the liver. It weighs only 2 to 3 ounces and is irregularly prismoid in shape. It is

situated behind the stomach. This gland has a secretion which is poured into the duodenum along with the bile and is known as the *pancreatic juice*. It plays a very important part in the digestion of food.

Thus far we have considered the digestive apparatus. Let us now see how this apparatus digests the food that we take and how it sends the nourishing material on to the cells.

In order to understand the problems of digestion and nutrition, it is necessary for us to know a few chemical and physical facts. Chemically examined the different articles of food we take fall into four heads, namely, *proteins*, *carbohydrates*, *fats* and *salts*. Out of these, carbohydrates contain starches and sugars. It is possible for the constituents of an article of food to fall under a single category, but generally foodstuffs combine the different chemical varieties noted above. For instance, sugar falls under carbohydrates only. Ghee is nothing but fat. But wheat, bajri or rice is a combination of proteins, fats and carbohydrates ; whereas milk contains all the four varieties mentioned above. Of course the proportion of different varieties differs in different foodstuffs. For example, the percentage of fat present in rice is only 0·4, but in wheat it is 1·7 and in buffalow's milk 9. Another fact which needs our attention in regard to these chemical constituents of food is their solubility or otherwise in water. Salts and sugars are soluble in water whereas proteins, starches and fats are insoluble. Now the membrane which covers the inner surface of the digestive tube allows only those chemical substances to pass through it which are soluble in water. Hence salts and sugars can pass through the membrane, but proteins, fats and starches cannot. We have, however, seen that the cells of the human body constantly stand in need of not only salts and sugars, but also of proteins, fats and starches. Now these latter varieties of food constituents, if they are to reach the cells, must do so, by getting into the blood current, and they can get into the

blood current only if they can pass through the membrane. Again they can pass through the membrane, only if they are rendered soluble in water. This is exactly what is done by the process of digestion. The different glandular secretions that are poured into the food tube, act upon the constituents of the food we take, and render them soluble in water. So we can define digestion as the process by which the different constituents of the foodstuffs are rendered soluble in water by the action of the glandular secretions of the alimentary canal, so that they could get into the current of the blood and be carried to the cells of the body for their nourishment.

Having studied the general nature of digestion, let us now know some details of this process. As seen in the last paragraph, out of the foodstuffs we take, sugars and salts are soluble in water and can pass to the blood current directly. But the starchy part of carbohydrates, so also proteins and fats require to be made soluble before they can pass through the mucous membrane of the food tube. Let us now see how this is accomplished.

The first operation which the food we take undergoes, is mastication. It is necessary for the foodstuff to be very finely powdered even while it is still in the mouth. The different juices which bring about digestion can act upon the food far more thoroughly, if the foodstuff is reduced to minute particles. Hence the need of thoroughly chewing our food whenever it is taken. Further the process of digestion starts right from the mouth. Saliva which is liberated by the salivary glands acts upon the starchy part of carbohydrates of our food and converts it into sugar thus rendering it soluble in water. Saliva which ordinarily keeps the mouth moist, moistens the masticated food and also helps us in swallowing it comfortably. As our experience tells us, dry stuff is so difficult to be pushed down the throat. After getting into the stomach through the gullet, the food comes in contact with the gastric juice which

is secreted by the gastric or peptic glands situated in the mucous membrane of the stomach. This juice acts upon the proteins and turns them into peptones which are soluble in in water. From the stomach the food goes into the small intestine. Here it meets with the pancreatic juice which is a very powerful digestive agent. It acts on all the insoluble constituents of our food, namely, starches, proteins, and fats. Out of these, fats are digested almost exclusively by the pancreatic juice. But in the cases of proteins and starches the work of the pancreatic juice is only supplementary. If a part of starches escapes the action of saliva or a part of proteins escapes the action of the gastric juice, these parts are taken care of by the pancreatic juice and the work of the saliva and the gastric juice is completed by it. It is to be remembered that the bile from the liver and the secretion of the intestinal glands also play some part in the process of digestion. While these different secretions are acting upon the food, it is travelling down the digestive tube; and by the time the food reaches the end of the small intestine, the process of digestion is almost completed.

Thus we see that the different constituents of our food are digested in the alimentary canal because of the action of different juices poured into it by various glands. These digested constituents having been rendered soluble in water become dissolved in it and a sort of solution is prepared. We have already seen that the membrane covering the inner surface of the digestive tube is so thin that it allows such a solution to pass through it. Now just beyond this membrane there is the blood current circulating through the capillaries. The walls of these capillaries too are very thin and allow the foodstuff to get right into the blood current. This passing of the digested food into the circulatory system for being carried to the cells all over the body, is known as *absorption.* Ultimately when the cells pick up the nutritive elements from the blood

and utilize them for their nourishment, the process is known as *assimilation* or *nutrition.*

The process of digestion starts in the mouth, but the process of absorption begins in the stomach. Whatever part is thoroughly digested becomes dissolved in water and is absorbed by the walls of the alimentary canal. Thus the stomach is responsible for the absorption of salts, sugars and peptones, whereas the small intestine absorbs not only these but also fat. Most of our nutrition is absorbed through these two parts of the food tube. Absorption does take place in the colon also, but this part of the bowel mostly extracts watery portions from the contents that are presented to it by the small intestine.

Bowel contents move very slowly through the colon. Food completes its journey of about 25 feet and reaches the ileo-cecal valve in four hours and a half, but it takes more than six hours to move along the 4 feet of the colon. Owing to this slow progress of the bowel contents in the colon, the watery portion gets ample time for being absorbed into the system and by the time these contents reach the last part of the large bowel, they become semi-solid. There they lie till they are evacuated in defecation.

The food tube is made of involuntary muscles. Hence their contraction which expresses itself in the form of peristalsis or anti-peristalsis is not under the control of our will. Students of Yoga can bring at least a part of these involuntary muscles under their control. But that is only an exception and not the rule. What is it then that ordinarily starts peristalsis and thus propels the food along the tube ? Generally it is the chemical stimulus of the food itself. The chemical contents of the food as it is being digested stimulate the nerves that control the intestinal muscles and set up a wave of peristalsis. In this connection the part played by the bile

is very important.[1] It greatly helps the bowel movement because of its chemical nature. Mechanical stimulus is also a factor to be taken into account in studying the intestinal action. It has been found that peristalsis becomes weak if a particular amount of internal or external pressure is not exerted on the food tube.

The few facts about the digestive system that we noted up to now, will show that digestion is bound to suffer if the juices necessary for this process are not available or being available are not of the necessary strength. This is exactly what happens in the case of the disease called dyspepsia. Again the peristaltic action of the food tube must be such as would push the contents right up to its end and throw them out. If this action is either weak or absent, constipation is the result. Either in dyspepsia or in constipation, foodstuff delayed in the tube begins to putrefy and dangerous toxins are manufactured. The process of absorption that is ever going on, puts these toxins into circulation throughout the system and poisons the different organs of the body. Hence health can be ensured only if the digestive system is able not only to digest the food but also to excrete the undigested and undigestible foodstuff.

Along with the digestive secretions, the bowels throw into the tube other things which are to be eliminated. So the ordinary stool consists of not only the undigested and undigestible food residue, but also some other things which the system does not want.

THE URINARY SYSTEM

In the foregoing part of this article we have seen that the food tube acts not only as an organ of digestion but also as an organ of excretion. There are other organs which have an equally important excretory function. They are the *kidneys*. Connected with the kidneys are the *ureters*, the *bladder*

1 The bile is also responsible for not allowing the contents of bowels to putrefy.

and the *urethra.* All these organs constitute what is called the urinary system.

While the body is functioning, it produces two poisonous substances called the uric acid and urea. It is necessary for the human organism to get rid of these poisons. The work of driving out uric acid and urea is done by the kidneys. They excrete a fluid called the urine in which these poisons are held in solution. The kidneys are situated in the back side of the abdomen. Each of them has a tube called the ureter passing from it to the bladder which is a muscular bag situated in the pelvis. Urine is secreted drop by drop and trickling down the ureters is collected in the bladder. When this bag is full we get a call for passing urine. If this call is not suppressed the bladder contracts and expels urine through a passage which is called the urethra. With urine both uric acid and urea are excreted. Failure of the urinary system to function satisfactorily leads to the accumulation of the uric acid and urea in the system causing different disorders therein.

THE NERVOUS SYSTEM

Up to now we have seen how nutrient material is introduced into the human body through the respiratory and the digestive systems and how the material thus introduced is taken to the different organs through the circulatory system. We have also seen how the excretory organs such as the lungs, the food tube and the kidneys throw out waste products. This study is sufficient to show that there is a sort of co-ordination amongst these systems working in the human organism. But if we observe things more closely this co-ordination becomes more evident. Let us watch a man that is engaged in doing some violent muscular work. We find that his respirations become more and more rapid and that his heart begins to beat faster and louder. This shows that the work the man is doing with his muscular system affects his respiratory and circula-

tory systems also. Why is it so ? It is because of the close co-operation of these three systems. Violent muscular work produces large quantities of carbon dioxide in the tissues. These abnormally large quantities must be brought to the lungs for being eliminated from the the body and for this the heart must do additional work by making the blood circulation rapid. That is why the heart beats faster and louder. Again when the blood presents these extra large quantities of carbon dioxide to the lungs for elimination, the lungs must put in additional work for throwing them out through exhalation. Hence exhalations and consequently inhalations too become rapid.

But how is this co-operation brought about ? Is there any agency which stands responsible for this co-operation ? Yes, the system which brings about this co-operation is the nervous system. It is connected with all the different systems working in the human body where it controls their functions and co-ordinates them. In the instance of co-operation we referred to in the last paragraph, the abnormal quantities of carbon dioxide thrown into the blood by the vigorously working muscles, require a message to be sent to two centres in the nervous system, communicating to them the necessity of rapid blood circulation and rapid respiration. These centres in their turn issue orders to the organs of circulation and respiration which in response immediately begin to do additional work. In this way all co-ordination in the different systems is brought about by the nervous system, its supreme ruling power making such a thing possible. Let us therefore study this nervous system in some detail.

The nervous system consists of two divisions, the *central* or the *cerebrospinal system* and the *autonomic system*. The latter is again divided into two parts : the *sympathetic* and the *parasympathetic*. The central nervous system mainly consists of the brain, twelve pairs of the cranial nerves, the spinal cord

and thirty-one pairs of the spinal nerves. The sympathetic is chiefly represented by two chains of ganglia placed one on each side of the spinal column. The parasympathetic is found near the brain and the sacrum.

Out of the different parts of the nervous system referred to above, the brain and the spinal cord are collections of nerve-cells. The brain, somewhat globular in form, is situated in the skull and its principal part is known as the cerebrum. The spinal cord which is elongated in shape is a prolongation of the brain and is held securely in the hollow of the spinal column. As the cerebrum and the spinal cord constitute the main portion of the central nervous system, it also goes by the name of the cerebrospinal system. Cranial nerves start from the brain and come out of the cranium. The spinal nerves start from the spinal cord and issue out from the spinal column. All these forty-three pairs of nerves spread themselves throughout the body and form a closely woven network. The whole surface of the human body is so thickly covered with nerve-endings that not a pin could be placed thereon without touching some one of them. That is why we are able to detect the slightest touch even of a very pointed instrument anywhere in our body. Nerves are made of fibres. They have the appearance of a thread. As they spread out they divide and subdivide themselves, till they reach all the inner and outer parts of the body in fine fibres called nerve-endings. At its origin each nerve is connected with a group of nerve-cells which has a specialized function and which is known as a nerve-centre.

Functionally these nerves may be divided into two classes: *motor* or *efferent* and *sensory* or *afferent*. Motor nerves are responsible for all the muscular activities of man. In their case the impulse starts at the centre and travels along the nerve to its further end where it sets up action in the muscle connected with it. For instance when I wish to pick up a

book from my table, that wish starts impulses in the brain which travelling along the nerves excite the muscles of my hand to do the work. The work of the sensory nerves is just of the opposite nature. They carry impulses to the centres from the further ends of the nerves. In the brain these impulses are interpreted into sensations. Nerves responsible for the sense of sight, smell, taste, touch etc., are all of this class.

The sympathetic nervous system mainly consists of two rows of ganglia, that is, groups of nerve-cells, mutually connected by means of cords composed of nerve-fibres. (Vide Fig. XXXII). Thus there are two gangliated cords, and they are placed one on each side of the spinal column. Branches starting from these cords spread themselves to the different glands and viscera situated in the thorax and the abdomen.

Life processes which are ever going on in our body without the intervention of our will, are all under the influence of the sympathetic nervous system. The manufacture of the bile in the liver, the secretion of the pancreatic juice in the pancreas, the peristaltic and anti-peristaltic actions of the intestines, the beating of the heart, the movement of the lungs, all are carried on by this part of the nervous system. As the sympathetic as well as the parasympathetic systems work their way independent of our will, they are called autonomic.

The foregoing study of the nervous system clearly shows that all other systems working in the body are under the influence of this system. In fact the nervous system rules the whole human organism. If the nerve supply of a particular organ is cut off, the organ immediately ceases to work and will ultimately be entirely useless. If the nerve supply of the hand is cut off, that hand will be immediately paralysed in spite of its possessing well developed muscles. If the visual centre in the brain goes out of order, the man will not be able to see even when his eye is in tact. Therefore if all the bodily

functions are to be satisfactorily carried on, the nervous system must be kept in a very efficient condition.

THE ENDOCRINE GLANDS

We cannot close this description of the human body without taking into consideration particular structures which influence all other structures in the human body including the nerves. These structures are known as *endocrine* or *ductless glands.* These glands are called endocrine because they have an internal secretion as opposed to the external secretion like the bile of the liver or the pancreatic juice of the pancreas. External secretions leave the secreting glands through ducts such as the bile-duct or the pancreatic duct. But internal secretions are thrown directly into the blood current without their leaving the glands of their origin. Hence endocrine glands have no ducts and that is why they are also called ductless. Endocrine glands are situated in the different parts of the body. Thus the thyroid and the parathyroids are situated in the neck. The pineal and the pituitary are situated respectively in the brain and at the base of the brain. The adrenals or the suprarenal glands are situated above the kidneys. The ovaries in the case of females are situated in the pelvis whereas the testes, the corresponding male reprodutive structures, are held hanging in the scrotum.

In the human body there are some glandular structures which have both an internal as well as an external secretion. The best examples of these are the pancreas and the testes. The pancreatic juice which we have already studied is the external secretion of the pancreas. The external secretion of the testes is known as semen. From its origin it is conducted through ducts to two sacks situated in the pelvis and is stored up there before being utilized.

It has been experimentally found that the endocrine secretions very powerfully affect the nervous system, and through

it as well as otherwise maintain the physiological balance of the human organism. If these secretions suffer in quality pathological conditions are rapidly established in the different parts of the human body. We take a striking illustration of extreme pathological conditions arising from the withdrawal of the internal secretory activity of an endocrine organ. The menopause which is characterized by physiological cessation of menstruation, occurs when the ovaries cease to give their internal secretion. This leads to irritation or depression, vertigo, faintness, tachycardia, cold sensations in the hands and feet, vicarious bleeding from various parts of the body, and many other symptoms, which show that the whole balance is upset. Generally speaking the disturbances are not so universal, but are confined to particular parts of the body. Still these disturbances can amply prove the supreme importance of the internal secretion of the ovaries. The thyroid secretion provides another example. As soon as this secretion suffers, the cells of the most distant parts of the human body slowly begin to undergo a change. The hair begin to grow gray, the nails have a tendency to be brittle, fatty degeneration starts in the arteries, the face tends to be wrinkled, weakness creeps over the brain, in fact, many senile symptoms begin to be apparent.

Preparations containing internal secretions are made out of endocrine organs of animals and are used in the treatment of diseases. This is what constitutes *organotherapy*.

Yogic Therapeutics aims at restoring the internal secretions to their normality by securing the health of the endocrine organs through Yogic practices.

CONCLUSION

From the study of the different systems working in the human body, it is clear that their aim is to bring nutrition to the millions of cells of which the body is composed and to

repair the constant waste which these cells undergo because of their ceaseless activity. This process of waste is called *catabolism.* The process of repair by assimilation is called *anabolism.* These two processes put together are known as *metabolism.* When anabolism is more active than catabolism the body gets an opportunity to grow. But when catabolism is more rapid than anabolism the body loses. In a growing child the anabolic process more than makes up the waste brought about by catabolism. Hence in the case of such a child there is constant development of the body. In a healthy adult both the anabolic and catabolic processes balance themselves and thus enable him to keep up his body unimpaired. In old age catabolism gets the upper hand and leads to a steady wastage of tissues.

In our study of this article we have seen that the different physiological systems of the human body are mutually co-operating with one another. When this co-operation is perfect, harmonious physiological functioning is ensured. This harmony is known in the ordinary language as *health.* If any of the systems fails to co-operate, this harmony is disturbed and disease sets in. The aim of Yoga is to avoid disease and ensure health by establishing and maintaining physiological harmony in the human body.

Following diseases, especially in their chronic condition, can be effectively treated by the Yogic methods :

1 *Constipation.*
2 *Dyspepsia.*
3 *Headache.*
4 *Piles.*
5 *Heart-disease (functional).*
6 *Neuralgia.*
7 *Diabetes.*
8 *Hysteria.*
9 *Consumption.*
10 *Obesity.*
11 *Sterility (certain types).*
12 *Impotence.*
13 *Appendicitis, &c.*

Therapeutical advice is given gratis at the Âśrama to patients coming for consultation.

Arrangements have been made under the supervision of the Âśrama for patients to stay on payment of actual expenses, Rs. 45/- per mensem.

The Popular Section

N. B.—Instruction in Yogic culture higher as well as lower will be given gratis at the Âśrama to everyone that earnestly seeks it.

PREPARING ONESELF FOR ÂSANAS

YOGA has a complete message for humanity. It has a message for the *human body*. It has a message for the *human mind* and it has also a message for the *human soul*.

Yoga-Śâstra unmistakably recognizes the interdependence of body and mind. It prescribes exercises both for the body and the mind, so that the two might develop themselves in a spirit of co-operation to such a balanced psycho-physiological condition that they should cease to enslave the human soul. Yogins are convinced that thus freed from the thraldom of body and mind, the soul realizes its boundless existence of infinite bliss.

While acknowledging the interdependence of body and mind, Yoga-Śâstra holds that the influence of the mind on the body is far more powerful than the influence of the body on the mind. Hence mental exercises form the bulk of the Yogic curriculum, although physical exercises have also a definite place in it. Âsanas are physical exercises. They form the third item of the Yogic curriculum. *Yamas*[1] and *Niyamas*[2] are mental exercises. They form the first two items. Yamas and Niyamas are given precedence in the curriculum, because without their practice, Âsanas will not give the desired results completely.

The preceding paragraphs have been written with a view to present to our readers the practice of *Yamas, Niyamas* and *Âsanas* in the right perspective from the point of view of Yoga-Śâstra. Out of the many points touched in these para-

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1 **अहिंसासत्यास्तेयब्रह्मचर्यापरिग्रहा यमाः** । P. Y. S. II 30.
[Inoffensiveness, truthfulness, non-stealing, continence, and non-receiving, are the Yamas.]

2 **शौचसंतोषतपःस्वाध्यायेश्वरप्रणिधानानि नियमाः** । P. Y. S. II 32.
[Purification, contentment, mortification, study and complete self-surrender to the Lord are the Niyamas.]

graphs, we shall now discuss at some length only those that directly concern a practical student of Yogic poses.

We shall start by making a brief reference to the results a student of Yoga expects to obtain from the practice of Âsanas. Next we shall examine the scientific evidence that is adduced to prove the interdependence of body and mind. Then we shall try to understand the general features of Yamas and Niyamas. When all this is done, we shall be in a position to see whether the practice of Yamas and Niyamas would enhance the results expected of the Yogic poses and whether the neglect of Yamas and Niyamas would impair their efficacy.

Âsanas are divided into two principal groups: *Cultural* and *Meditative*. Śîrsha, Sarvâñga, Bhujañga, Dhanus, Śalabha etc., are cultural whereas Padma, Siddha, Svastika and Sama are meditative. Individuals who take to the practice of Âsanas are also of two types: those who seek only physiological advantages and those who are anxious to secure spiritual advantages also. People of the first type may be called physical culturists and those of the second type may be termed spiritual culturists. In trying to obtain physiological results by the practice of the cultural poses, both spiritual culturists as well as physical culturists wish to maintain the nervous and the endocrine systems in excellent health, because through these two systems the health of the whole human organism can be secured, as we have seen in the *Semi-Scientific Section*. A student of spiritual culture, moreover, undertakes to practise the cultural poses with an additional object in view. He wants the nervous system to be so trained as would easily bear the interaction of the spiritual force called Kuṇḍalinî, to awaken which is one of his principal aims. Moreover, a student of spiritual culture cannot be satisfied only with the cultural poses. He must very earnestly practise the meditative poses as well, because these Âsanas reduce the metabolic activity of his body to a minimum and thus get the mind freed from

all physical disturbances, so that it can be left to itself and be brought to a point, making concentration required for Dhâraṇâ, Dhyâna, and Samâdhi possible. To put the whole thing in a nutshell, we can say that the cultural poses are practised for training the nervous and endocrine systems, whereas the meditative poses are undertaken to eliminate physiological disturbances from mental activity.

Having known the results Âsanas are expected to yield, we proceed to study the interdependence of body and mind. The old adage, "sound mind in a sound body", unmistakably teaches the influence the body has upon the mind. The general experience that strong and healthy persons are of quiet temperament whereas weak and unhealthy persons are irritable in temper, goes to prove that the body profoundly influences the mind. Take the case of a patient lying on his sick-bed. He can rarely maintain his optimism when his health is rapidly ebbing. The same person begins to have a brighter outlook on life, the moment he begins to recover. It is well known that the drink habit can often be traced to the power of alcohol to free the individual from worries, never mind temporarily. The powerful influence the nervous system has upon the mind can easily be proved by taking into consideration the experience of constipated people. When their rectum is loaded with hard masses of fecal matter, the nervous system is very badly affected and this leads to terrible depression and very miserable brain-fag. If in this condition, these persons clear their rectum by the use of the enema, they at once experience a spirit of exhilaration and their thinking becomes as clear as ever. The endocrine glands also have been found to influence the mind powerfully. In fact the most enthusiastic section of endocrinologists thinks that they can change the very temperament of individuals by treating their endocrine glands. All these facts go conclusively to prove that the body can powerfully influence the mind.

The influence of the mind on the body can also be proved on the strength of an equally convincing evidence. The aspect of mind which most powerfully affects the body and especially the nervous and endocrine systems is its emotional side. In order to understand how we are night and day under the influence of emotions, mild or violent, we have simply to know what emotions are and how they enter into our very being.

Love, anger, greed, infatuation, elation, hatred, jealousy, envy, fear, disgust, distress, regret, remorse, despondency, despair, confidence, hope, shame, pity, admiration, reverence, devotion, gratitude are all emotions.[1] Emotions of high intensity that last only for a short time are called passions. Thus the *emotion of anger* when it becomes violent the affected person flies into the *passion of rage*. The *emotion of disgust* when intensified develops into the *passion of horror*. Most of us have *moods*. They are emotions and differ from passions because of their longer duration and smaller intensity. When a mood becomes so habitual that it becomes a characteristic of an individual, it is called temperament. Now although a few of us may be free from passions, every one of us has his own temperament and moods. Thus none of us is entirely free from emotions. Our very being is in the grip of our mind !

These emotions are found to affect our body more or less profoundly according to the degree of their intensity. Thus if the emotions are violent and sudden they may prove even

1 It will be readily seen that the first six emotions respectively represent **काम, क्रोध, लोभ, मोह, मद** and **मत्सर,** which are said to be the foes of the higher interests of man. After studying the present article our readers will see that they are the enemies of our physical health also.

The Bhagavadgîtâ mentions the first three as destructive forces working against the spiritual growth of an individual as they try to drag him to hell.

Cf. त्रिविधं नरकस्येदं द्वारं नाशनमात्मनः ।
कामः क्रोधस्तथा लोभस्तस्मादेतत्त्रयं त्यजेत् ॥ B. G. XVI 21.

deadly. The famous surgeon Vesalius dropped dead when he discovered that the dead body he was dissecting was still throbbing with life-blood in the heart. He was so powerfully overcome by sorrow. Even pleasing emotions may result in death. The death of Sophocles and the niece of Leibnitz are cases in point. One of the tragedies of Sophocles was awarded the highest prize. This so much filled him with joy that the emotion proved fatal. The niece of Leibnitz discovered a large amount of gold under the bed of her dead uncle. A terrible emotion of joy seized her and put an end to her life. If the effect of joy is identical with that of sorrow, it is because in both these cases what really takes effect is the surprise, the overwhelming astonishment which is common to both.

When the emotions are not so powerful, but are less violent, they may not lead to death, but they may so affect the nervous system that some disease may appear as a consequence. Prof. Naunyn states that after the bombardment of Strasburg in the year 1870, many cases of diabetes developed in consequence of the fear and anxiety brought about by it.

These disturbances of the nervous system lead to the degeneration of the ductless glands which are admittedly governed by the sympathetic and the vagus. Doctors Lorand, Sajous and many others have conclusively proved that the soundness of different vegetative functions depends mainly on these ductless glands; and that if their internal secretions suffer, premature old age and even premature death may follow. Thus emotions through the degeneration of the nervous system and also of the ductless glands, prove to be a serious disturbance to the health of the human body.

As we already know from the *Semi-Scientific Section*, the most important ductless glands in the body are the thyroid, pituitary, adrenals and gonads or the sexual glands. We shall see how these several glands are affected by emotions.

The effect of emotions on the adrenals is to produce higher blood pressure which favours the development of *arteriosclerosis* and other diseases of the circulatory system.

The thyroid is so much affected by mental depression that this emotion is mentioned by scientists as one of the causes of *myxœdema*. This gland is one of the most powerful agencies set up by Nature to protect the body against poisons. A degenerated thyroid means disease and even premature old age. So serious is the effect of continued mental depression upon the human body.

The pituitary is also affected by emotions. Prof. Pel and others have noted cases of *acromegaly* after violent emotions. Dr. Sajous has often pointed out this gland as the central organ upon which all stronger emotions react.

Sexual glands are also powerfully influenced by emotions. Cases are often noted where menstruation has suddenly appeared after violent mental shocks. In the case of males mental emotions result at times in impotence.

In the previous paragraphs we have referred to the effects of violent emotions upon the human body. Emotions that are less violent, although they do not immediately show any serious disturbances, surely have an injurious effect upon the different systems of the human organism.

Up to now only the adverse effects of emotions have been discussed. This should not mean that all emotions are injurious. There are particular emotions which exercise a healthy influence upon the nervous system. Hope and confidence which invariably enable a man to maintain an optimistic frame of mind, always promote the health of the nerves. Joy and happiness kept within proper limits are of great help in building a healthy nervous system. Devotion to the Lord or in fact to any principle of life that ensures mental peace, enables a person to maintain healthy and stable nerves.

We believe the evidence that we have put forth up to now is sufficient to establish the interdependence of body and mind. Both of them affect each other favourably as well as adversely. But if we probe the question of this interdependence a little deeper, we find that the mind has the strength to rise superior to all the influences of the body. To verify the truth of this statement we have simply to study the lives of the heroes of different nations who had to undergo terrible physical sufferings in order to serve their motherland. Their iron will not only knew no bending but it ever grew stronger and stronger as they were forced to face physical tortures. We read the glorious history of religious martyrs who did not in the least swerve from their convictions even when their bodies were actually being burnt to ashes !

On the contrary we find the strongest bodies being paralysed, if the man is overcome by fear. The healthiest constitutions are shattered under the baneful influence of worries. Physical giants actually totter when in a fit of rage and are not able to effectively use their strength. We personally know two youths turned impotent in a moment because of an imaginary misgiving !

This should convince us beyond any shadow of doubt that even when there is interdependence between body and mind, the influence of the mind on the body is far more profound than the influence of the body on the mind.

Reverting to the practice of Yogic poses, as we have read from time to time in the pages of this journal, these poses are bodily practices calculated to bring about particular physiological results. Now knowing as we do the profound influence of the mind on the body, can we think of training our body without undertaking the training of our mind ? Can we ever hope to build a healthy thyroid or powerful sexual glands by means of Sarvâñgâsana, if we allow our mind to run riot in

the body and permit ourselves to be visited by terrific sexual storms shattering the tissues of the endocrine structures ? Can Śirshâsana ever give us mental peace and vigour, if we suffer the canker of worries to eat into the very cells of our brain ? We are sure our readers will answer these questions emphatically in the negative, because we believe that they stand convinced by now that physical training will never give the desired results unless and until it is backed up by mental training. So the two trainings must go hand in hand or, to put the matter more accurately, mental training should be given precedence to physical training.

This is exactly why Yoga-Śâstra has placed Yamas and Niyamas as the first and second items of Yogic curriculum and has assigned Âsanas the third place. Yamas and Niyamas put together constitute ten principles of conduct which, if followed faithfully, invariably give supreme mental peace to a student of Yoga. He is freed from all violent emotions. His adamantine faith in the Lord develops in him a robust optimism. He maintains a clear conscience and can carry the sunshine of happiness wherever he goes. In short he is able to ensure perfect health for his mind.

It is to be frankly admitted that perfection in the practice of Yamas and Niyamas is extremely difficult of attainment. Not even one in a million can make even a near approach to this perfection. But the incalculable value of Yamas and Niyamas lies in their capacity to bestow mental health even on those who sincerely try to make a humble beginning. Of course the degree of health will vary according to the degree of sincerity and the degree of success achieved. But even the meanest success will never fail to bring its heavenly blessings to the aspiring individual. So what is required as a preparation for Âsanas is only a determined effort to practise Yamas and Niyamas with a view to develop a healthy mind.

We do not want our readers to carry the impression that the practice of Âsanas cannot be started unless and until one achieves a certain degree of success in the observance of Yamas and Niyamas. In fact the two practices may start at one and the same time. What we want to impress upon our readers is the utmost necessity of putting into practice Yamas and Niyamas, if Âsanas are to be made to yield the best results.

Here some of our readers who look to Yoga from the point of view of physical culture only, may put forth the following argument. If the rigorous mental hygiene of Yamas and Niyamas is absolutely necessary for a successful practice of Âsanas even as a system of physical culture, these Âsanas stand at a tremendous disadvantage when compared with other systems of physical culture which do not require any mental discipline. Such an argument is unsound for the following reasons.

(1) It has already been pointed out that the only thing required of a student of Âsanas is a determined attempt to practise Yamas and Niyamas. None should be alarmed at the names of Yamas and Niyamas. Expressed in the ordinary language their practice on a humble scale means nothing more than moderation in every habit of ours with a living faith[1] in our Maker.

(2) Unluckily it is a fact that the advocates of other systems of physical culture do not insist upon mental culture to go on side by side. But this does not mean that these systems can ensure physical health in spite of mental disadvantages. The interdependence of body and mind is a scientific fact common to all individuals whether they practise Yogic or some other system of physical culture. We are sure that the results of other systems would be far more encouraging if they

1 This should not be interpreted to mean that atheists cannot take to the practice of Yogic poses. We, however, certainly want to say that all other things being equal, a genuine theist can practise Âsanas with greater efficacy than an atheist.

also required their followers to practise mental hygiene simultaneously with the physical exercises.

Thus we see that the observance of Yamas and Niyamas is the most essential preparation for the the practice of Âsanas.

Some hints to the students of Yogic culture have been given in the *Miscellaneous Section*. These hints when read in conjunction with those given on pp. 287-92 of Vol. II represent the irreducible minimum of Yamas and Niyamas.

We shall close this article with a few words of advice to the students of meditative poses.

Meditative poses are of the highest value to a student of spiritual culture. They establish in the body such physiological conditions, that the mind ceases to be disturbed by any stimuli received from the body. In fact the body stops entering into consciousness altogether. All this becomes possible only after a continued practice of one of these poses for a period of at least six months. One or even two hours must be devotedly given to some one of the meditative poses almost without a break. If this is done, appreciable results will follow in six months and the mind will be left to itself without any interference from the body.

It must be, however, borne in mind that all this physiological advantage will not help a spiritual culturist in a substantial degree in concentrating his mind, if he does not scrupulously and zealously take to the observance of Yamas and Niyamas. Meditative poses will, indeed, free the mind from physical disturbances, but its wandering propensities will never stop and it can never be brought to a point unless it becomes free from emotions mild or intense. So in the case of spiritual culturists, the practice of Yamas and Niyamas on the largest possible scale is an absolute necessity. This is the one preparation without which it is impossible for him to make any headway in concentration.

We shall now refer to two minor preparations for the meditative poses and finish. A student of meditative poses should fix up for his work a place from which he can exclude all disturbing factors. In his case the need for utmost concentration is extreme. Hence it is desirable that he chooses a thoroughly ventilated room which is free from mosquitoes etc., and where he would be left to himself. Even the possibility of being disturbed comes in the way of perfect concentration. If he could reserve a room for this work and build up a spiritual atmosphere there, it will help him a good deal in his work.

So far as his seat is concerned, the traditional arrangement of seating is excellent. A carpet of Kuśa[1] grass, with a well tanned deer-hide[2] spread on it, the hide in its turn being covered with a daily washed piece of thick khaddar, makes a very comfortable seat. The pleasures of such a seat are the peculiar privilege of those god-intoxicated aspiring souls who seek salvation through Yoga. The thrilling spiritual experiences that this seat affords to the student from day to day, make it more attractive to him than even the throne of an emperor !

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1 In the absence of Kus'a grass carpet, any other grass carpet will do.

2 Those that may have a conscientious objection to the use of a hide should make use of a thick woollen cloth folded over several times.

SCIENTIFIC SURVEY[1] OF CULTURAL[2] POSES

As stated in the previous article, Âsanas form the third item of the Yogic curriculum. These Âsanas can be divided into two groups, namely, meditative and cultural. The aim of the cultural poses is to produce physiological balance in the different systems working in the human body, so that it can possess the best organic vigour. They are specially intended to take particular care of the spinal column, and through it and also through other parts of the body to train the spinal cord and the brain, so that both of them can sustain the interaction of the spiritual force of Kuṇḍalinî when the same is awakened with advanced Yogic practices. These cultural Âsanas involve different physical movements before the final pose is assumed, and the final arrangement of the various parts of the body, being essentially of an out-of-the-way fashion, renders meditation difficult, if not impossible. Śîrshâsana, Sarvâṅgâsana, Halâsana and others included in the *Course of Yogic Physical Culture* (vide Vol. II, p. 286), fall under this category. The aim of the meditative poses is to offer a comfortable posture for Prâṇâyâma, Pratyâhâra, Dhâraṇâ etc., and in co-ordination with other Yogic exercises to help the student of Yoga in the awakening of Kuṇḍalinî. These meditative poses are such as can be maintained for hours without much discomfort. They do not involve in their technique any out-of-the-way movements of the body, and are in their final stage some variety of ordinary sitting, with a few

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1 This survey of the field of Âsanas is by no means complete. We have mapped out only the most important landmarks. For exhaustive information on some of the points touched in this article we refer our readers to the article on the 'Rationale of Yogic Poses' in *Yoga-Mîmâṅsâ, Vols. II and III.*

Although the subject matter of the present article and the article on the 'Rationale of Yogic Poses' is the same, the method of treating the subject is different in the two articles. Hence this new article has been included here.

2 For a scientific survey of the meditative poses refer to our article 'Some Physiological Aspects of Meditative Poses'. Vide Vol. III, pp. 245-50.

changes introduced to make the pose more useful for the purposes of meditation. Up to now we have studied four meditative poses—Padma[1], Siddha[2], Svastika[3] and Sama[4]. In the present article we wish to pass under rapid survey all the cultural poses[5] so far described in this journal, and try to see whether there is any scientific justification for claiming for them the results that they are declared to bring about.

As stated in the foregoing paragraph cultural poses are claimed to produce two results—

(*i*) Giving best organic vigour to the whole body.

(*ii*) Training the spinal cord and the brain for the interaction of Kuṇḍalinî.

Let us proceed to examine the first claim. As can be seen from the *Semi-Scientific Section*, all organs of the human body are made of tissues. If these tissues could be kept in perfect health, the human body becomes capable of showing the best organic vigour. Now if we study the conditions necessary for maintaining the health of the different tissues of the human body and if we find that the cultural poses are capable of bringing about those conditions, we can come to the conclusion that these poses can claim to yield the best organic vigour. Let us, therefore, briefly study the conditions which ensure the health of the tissues.

According to the science of physiology, three conditions may be considered to be of vital importance for maintaining the health of the tissues, namely, (*i*) constant supply of proper nourishment and of the internal secretions of the endocrine

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1 Vide Vol. II, p. 225. 2 Vide Vol. II, p. 227.

3 Vide Vol. III, p. 253. 4 Vide Vol. III, p. 256.

5 In this survey we are going to take into account four additional exercises, namely, Uḍḍiyâna, Nauli, Viparita-Karaṇî and Yoga-Mudrâ, although these exercises cannot be called Âsanas technically. In fact the present article is a scientific study of all Yogic exercises of physical value that have appeared in *Yoga-Mîmâṅsâ*. Only the breathing exercises have been excluded.

glands, (*ii*) effective removal of waste products, and (*iii*) healthy functioning of the nerve connections. Now the elements of nourishment required by the tissues consist of proteins, fats, sugars, salts, and oxygen. They are all carried to the tissues by the blood. The first four elements are derived from the food and drink a man takes; and their supply is dependent not only upon the quantity and quality of food and drink taken by the man, but also upon the power of digestion and absorption of his digestive system. So we see that the digestive and the circulatory systems must be kept in an efficient condition, if the tissues are to be fed properly with proteins, fats, sugars and salts. We have, therefore, first to examine the efficacy of Âsanas in maintaining the efficiency of these two systems.

Taking the digestive system into consideration first, we find that the principal organs responsible for digestion are the stomach, the small intestine, the pancreas and the liver. All of them are situated in the abdominal cavity which is supported by the pelvis from below and by very strong muscles on all the other sides. Nature has made ample provision for maintaining the health of the digestive organs by arranging for an automatic and gentle massage of these organs for all the twenty-four hours of the day. To understand how this massage is carried out, one has to observe the abdominal movements of a man in normal respiration. With every exhalation the front abdominal muscles are contracted and they push all the abdominal viscera including the organs of digestion inwards and upwards. In doing this they gently massage these abdominal viscera. Again at the time of inhalation the diaphragm presses the abdominal viscera downward and forward; and the relaxing abdominal muscles while being driven forward by the pressing viscera, again give them a gentle massage. In this way something like fourteen to eighteen times every minute the digestive organs are being massaged by

the abdominal muscles gently and automatically. This gentle and automatic massage is the most important provision made by Nature for keeping the digestive organs healthy. Now it is obvious that this automatic massage can be most effectively given only if the abdominal muscles are strong and elastic. But if they are weak, they cannot massage the abdominal organs properly, and indigestion is the result. In people suffering from dyspepsia, these abdominal muscles are found to be too rigid or too weak. Hence if perfect digestion is to be secured, the abdominal muscles must be kept strong and elastic. Do the Yogic poses make any provision for preserving the strength and elasticity of the abdominal muscles ? Yes, they do. The Yogic poses not only keep the abdominal muscles strong and elastic, thus ensuring an effective automatic massage of the digestive organs, but they also make a special provision for giving a forced and vigorous internal massage to the abdominal organs with such a degree of efficiency as is hardly to be met with in any other system of health culture.

It is an admitted scientific fact that muscles can maintain their strength and elasticity, if they are subjected to stretching and contracting exercises. Bhujañgâsana, Śalabhâsana and Dhanurâsana are fine stretching exercises for the front abdominal muscles, and serve as contracting exercises for the back muscles. Yoga-Mudrâ, Paśchimatâna and Halâsana require vigorous contraction of the front abdominal muscles and put the back muscles on a very healthy stretch. What these six poses do for the front and back muscles of the abdomen, is done by Ardha-Matsyendrâsana for the side abdominal muscles. Śalabhâsana very vigorously exercises the diaphragm. Thus it will be clear that Âsanas can give an efficient exercise to all the abdominal muscles and enable them to carry out the automatic massage of the viscera very effectively.

However, when we take into consideration Uḍḍiyâna and Nauli, we see the real beauty of the Yogic exercises. Uḍḍi-

yâna gives a vertical massage to the abdominal organs. One can see with his own eyes the abdominal viscera slipping up and down behind the front abdominal muscles and thus getting themselves massaged vertically. Nauli gives a lateral massage to the abdominal organs. The two contracted recti roll from side to side across the whole expanse of the abdomen several times a minute, giving all the viscera lying behind them a massage the efficacy of which is simply surprising. No impartial student of the different systems of health culture can resist the conclusion that Uḍḍiyâna and Nauli have no parallel in any other system and that the Yogic seers have taken the best care of the abdominal muscles.

The strength of the abdominal muscles is useful not only in giving massage to the viscera, but it is also of a singular importance in keeping the abdominal organs in their proper places. These organs are either loosely hanging in the cavity of the abdomen or are feebly attached to its back wall. Thus they require a very strong support from the front. Otherwise they become displaced downwards and lead to various disorders, and to dyspepsia and constipation in particular. Now this front support is offered by the front abdominal muscles and its strength is proportionate to the strength of these muscles. By keeping the front abdominal muscles strong and elastic, Yogic poses not only give an automatic massage to the abdominal organs, but they hold all the abdominal viscera in their proper places and thus ensure proper digestion and absorption. When this is done, the part to be played by the digestive system in supplying the tissues all over the body with proteins, fats, salts and sugars is satisfactorily discharged.

The other system vitally connected with the supply of nourishment to the tissues is the circulatory system, because the work of carrying nutrition to the different tissues is done by the blood circulating through the human body. The circulatory system consists of the organs responsible for the circu-

lation of the blood, namely, the heart, the arteries, the veins and the capillaries. Let us now examine the help Yogic poses render to this circulatory system.

The most important organ of blood circulation is the heart, because it is the contraction and relaxation of the heart that circulates the blood throughout the human body. The heart is made of the strongest muscular stuff, but it can always be made healthier by means of proper Yogic exercises. Uḍḍiyâna and Nauli raise[1] the diaphragm so high that they give a very good massage from below to the perpetually working heart. Again one of the ways of promoting the health of a muscle is to subject it to an alternate increase and decrease of pressure. The heart muscle is situated in the mediastinal cavity. Hence any increase or decrease of pressure in this cavity is shared by the heart. Now in Uḍḍiyâna[2] and Nauli[2] the heart is alternately subjected to a decrease of pressure and thus gets an opportunity for building a healthier muscle. Again Bhujañgâsana, Śalabhâsana and Dhanurâsana alternately exert an increased pressure on the heart and the same thing is done by the first parts of Sarvâñgâsana, Viparîta Karaṇî and Halâsana. This alternate increase and decrease of pressure brought about by the different Âsanas promote the health of the heart and thus add to the efficiency of the circulatory system.

Out of all the organs of blood circulation the veins are the weakest, and yet they have to collect the blood from nearly the whole of the human body and raise it to the heart against the force of gravity. It is this uphill task that puts a very heavy strain on the weak structure of the veins and is responsible for such troubles as varicose veins. It is, therefore, the veins that stand in greater need of external help for

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1 For studying the position of the diaphragm in Uḍḍiyâna and Nauli, vide *Yoga-Mîmâṅsâ, Vol. III.*

2 For pressure changes in the thorax during different Yogic exercises, vide *Yoga-Mîmâṅsâ, Vol. IV.*

preserving their health than any other part of the circulatory system. Yogic seers have found out a very easy way of helping these veins. They have invented Śîrshâsana, Sarvâñgâsana and Viparîta Karaṇî in which because of the upside-down position of the human body, the veins are enabled to drain themselves into the heart without the least exertion on their part. The veins are very substantially relieved from the pressure of the blood flowing through them. The result is wonderful. The short relief that the veins get because of these Âsanas is so effective in preserving and even recovering the health of the veins, that patients suffering from varicose veins can get over their trouble by practising these Âsanas for a few minutes every day. In this way the veins being helped to better health and the heart being rendered healthier for the massage, the whole circulatory system satisfactorily performs its function of carrying proteins, fats, sugars and salts to all the tissues constituting the different parts of the human body.

The fifth element of nourishment is oxygen. Like the other four elements of nourishment this element is also carried to the tissues by the circulatory system. And as we have seen that the practice of Âsanas keeps the circulatory system healthy, we feel convinced that there would be no difficulty in feeding the tissues with oxygen, once it is taken up by the blood in the necessary quantity. Proteins, fats, sugars and salts are taken by the blood current from the digestive system. Oxygen is, however, taken from the respiratory system. We have, therefore, to see whether Âsanas can keep even the respiratory system in an efficient condition.

As has been stated in the *Semi-Scientific Section*, the principal organ of respiration is the lungs. Satisfactory breathing activity does not, however, depend only upon the health of the lungs. Respiratory muscles play a very important part in this activity. They must be strong and healthy. Again the passage through which the lungs draw fresh air from the atmos-

phere, must be clear, so that the full breathing capacity of the lungs may be utilized in providing the system with oxygen. Thus we see that three conditions should be satisfied before the circulatory system gets the required amount of oxygen : (*i*) The lungs must be healthy. (*ii*) The respiratory muscles must be strong. (*iii*) The respiratory passage must be clear. Let us see whether the practice of Âsanas can satisfy all these conditions in the case of a student of Yoga.

Broadly speaking the health of the lungs depends upon the degree of their elasticity and upon the activity of the air-cells that go to compose them. If the lungs remain fully elastic and no air-cell in them remains idle, the health of the lungs can be taken to be ensured. Do the Âsanas render the lung tissue elastic and get every air-cell to take an active part in breathing ? Yes, they do. The two Âsanas Śalabha and Mayûra have very great efficacy in this direction. Śalabhâsana requires deep inhalation and retention of breath for a few seconds at least under a high pulmonic pressure. This high pressure forces air into every cell of the lungs and opens it out for active work. A few turns in Śalabhâsana taken every day would allow no air-cell to remain idle even in ordinary respiration, because once an air-cell is made habitually to take part in respiration, it does not easily lapse into inactivity whether the pressure is low or high. What is true of Śalabhâsana, is also true of Mayûrâsana, as will be clear from the technique of the two poses given in the first volume of this journal. The difference between Śalabhâsana and Mayûrâsana in this regard is as follows. In the former Kumbhaka is absolutely necessary whereas in the latter it is optional. The option of Kumbhaka in the practice of Mayûrâsana is due to the fact that a practised student of Yoga can balance himself in Mayûrâsana even without retaining his breath. Thus we see that Śalabhâsana and Mayûrâsana are quite capable of bringing every air-cell into its normal activity. Again Śalabhâsana is equally

useful in keeping the lung tissue fully elastic. As every medical man knows that an elastic tissue retains its complete elasticity if it is fully stretched at least a few times every day. As Śalabhâsana requires deep inspiration and retention of breath, during the practice of this Âsana, lungs are stretched out to their fullest extent. If Śalabhâsana is repeated three to seven times daily, the exercise will be quite sufficient for keeping the lungs fully elastic. Thus it is evident that complete elasticity of the lung tissues and full activity of their air-cells, can be secured by means of Âsanas and that the health of the lungs can be satisfactorily maintained by a student of Yogic poses.

Regarding the second condition—the strength of the respiratory muscles—deep inspiration required in Śalabhâsana and the deep expiration necessary in Uḍḍiyâna and Nauli, build powerful respiratory muscles, thus satisfactorily fulfilling the second condition upon which adequate supply of oxygen to the circulatory system depends.

Next we turn to the third condition—clearness of the respiratory passage. This passage at times becomes obstructed because of inflamed tonsils, adenoids, polypus, chronic nasal catarrh and deviated septum. Can the practice of Âsanas keep these obstructions away? Âsanas can surely deal with tonsils and in many cases even with chronic nasal catarrh. But against the other forms of obstructions Âsanas are powerless. Sarvâṅgâsana, Viparîta Karaṇî, Matsyâsana, Jihvâ-Bandha and Siṁha-Mudrâ[1] have been found very much useful in treating cases of tonsilitis. Chronic nasal catarrh also very often[2] yields to these exercises. So if we exclude the few cases of adenoids, polypus and seriously deviated septum, we find Âsanas are quite capable of keeping the respiratory passage clear.

1 The arrangement of the jaws and the tongue as in Siṁhâsana (vide Vol. III, p. 129), is called Siṁha-Mudrâ or the *Symbol of Lion.*

2 Nasal catarrh can be successfully treated by means of the different types of Neti and breathing exercises taught in Yoga.

Summing up our discussion about the three conditions upon the fulfilment of which depends the adequate supply of oxygen through the respiratory system, we see that Yogic poses do satisfy these conditions. Again, as has already been proved, these poses ensure the health of the circulatory system which carries this oxygen to the tissues. That means everything necessary for an adequate supply of proteins, fats, salts, sugars and oxygen to the tissues is done by the Âsanas for a student of Yoga.

As stated in the beginning of this article, the health of the tissues depends upon the adequate supply not only of these five elements of nourishment but also of the internal secretions of the endocrine glands. We have, therefore, to examine the efficacy of Âsanas in preserving the health of these endocrine structures. The thyroid, the pituitary, the pineal, the testes in the case of males and the ovaries in the case of females, may be looked upon as the most important of the various endocrine glands in the human body. Deficiency of secretion of any of these glands has been found to lead to serious consequences. Can Âsanas keep these endocrine glands healthy? The answer is surely in the affirmative. Sarvâñgâsana, Viparîta Karaṇî, Matsyâsana, Jihvâ-Bandha and Siṁha-Mudrâ have been found to be excellent exercises for the thyroid. The pituitary and the pineal glands are best taken care of by Śîrshâsana. For making the testes and the ovaries healthy Sarvâñgâsana, Uḍḍiyâna and Nauli have been observed to have great efficacy. Thus it will be seen that the practice of Âsanas can ensure the health of the most important endocrine glands and they can be made to supply the necessary secretions to the tissues.

This rapid survey of the physiological effects of Âsanas proves beyond all doubt that they amply satisfy the first condition upon which the health of the tissues depends, namely, a constant supply of proper nutrition and the internal secretions of the endocrine glands.

The second condition which needs be satisfied for maintaining the health of the tissues, is the effective removal of the waste products. Let us now study what these waste products are and whether Âsanas help the human body in effectively throwing them out.

The following may be stated to be the waste products. Carbon dioxide, uric acid, urea, bile, urine containing uric acid and urea, and the fæcal matter containing bile along with undigested and indigestible matter from the foodstuffs. These waste products are poisonous and if allowed to linger in the body unnecessarily, lead to serious disorders. It is, therefore, of utmost importance for the health of the tissues that they are properly excreted from the human body. Out of the different waste products, carbon dioxide is eliminated by the respiratory system, the urine containing uric acid and urea is discharged by the urinary system and the fæcal matter containing bile along with the refuse of the foodstuffs, is excreted by the digestive system. It is, therefore, evident that the waste products can be effectively removed from the body only if the three systems, namely, the respiratory, the urinary and the digestive, are able to function quite satisfactorily. While studying the question of nutrition, we have seen that the Yogic poses coupled with Uḍḍiyâna and Nauli, can keep the respiratory and the digestive systems in the most efficient condition. We find that Âsanas can take equal care of the urinary system. As stated in the *Semi-Scientific Section*, this system consists of the kidneys, the ureters, the bladder, and the urethra. Out of these the organ which really excretes urine is the kidneys, while others merely afford a sort of passage for the urine to leave the body. Now these kidneys are situated in the abdomen and we have seen that some of the Âsanas are very fine abdominal exercises. When these Âsanas are supplemented by the exercises of Uḍḍiyâna and Nauli, the degree of their efficacy becomes remarkably high, and they are found to be quite competent to

preserve the health of the kidneys. This being done the body is enabled satisfactorily to get rid of urine along with uric acid and urea which two substances the urine holds in solution.

In this way Âsanas have been found to satisfy the second physiological condition upon which the health of the tissues depends, namely, the effective removal of waste products.

Now we come to the study of the third and the last condition. It requires healthy functioning of nerve connections. Let us first understand what is meant by the expression 'healthy functioning of nerve connections', and then we shall try to see whether Âsanas can bring it about.

The most important part of the nervous system is the brain. Next to it is the spinal cord, and the two cords of the sympathetic. From the brain and from the spinal cord different nerves start and branching off several times, spread themselves to all the parts of the human body. The network of nerves thus prepared is so complete that there is not a single tissue in the human body that has not got its own nerve connection. It is mainly because of their nerve connections that the tissues are able to perform their work. If these nerve connections degenerate, the function of the tissues also degenerates and if the nerve connections are completely destroyed, the tissues do not function at all. Thus if the nerves supplying the colon degenerate, the tissues of the colon will not work and constipation will be the result. If one of the facial nerves is cut off, or becomes paralysed, the muscles of the cheek supplied by that nerve, will not contract, but will remain perpetually in a relaxed condition, thus allowing the muscles of the other cheek to pull the face towards themselves, giving it the typical appearance presented by the patients of facial paralysis. Thus we see that the tissues of the human body will remain healthy and active only if the nerves connected with them are in a healthy condition. Hence the third con-

dition required for the health of the tissues, is the satisfactory functioning of their nerve connections.

Can Âsanas keep the nervous mechanism of the whole body in an efficient condition? Yes, they can. Śîrshâsana and Viparîta Karaṇî by sending a richer blood supply to the brain, ensure its health and also the health of the cranial nerves supplying the different organs of senses. All the Yogic poses are excellent spinal exercises. By giving the spine forward and backward bents and also the right and left twists, Âsanas ensure perfect elasticity for it and lead to the health of the spinal cord which is held within the spinal column and also to the health of the two cords of the sympathetic, which lie imbedded in the muscles roundabout the spine. Uḍḍiyâna and Nauli operating through the diaphragm are of special value in promoting the health of the spinal cord and also of the sympathetic cords. As for the nerves issuing from the brain and the spinal cord, they are situated for the most part in the chest and the abdomen. As already noticed Âsanas, along with Uḍḍiyâna and Nauli, provide excellent exercises for both these parts of the human trunk and thus promote the health of the nerves lying within them. Śalabhâsana, Ardha-Śalabhâsana and the first parts of Sarvâñgâsana and Viparîta Karaṇî take care of the nerves of the lower extremities, whereas the part played by the upper extremities, in the technique of Śalabhâsana, Mayûrâsana, Sarvâñgâsana, Viparîta Karaṇî etc., preserves the health of the nerves supplying them. Thus Âsanas are found capable of preserving the health not only of the brain and the spinal and sympathetic cords, but also of all the cranial and spinal nerves spreading throughout the body.

In this way our readers must have seen that all the three physiological conditions necessary for the health of the tissues can be thoroughly satisfied by the practice of Âsanas. Constant supply of proper nutrition and the internal secretions of the endocrine glands can be made available to the tissues all

over the human body, waste products of all sorts can be effectively thrown out of the system, and all the nerve connections can be kept healthily functioning. All these conditions being satisfactorily fulfilled every tissue in the body is rendered healthy, yielding the maximum vigour to the whole organism of which it is capable. As the different systems working in the human body are made of these tissues, every system discharges its function quite efficiently, thus producing a perfect physiological harmony which ensures health and which yields the highest organic vigour.

In the last but one paragraph we have seen how Âsanas are peculiarly capable of training the spinal cord and the brain. These are the most important parts of the nervous system, and the spiritual force of Kuṇḍalinî when awakened works through them. If the brain or the spinal cord are not in a healthy condition and do not possess the strength necessary for sustaining the interaction of Kuṇḍalinî, a student of Yoga very often has to pass through a variety of troubles. Hence the extreme desirability of educating the brain and the spinal cord in the case of people who want to develop themselves spiritually through Yogic practices. That is why the training given through the cultural poses both to the brain and the spinal cord, is of special value to a spiritual culturist. Even individuals who look to Yoga only for their physical health, the training of the brain and the spinal cord has a special significance. As stated in the *Semi-Scientific Section*, all the systems working in the human body are controlled by the nervous system. And as the brain and the spinal cord are the most important parts of the nervous system and as upon their health depends the health and satisfactory functioning of the other parts of that system, the education of the brain and the spinal cord is as much essential to a student of health culture as to a spiritual culturist.

We cannot close this survey of the cultural poses before saying a word about the skeletal muscles. Not only all the physical activities of an individual but also his very health depends upon these skeletal muscles. If the hands and legs

have no muscles or have defective muscles, no physical work will become possible. Again if the muscles of the chest and the abdomen degenerate, man would become a prey to various ills. Weak abdominal and pelvic muscles in the females are often responsible for the alarmingly large infant mortality and the surprisingly large number of miscarriages in India. This will clearly show the importance of the skeletal muscles. Do Âsanas educate these skeletal muscles? The answer is both in the affirmative and in the negative. So far as the thoracic and abdominal muscles are concerned, Yogic poses do train them quite satisfactorily. Hence a habitual student of Yogic poses will have no difficulty either in respiration or in digestion; and if she is a female, she can be sure of healthy pregnancy and safe delivery. But the Yogic poses are not calculated to develop strong muscles for the arms or the legs. In the Yogic poses, there is ample provision of exercises that would preserve and promote the *health* of the muscles of the upper and lower extremities, but so far as *strength* is concerned, there is no special provision for it in Yogic Physical Culture. People whose profession requires muscular arms and legs must look to some other[1] system for training the muscles of these parts. It must, however, be borne in mind that the ordinary muscular needs of a civil life are entirely satisfied by the Yogic poses, whatever part of the human body the muscles may belong to.

This short scientific survey of cultural poses when read along with the scientific study of the meditative poses[2] drives us irresistibly to the conclusion that the advantages claimed for Âsanas are fully justified, and that no man wishing to develop his body, mind, and soul by taking to the practice of only one system of exercises, can afford to overlook Yogic Âsanas.

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1 The dynamic form which we have given to the Yogic exercises and which has now been introduced by the U. P. Government in their educational institutions, is free from the shortcoming that is pointed out in these lines. Hence people who are keen on having muscular arms and legs, should take to this dynamic form of Yogic exercises. A text-book of these exercises has already been edited and will be soon in the hands of the public.

2 Vide Vol. III, pp. 245-50.

CULTURAL AND THERAPEUTICAL ADVANTAGES OF ÂSANAS

ŚÎRSHÂSANA OR THE TOPSYTURVY POSE

Cultural Advantages :—

All the activities of man, whether mental or physical, are governed from the brain. The whole nervous system which spreads throughout the body like a network of wires, is directly or indirectly connected with this organ. When a man stands on his head he sends a richer supply of the arterial blood to the brain and thus maintains the health of not only the brain itself, but of the whole nervous system.

The organs of the sense of sight, smell, hearing and taste depend for their efficient functioning upon the different centres situated in the brain. Śîrshâsana exercises a very beneficial influence upon the health of these centres and preserves the efficiency of the sense organs.

Some of the most important endocrine glands are situated above the heart. When a man stands upside-down these glands are richly supplied with fresh blood and their health is promoted. The pineal gland and the pituitary body get the greatest advantage. The thyroid and the parathyroids have also their share in this advantage; but it is not so large.

Organs of digestion are immensely benefited because of Śîrshâsana. The blood circulation through these organs passes to the liver through the portal vein, which in its turn drains it into the inferior vena cava. In the Topsyturvy Pose this portal circulation of the venous blood is very greatly helped because of the inverted position of the body. It is a general physiological rule that an organ which can satisfactorily drain its venous blood gets a rich supply of fresh blood from the arteries. The portal circulation of the venous blood being

satisfactorily established, the organs of digestion get a richer supply of the arterial blood, and are made healthier for it. Thus it will be seen that Śîrshâsana beneficially influences the health of the nervous system, of the endocrine system, and of the digestive system, the last including the organs of excretion. As the general well-being of an individual depends upon the satisfactorily functioning of the systems mentioned above, Śîrshâsana is a very great help in maintaining one's general health satisfactorily.

Therapeutical Advantages :—

Under *Cultural Advantages* we have said that Śîrshâsana favourably influences the nervous, the endocrine and the digestive systems. Now if any of these systems go out of order diseases arise. These diseases, under particular circumstances, can be treated with Śîrshâsana.

NEURASTHENIA—This is a disease developing out of the degeneration of nerves. The symptoms which mark this disease are lack of energy, a sense of fulness of pressure at the top of the head, easy fatigue, dullness, failure of memory, want of sleep, dyspepsia and constipation. All these symptoms are due to one cause, the degeneration of nerve-centres. Now as all the nerve-centres are directly or indirectly connected with the brain, these systems can be treated by treating the brain by means of Śîrshâsana.

DYSPEPSIA & CONSTIPATION—These two diseases develop when the organs of digestion go out of order. If the digestive disorder is due to defective blood circulation or to the degenerated nervous mechanism, it can be set right by means of Śîrshâsana.

CONGESTED THROAT—Congestion in the throat, especially if it is due to dyspeptic conditions can be relieved by Śîrshâsana.

Congested Liver & Spleen—The liver and the spleen very often become congested. This congestion can be relieved by establishing free blood circulation in these organs by means of Śîrshâsana.

Visceroptosis—Due to the weakness of the abdominal muscles and consequent presence of constipation, the abdominal viscera have a tendency to droop into the pelvic region. This disease is known as visceroptosis. The trouble can be considerably counteracted by Śîrshâsana.

Hernia—This disease can be effectively checked in its incipient stage and may be kept under fair control even after it has established itself. When Śîrshâsana is being practised for a cure of hernia, great care must be taken to get the technique of the pose modified according to the needs of the individual. For this modification expert advice is imperative.

Seminal Weakness—Due to the situation of the seminal sacks between the bladder and the rectum, frequently nocturnal discharges take place in the latter part of the night, because both the bladder and the rectum happen to be loaded during these hours especially in the case of constipated people. These discharges can be checked by the practice of Śîrshâsana.

Many people suffer from the trouble of premature ejaculations and also of wet dreams, because their genitals are congested with venous blood. When this is the case, Śîrshâsana is found to be of great help.

Asthma—Śîrshâsana can be taken advantage of in the cure of particular types of asthma, especially of the nervous and hepatic types.

DEVELOPMENTS OF ŚÎRSHÂSANA

Cultural Advantages :—

Developments of Śîrshâsana constitute an excellent exercise for the deep and superficial muscles of the back as well

as for the muscles of the abdomen. The developments may be retraced ; and when this folding and unfolding is repeated several times, all the muscles of the trunk are alternately contracted and relaxed.

Therapeutical Advantages :—

These developments are somewhat strenuous and should not be taken advantage of in therapeutical work.

SARVÂÑGÂSANA OR THE PAN-PHYSICAL POSE

Cultural Advantages :—

The principal cultural advantage of Sarvâñgâsana lies in the maintenance of a healthy thyroid. As is well-known this gland is responsible for the general health of an individual. Hence Sarvâñgâsana is able to maintain the whole human organism in a healthy condition by taking care of the thyroid gland.

The difference between Śîrshâsana and Sarvâñgâsana lies in the position of the head. In both the poses the remaining part of the body stands vertical to the ground. Hence the cultural advantages that accrue from Śîrshâsana due to the vertical position of the body, are also secured in Sarvâñgâsana. The Pan-Physical Pose very beneficially influences the sex glands both in males and females.

Therapeutical Advantages :—

Symptoms of old age due to the faulty functioning of the thyroid are counteracted by means of Sarvâñgâsana. Seminal weakness arising from the degeneration of the testes in the case of males and sexual disorders arising from the degeneration of the ovaries in the females can be extensively controlled by the practice of Sarvâñgâsana. Dyspepsia, constipation, hernia, visceroptosis can be treated by Sarvâñgâsana as well as by Śîrshâsana.

MATSYÂSANA OR THE FISH POSE

Cultural & Therapeutical Advantages :—

This pose is to be practised as complementary to Sarvâñgâsana. It greatly helps an individual to ensure the benefits he would get from the practice of Sarvâñgâsana.

HALÂSANA OR THE PLOUGH POSE

Cultural Advantages :—

Halâsana is one of the finest exercises for keeping the spine elastic and the spinal nerves healthy. When we remember that real youth is invariably characterized by an elastic spine and old age always renders the spine rigid, we can at once understand the cultural value of this exercise. Halâsana is also very helpful in developing strong abdominal muscles. In developing a healthy thyroid the effect of this Âsana is inferior only to that of Sarvâñgâsana.

Therapeutical Advantages :—

Halâsana is useful in combating dyspepsia and constipation, especially when they are due to the degeneration of the abdominal muscles or the nervous mechanism of digestion. The pose is available also for reducing the enlarged liver and spleen, provided that enlargement is not excessive. In particular types of diabetes, this Âsana may be practised with advantage. Also read therapeutical advantages of Bhujañgâsana.

BHUJAÑGÂSANA OR THE COBRA POSE

Cultural Advantages :—

The deep muscles of the back are alternately contracted and relaxed in working out this pose both ways. The exercised muscles gain in health and keep the spine elastic. Dur-

ing their work these muscles induce a liberal blood supply by promoting blood circulation which is ordinarily somewhat slow in this part of the body.

This pose has such a good effect upon the deep muscles, that even a single successful attempt at it, relieves an aching back, if thè pain is due to overwork.

The whole spine receives a steady pull anteriorly, every vertebra and its ligaments having their share in the work. If there be any slight displacement in the spinal column, it is adjusted to the normal condition.

All the thirty-one pairs of the spinal nerves exit through the spaces left between every two adjoining vertebræ. The two gangliated chains of the sympathetic also stand imbedded in the muscles situated on the two sides of the spinal column. This exercise, by promoting the blood circulation of these parts, very favourably influences these nerves and helps them in maintaining their health and activity. Bhujañgâsana considerably influences the development of the abdominal muscles.

Therapeutical Advantages :—

Bhujañgâsana along with Śalabhâsana or Ardha-Śalabhâsana and Dhanurâsana may best be practised in combination with Halâsana. This combination accentuates the results expected of the Plough Pose.

People suffering from flatulence immediately after meals, should emphasize Bhujañgâsana ; but those that feel flatulent some time after the meals, should devote more time to Śalabhâsana or Ardha-Śalabhâsana. Dhanurâsana may be useful to all such people. Unlike Halâsana these three or four Âsanas have no direct influence upon the thyroid.

(To be continued)

Miscellaneous

SOME HINTS TO YOGIC CULTURISTS

1 Every man should try to find which food suits him the best, irrespective of the dictates of his palate.

2 Even people who maintain more than average health, should restrict themselves to such varieties of food as they find agreeable. Every meal should be of a moderate quantity which must be well masticated, so that it may become freely mixed with the saliva and its digestion may become easier.

3 People with weak digestion should take to low protein diet. They should satisfy themselves with two meals per day and preferably even with one, the place of the other meal being taken by light refreshment.

4 Those who suffer from dyspepsia and constipation or have some uric acid trouble, will do well to eliminate all sorts of pulse. They should also avoid potatoes, brinjals and onions.

5 Water taken half an hour after the meal suits almost every constitution. Those that have their digestive capacity unimpaired may take water along with their food.

6 All alcoholic drinks are to be cautiously avoided. Stimulants such as tea and coffee are never to be taken in excess and may preferably be eliminated altogether. For a man that cares for his health, there cannot be a more luxurious drink than plain water.

7 Heavy smoking of whatever sort invariably shatters the nerves, if carried on across many years. Weak nerves, persistent cough, sore throat etc., always harass a heavy smoker; and may often beset the path even of a light smoker.

8 All unnatural and illegitimate sexual acts are sinful. Excess committed even in natural and legitimate sexual acts do not stand upon a different footing.

9 No sexual intercourse is healthy unless it is undertaken as a matter of absolute physiological necessity.

KAIVALYADHÂMA: BOMBAY BRANCH

HEALTH CENTRE

SUMMARY OF THE MEDICAL OFFICER'S REPORT

1932

In the year 1932, 561 people took advantage of the Health Centre. Out of these 103 took advice of the Director for improving their health whereas 458 underwent exercises at the Health Centre. Again out of these 458, 195 came as physical culturists for improving their health, and 263 took exercises as patients for getting rid of some chronic disease.

Most of the physical culturists were benefitted. Out of the patients 82·5 per cent. were found to be benefitted by the treatment of Yogic exercises.

The following diseases were treated at the Health Centre: Constipation, Dyspepsia, Functional Heart Disease, General Debility, Neurasthenia, Asthma, Piles, etc.

The ages of people who attended the Health Centre in the year under report varied from 9 to 65.

The patients and physical culturists came from different professions. They were clerks, government officers, merchants, professors, solicitors and even doctors.

As people are admitted to the Health Centre without any distinction of caste or creed, the record does not give any definite information on this point. But it is clear from the names of the people that the Health Centre was attended by Hindus, Parsis, Muslims, Christians and Jews.

DIRECTOR OF PUBLIC INSTRUCTION

ON

KAIVALYADHÂMA PHYSICAL CULTURE WORK

for U. P. Government

"With a view to improving the health and physique of school children the Education Department of the United Provinces have recently given considerable attention to physical training. Amongst indigenous systems one of the most renowned is the Yogic system of physical culture which Swami Kuvalayananda has perfected at his wellknown Ashrama at Lonavla near Poona. In order that teachers might have an opportunity of acquiring some knowledge of the fundamentals of the system taught by Swami Kuvalayananda the Education Department invited him in February this year to conduct classes for a fortnight at Lucknow. Twenty-eight teachers attended the classes. Swami Kuvalayananda also delivered two public lectures, one at the Lucknow University and the other at the Medical College, Lucknow. The Swami's demonstrations and lectures were much appreciated by the students under training and aroused much interest amongst educationists, officers of the Public Health and Medical Departments and the general public. The Education Department hope that as a result of the Swami's visit to the United Provinces selected teachers will be able in their teaching of physical exercises to combine what is best in Western and indigenous systems of physical training."

(*Sd.*) A. H. MACKENZIE,
C. I. E.
Director of Public Instruction,
United Provinces.

10.3.1932.

A TYPICAL LETTER FROM EUROPE

Harry Dikman,
Liela iela Nr. 20,
P. O. Tukum.
Latvia-Europe.

Tukum,
December 21, 1931.

To

Shrimat Swami Kuvalayananda,
Director, Kaivalyadhama.
Bombay—India.

Dear Swamiji,

... ...

I have succeeded in rousing an interest in our country to the Yogic philosophy. Dr. Vestaphal has now acknowledged that the Yoga Âsanas are the most ideal exercises for the spinal column. Dr. Rudsit is deeply interested in Yogic Basti and gives lectures to his students on this point.

Myself and a friend of mine Mr. Vessel, we both can perform Basti even without instrumental aid.

I enclose herewith some photos. In the group photo the eldest gentleman is 70 years old, and still practising Shirshasana.

... ...

Awaiting good news in return, I remain,

Dear Swamiji,

Yours most obediently,
(*Sd.*) H. DIKMAN.

तदेकोऽवशिष्टः शिवः केवलोऽहम् ।
I alone persist : Blissful : Absolute.

सर्वं खल्विदं ब्रह्म ।
All this is, indeed, Brahman.

नेह नानास्ति किञ्चन ।
There is nothing here apart from it.

ॐ

सोऽहम् ।

Yoga-Mîmânsâ

EDITED BY

S'RÎMAT KUVALAYÂNANDA

(J. G. Guṇe)

October, 1933

Vol. IV No. 4

KAIVALYADHÂMA

Post-Lonavla

(Bombay-India)

शरीरमाद्यं खलु धर्मसाधनम् ।
Surely Health is the primary requisite of spiritual life.

Printed by Y. K. Padwal at 'The Tatva-Vivechaka Press', Byculla, Bombay No. 8;
and published by S'rîmat Kuvalayânanda (J. G. Gune), at Kun'javana
(117 Valvana), Lonavla, G.I.P. (Bombay-India).

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वदेकोऽवशिष्टः शिवः केवलोऽहम् ।

सोऽहम् ।

YOGA-MÎMÂṄSÂ

VOL. IV OCTOBER, 1933 NO. 4

Editorial Notes

MAY the Maker of all make this journal a success. Blessed is the name of the Lord. May He bless the workers of the Âśrama with a happy and prosperous career as servants of the world which is only the Lord Himself objectified. May He, that has created us in His infinite wisdom, lead us to the light that is beyond all darkness.

◈ ◈ ◈

THIS number completes the fourth volume of our journal. The principal theme of this volume as of the last has been Prâṇâyâma, although a lengthy article on Yamas and Niyamas, along with very valuable information on Âsanas has also appeared therein. In this volume we have fully described the technique of two breathing exercises, namely, Kapâlabhâti and Bhastrikâ. A large number of experiments regarding the pressure changes in and the chemistry of Prâṇâyâma have appeared in the pages of this volume. The experiments on pressure changes clearly indicate the effects of Prâṇâyâma on blood circulation. Experimental work in the chemistry of Prâṇâyâma has led to definite conclusions regarding the value of Kumbhaka so far as it is undertaken to absorb O_2 or to eliminate CO_2. All this laboratory work published in this and the last volumes, however, has not touched even the

fringe of a scientific study of Prâṇâyâma, because the subject of Prâṇâyâma is very very vast especially when an attempt at its co-ordination with modern sciences is systematically made.

For our readers, however, we are going to give a sort of completeness to this subject of Prâṇâyâma by the end of the next volume. We wish to include in the fifth volume a complete description of the technique of three other types of Prâṇâyâma— Sûryabhedana, Sîtkârî and Śîtalî. These three varieties of Prâṇâyâma along with Ujjâyî and Bhastrikâ are quite sufficient either for a student of *Yogic Physical Culture* or *Yogic Spiritual Culture.* Our article 'Ujjâyî Prâṇâyâma Explained' will be concluded in the next volume. The question of O_2 absorption and CO_2 elimination in Prâṇâyâma will also be brought to a definite line of demarcation. In this way Volumes III, IV and V will form a sort of unit, a unit dealing chiefly with Prâṇâyâma. Different indexes will also be given at the end of the fifth volume as they were given at the end of Volume II.

It will thus be seen that Volume V will be found indispensable for a clear understanding of the subject of Prâṇâyâma, especially by those of our readers who wish to understand this branch of Yogic studies from the modern point of view.

In the volume that we are completing with this number, an exhaustive note on the determination of CO_2 and O_2 has appeared in the second number. The note has been written with a view to enable even those of our readers who are innocent of any knowledge of chemistry, to follow our research work intelligently. It is written so concisely and yet so lucidly, that in a few pages it discusses the most elementary as well as some of the advanced problems of modern chemistry. No student of Prâṇâyâma can understand the subject from the modern point of view, unless he knows the contents of this note.

Our article on Human Body which appeared in the third number is equally important. It offers a synthetic study of human anatomy and physiology which is so indispensable to those who want to understand the fundamental principles underlying *Yogic Physical Culture.*

Thus it will be seen that the contents of Volume IV are so important that every reader of Volume V will find it essential to have studied the fourth volume carefully.

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ALTHOUGH Prâṇâyâma will continue to be the principal theme of the fifth volume, some other important exercises will also be studied therein. We propose to describe the technique of Aśvinîmudrâ, Mahâ-Mudrâ, Mahâbandha and if possible of one or two of the Shaṭ Kriyâs. The exercises of Aśvinîmudrâ will be accorded special treatment. Students of Yoga interested in the sublimation of sex energy or the treatment of seminal weakness will find a fund of original information in our article on Aśvinî, as the same will be based upon a critical study of scientific facts as well as clinical and cultural experiences. In short, we will try our best to make Volume V as interesting and instructive as the preceding volumes of *Yoga-Mîmâṅsâ,* if not more.

◈ ◈ ◈

YOGA-MÎMÂṄSÂ is not a money-making concern. An average Indian has little knowledge of the remarkably expensive character of laboratory experiments where the subjects are trained students of Yoga. This circumstance at times leads to the erroneous impression that the subscription of *Yoga-Mîmâṅsâ* is heavy enough. Some of our readers might argue that they are concerned with the *Semi-Scientific* and the *Popular Sections* of the journal and not with the *Scientific Section* of it. Such an argument betrays colossal ignorance about the nature of relation between the *Scientific Section* and the *Semi-Scientific* and *Popular Sections* of *Yoga-Mîmâṅsâ,*

Almost everyone of our readers finds the latter two Sections as uncommonly interesting and instructive as they are original. This peculiar character of the two Sections is due to their being based upon the *Scientific Section.* If we eliminate the scientific research and its conclusions from *Yoga-Mîmâṅsâ*, it will be reduced almost to a trash!

This explanation will bring it home to our readers that the material published in *Yoga-Mîmâṅsâ* is got together at a very heavy cost. Further this heavy cost is rendered heavier still because of the present low rate of subscription and the limited number of our subscribers. We have no mind to increase the rate of subscription. So the only way to lessen the burden of the Âśrama in bringing out *Yoga-Mîmâṅsâ* is for the present subscribers to continue their patronage and to find as many new subscribers as they possibly can. Let us assure our readers that we have been able to keep the journal going simply because of the extreme sacrifice of the inmates of the Âśrama. It is, therefore, the sacred duty of all the educated Indians who are interested in Yoga, to subscribe to *Yoga-Mîmâṅsâ* and thus help the propagation of Yogic Culture which all of us have at heart and which the *Yoga-Mîmâṅsâ* journal is doing with remarkable success.

◈ ◈ ◈

For the last few years one volume or another of the *Yoga-Mîmâṅsâ* journal used to go out of print. This proved a great handicap to our readers who wanted to purchase all the back volumes for their study. But now this handicap has been removed. We have reprinted all the back volumes and our readers can now have every one of the *Yoga-Mîmâṅsâ* numbers serially from the very beginning.

◈ ◈ ◈

On page 264 of this number will be found a few words addressed to our readers by the Manager of the Yoga-Mîmâṅsâ Office. We want to draw our readers' attention

especially to the intimation card being circulated therewith. Those of our subscribers who wish to discontinue their patronage are very earnestly requested to send us instructions to that effect at the earliest opportunity. At any rate their intimation should reach the Yoga-Mîmâṅsâ Office before the 20th of January, 1934. A little negligence in this respect on the part of such subscribers, puts us to a heavy loss. After each subscriber the Office loses upwards of 5 annas for postage and packing, not to speak of the damage done to the copies of the journal because of the double transit. Therefore, it behooves every subscriber who intends discontinuing to send us timely information about his intention.

We will feel obliged to all the subscribers who wish to continue, if they send their subscriptions by *Money Order.* This method is *cheaper* for the subscribers and *more convenient* for the Yoga-Mîmâṅsâ Office.

This much for the inland subscribers. Foreign subscribers are requested kindly to follow faithfully the instructions given on the next page by the Manager of the Yoga-Mîmâṅsâ Office.

Before concluding these *notes* we wish to offer our cordial thanks to all the subscribers past and present, who have thus far patronized *Yoga-Mîmâṅsâ.* Needless to say that it is their active sympathy that has enabled us to keep the journal going up to now.

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MAY the Lord that enabled us to found the Âśrama, give us strength enough to carry on its work! May He ever widen the circle of our sympathizers and thus allow us to serve Him and His children to the best of our ability!

READERS

Kindly do not fail to get your name registered as a subscriber for *Vol. V*, by posting, even to-day, the accompanying card duly signed and stamped. It is hoped that you will enter your full name and address in legible handwriting, clearly stating your Post Office. Please do not lose this opportunity of studying or helping the study of this ancient Yogic Culture of the Âryans.

The first number of Volume V will be posted in the first week of February 1934. If you do not send definite instructions or remittances, so as to reach the Yoga-Mîmânsâ Office on or before the 20th of January 1934, it will be taken for granted that you want to continue as a subscriber and that you want us to send you the number per V. P. P., charging you for the next volume.

If you are an inland subscriber, the *Money Order System is cheaper for you than the V. P. System. It will save you five annas and will save us much trouble. Cheques will not be accepted.* If you are a foreign subscriber, residing in British Colonies, Possessions or Agencies, remittance in British Postal Orders or in Sterling Currency Notes is cheaper and quicker for you and more convenient for us than payment through Foreign Money Order System. If you happen to be an American subscriber, you can best send us your remittance in Dollar Currency Notes. Above all, remittance through a Draft is a facility, most convenient in all respects that is available to a foreign subscriber.

All remittances should be made payable to the "*Manager, Yoga-Mîmânsâ Office*".

MANAGER, YOGA-MÎMÂÑSÂ OFFICE,
P. O. ***BORIVLI,*** *(B. B. & C. I.)*
(Bombay–India)

The Scientific Section

O_2 ABSORPTION AND CO_2 ELIMINATION IN PRÂṆÂYÂMA[1]

INTRODUCTION

IN the second number of this volume we studied the question of CO_2 elimination in Prâṇâyâma with the help of eight experiments described in the *Scientific Section* of that number. In the present article we wish to discuss the question again in the light of further experiments, and also to try to solve the question of O_2 absorption in Prâṇâyâma. The questions of O_2 absorption and CO_2 elimination go hand in hand and occupy an important place in the study of Pranayamic chemistry. Hence they may be studied together with great advantage.

In the second number, five questions were raised regarding the problem of CO_2 elimination in Prâṇâyâma. The last three of these questions were satisfactorily answered; but the first two were left over for future discussion. Here we shall reproduce those very questions. We shall only include therein the question of O_2 absorption. When this is done, the questions would stand as follows :—

(*i*) Whether Prâṇâyâma enables a man to absorb more O_2 and to eliminate more CO_2 than the ordinary normal breathing in a particular unit of time ?

(*ii*) What would be the most advantageous time unit for a round of Prâṇâyâma for O_2 absorption and Co_2 elimination ?

(*iii*) Whether a larger time unit for a Pranayamic round leads to larger O_2 absorption and CO_2 elimination ?

(*iv*) Has Kumbhaka a special value in Prâṇâyâma, so far as O_2 absorption and CO_2 elimination are concerned ?

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1 Readers are requested to preface their reading of the present article and the following experiments by a careful study of what we have said in the second number of this volume about CO_2 elimination in Prâṇâyâma on p. 95 and the following. We especially draw our readers' attention to the foot-note on p. 95.

(*v*) Is it desirable to omit Kumbhaka from the technique of Prâṇâyâma, if only O_2 absorption and CO_2 elimination are aimed at?

As in the second number, so here, we can attempt to solve only the last three questions satisfactorily on the strength of direct laboratory evidence. The first two questions have still to await further laboratory evidence for being convincingly answered in definite terms.

Starting with the third question, we want to know whether a larger time unit for a Pranayamic round leads to larger O_2 absorption and CO_2 elimination. So far as CO_2 elimination goes, we have already answered this question in the negative. When we examine the evidence obtainable from the new experiments described in this *Section*, we will find our previous answer amply supported.

Reference to last page of this *Section* will show that we have used four time units in these experiments. They are 14″, 21″, 28″ and 35 seconds. Let us compare the results obtained from Pranayamic rounds of these different units so far as O_2 absorption and CO_2 elimination are concerned. Let O_2 absorption be considered first.

In 14″ Pranayamic round the percentage of O_2 absorption is 5.74, whereas in 21″ Pranayamic round it is 6.43. Thus we see that the percentage in the longer round has increased by .69. But we have to know whether this increase really compensates for the additional time of 7″ given to the longer round. When we do this we find that the increase in percentage is not proportionate to the additional time. At the rate of 5.74 per cent. for 14″, we must get 8.61 per cent. for 21″, but the actual percentage is only 6.43! This will clearly show that the longer units of Prâṇâyâma place us at a disadvantage so far as the absorption of O_2 is concerned. If we compare the results of the other two units of 28″ and 35″, we will discover the same truth.

The conclusion arrived at in the last paragraph will become more striking, if we work out the total absorption of O_2 in 14″, according to the different percentages of absorption obtained in different Pranayamic rounds.

Let us start with the rounds of 14″ and 21 seconds. And let us suppose that the average quantity of the exhaled air of each subject is 2800 c.c.[1] Now in the first Pranayamic round of 14″, the subject absorbs 5.74 per cent. of this, that is, 160.72 c.c. of oxygen; whereas in the second round of 21″, he absorbs 6.43 per cent. that is, 180.04 c.c. of that gas. This shows that in the second round the subject absorbs 19.32 c.c. of oxygen more than in the first round. But in the second round he spends 7″ more than in the first. Let us therefore see how much oxygen the subject absorbs in 14″ while he is practising Prâṇâyâma of the second unit which is to be completed in 21 seconds. It would work out at 120.02 c.c. only. That is, in the 21″ round, the subject absorbs 40.70 c.c. of oxygen less than in the 14″ round. If we work out similar figures for 28″ and 35″, we will find that the longer the unit of time of a Pranayamic round, the greater is the disadvantage, so far as the absorption of O_2 is concerned. The following table will at once make the conclusion clear.

Time unit of a Pranayamic round	Percentage of O_2 absorption	Total absorption of O_2 in a single round	Proportionate absorption of O_2 in 14″ in different time units.
14″	5.74	160.72 c.c.	160.72 c.c.
21″	6.43	180.04 c.c.	120.02 c.c.
28″	7.03	196.84 c.c.	98.42 c.c.
35″	7.58	212.24 c.c.	84.90 c.c.

1 Properly speaking this average would have been in the neighbourhood of 3500 c.c. in the case of the present subjects. We have, however, purposely taken it to be

(*Continued*)

Nor do we gain any advantage by choosing longer time units for Prâṇâyâma even in the case of CO_2 elimination. This will be clear from the results of the experiments described at the end of this article. These results are tabulated on the last page of this *Section*. In the following table we have tried to work out the figures of actual CO_2 elimination, taking 2800 c.c. to be the quantity of the expired air in a Pranayamic round. We have shown how much CO_2 can be eliminated in 14″ according to the different time units employed in Prâṇâyâma in the experiments under examination. Here is the table.

Time unit of a Pranayamic round	Percentage of CO_2 elimination	Total elimination of CO_2 in a single round	Proportionate elimination of CO_2 in 14″ in different time units
14″	5.22	146.16 c.c.	146.16 c.c.
21″	5.38	150.64 c.c.	100.42 c.c.
28″	5.91	165.48 c.c.	82.74 c.c.
35″	6.05	169.40 c.c.	67.76 c.c.

We find from this table that one can eliminate 146.16 c.c. of CO_2 in 14″, if a round of Prâṇâyâma is completed in 14″; whereas one can eliminate only 67.76 c.c. in 14″, if the round is extended to 35 seconds.

Here we wish to draw the attention of our readers to the difference in the results of the experiments published in the second number, and the experiments published here. In those experiments the percentage of CO_2 elimination in 14″ Pranayamic round was found to be 3.97, whereas in the present

2800 c.c. The idea is to show to our readers that longer Pranayamic rounds entail a loss in O_2 absorption even in the case of people having a small lung capacity. It is needless to point out that with larger lung capacity the loss will be greater still. It may be noted that in the second number we have chosen the same measure of expired air as here.

experiments it comes out to be 5.22. Thus there is a difference of 1.25 per cent. This difference is obviously due to the difference in the sets of subjects examined in these two series of experiments. If our readers study carefully the details tabled in each experiment against the name of each subject, they will find ample evidence for this difference in different subjects. This individual difference in the percentage of CO_2 elimination or O_2 absorption is a physiological fact. Hence the need of examining each subject twice and also examining several subjects in one and the same experiment and then finding out averages for arriving at the correct results.

The difference in the results of the two sets of experiments to which we have drawn our readers' attention in the preceding paragraph, does not, however, vitiate our conclusion, namely, longer rounds of Prâṇâyâma do not lead to larger CO_2 elimination. The following table prepared according to the results arrived at in the previous series of experiments will convince our readers.

Time unit of a Pranayamic round	Percentage of CO_2 elimination	Total elimination of CO_2 in a single round	Proportionate elimination of CO_2 in 14″ in different time units
14″	3.97	111.16 c.c.	111.16 c.c.
21″	4.56	127.68 c.c.	85.12 c.c.
28″	5.2	145.6 c.c.	72.8 c.c.
35″	5.3	148.4 c.c.	59.8 c.c.
49″	6.02	168.56 c.c.	48.16 c.c.

Thus we see that a longer round of Prâṇâyâma is a disadvantage so far as the absorption of O_2 or elimination of CO_2 is concerned. Hence our reply to the third question is in the

negative and we can emphatically say that a longer time unit for a Pranayamic round does not lead to larger O_2 absorption or CO_2 elimination.

Next we have to see whether Kumbhaka has a special value in Prâṇâyâma, so far as O_2 absorption and CO_2 elimination is concerned.

In the following experiments two time units, 28″ and 35″, have been employed for Prâṇâyâma once with Kumbhaka and once without Kumbhaka. If we examine the results of these, we can understand the O_2 and CO_2 value of Kumbhaka. Let us first take 28″ unit. In this we have 7.03 per cent. of O_2 absorption when Prâṇâyâma is done with Kumbhaka and 6.94 per cent. when Prâṇâyâma is done without Kumbhaka. Thus there is an advantage of .09 per cent. in Prâṇâyâma with Kumbhaka. When we remember, however, that this advantage is so trifling and obtained in 28″, we can safely say that Kumbhaka has no special value in O_2 absorption. We shall make this position a little clearer still. If we take a subject with 2800 c.c. lung capacity, according to the results of our experiments, he would be able to absorb 2.5 c.c. more of oxygen because of his Kumbhaka in a Prâṇâyâma of 28 seconds. Now according to the general physiological observations, an average adult absorbs at least 4 c.c. of O_2 in one second in his normal breathing. When we take into account this normal absorption of O_2, we at once see how insignificant is the advantage of 2.5 c.c. for a period of 28 seconds.

The results of 35″ unit are more conclusive. There the percentage of O_2 absorption is 7.54 for Prâṇâyâma with Kumbhaka; and 7·58 for Prâṇâyâma without Kumbhaka. So there is a disadvantage of .04 per cent. for Kumbhaka instead of there being any gain at all. Thus it is clear that Kumbhaka has no special value in Prâṇâyâma so far as O_2 absorption is concerned.

Next we come to CO_2 elimination value of Kumbhaka. In the 28″ round the percentage of CO_2 elimination is 5.91 with Kumbhaka and 5.69 without Kumbhaka. That means Kumbhaka has an advantage of .22 per cent. When we see that this advantage comes to only 1 in 500, we at once realize the insignificance of it. Nor are the results of the 35″ round more favourable to Kumbhaka. There CO_2 elimination is 6.05 c.c. with Kumbhaka and 5.95 c.c. without Kumbhaka. It means that Kumbhaka has an advantage of .1 per cent. that is of 1 in 1000, which is even less favourable than the last one. Hence Kumbhaka is found to be of no special value in CO_2 elimination in Prâṇâyâma.[1] So our answer to the fourth question is that Kumbhaka has no special value in Prâṇâyâma so far as O_2 absorption or CO_2 elimination is concerned.

The solution of the fourth question also satisfactorily solves the fifth question. As Kumbhaka has no special value in absorbing oxygen and eliminating carbon dioxide, we can safely omit Kumbhaka, if O_2 absorption or CO_2 elimination is the only object of practising Prâṇâyâma.[2]

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1 This conclusion confirms the one that we arrived at in the second number of this volume.

2 When our readers study the article 'Physiological and Spiritual Values of Prâṇâyâma' appearing in the *Popular Section* of this number, they will see that the real advantage sought by students of Yoga in practising Prâṇâyâma and especially Kumbhaka is the culture of nerves. It is neither the absorption of oxygen nor the elimination of carbon dioxide. This subject will be discussed at greater length in Vol. V.

GENERAL CONDUCT OF EXPERIMENTS

For the experiments published in this number five subjects were tried. They were all young adults of ages varying from 25 to 30. Their health was normal. Not only during the days of experimentation, but even ordinarily these subjects were not given to any hard physical labour. Subjects A_1, B_1, D_1, and E_1 were regularly undergoing Yogic exercises daily. Subject C_1 was trained as a regular athlete and although he was latterly doing Yogic exercises, his daily programme included quite a good amount of muscle culture. We make a special mention of this fact, because those of our readers who are interested in the details of metabolic experiments, will find a remarkable difference between the results of the muscular and non-muscular subjects. The percentages of O_2 absorption and CO_2 elimination differ in different individuals and in the same individual under different metabolic conditions. We tried to maintain uniformity of metabolism as best as we could and to eliminate error we tried the same subject twice on two different days for the same experiment and struck out an average. Again to make up for individual differences, we tried five subjects for one and the same experiment for finding out an average. Wherever a close comparison was necessary, as in the cases of Prâṇâyâma with Kumbhaka and without Kumbhaka, we tried both the experiments with a particular subject the same morning. Thus it will be seen that errors due to metabolic differences have been reduced to a minimum.

Every time the expired air was collected in a rubber bag previously exhausted of all ordinary air. Out of this a sample of 100 c.c. was taken in a gas burette for analysis. This sample was first treated with a solution of caustic potash for determining CO_2 elimination percentage and afterwards with potassium pyrogallate solution for finding O_2 absorption percentage. Throughout, barometric pressures and temperatures were noted and necessary corrections applied.

The apparatus used has been described at great length in the *Semi-Scientific Section* of the second number of this volume.

O_2 ABSORPTION AND CO_2 ELIMINATION IN PRÂṆÂYÂMA

EXPERIMENT IX

OBJECT OF THE EXPERIMENT :—

The object of the experiment was to ascertain the average percentage of O_2 absorption and CO_2 elimination per normal respiration of the five subjects under examination, with a view to understand their average capacity in this connection.

PREPARATION OF THE SUBJECTS :—

Five subjects were examined in this experiment. All of them were young adults of ages varying from 25 to 30. There was no special preparation except that they were made to avoid all abnormal physical work before the experiment.

THE APPARATUS :—

The apparatus used has been described in the *Semi-Scientific Section* of the second number of this volume.

THE EXPERIMENT PROPER :—

The expired air of three normal exhalations in the case of each subject was collected in a rubber bag which was completely exhausted of ordinary air. Out of this a sample of 100 c.c. was analyzed for finding out percentages of O_2 absorption and CO_2 elimination, as described in the introduction to these experiments. Each subject made two attempts. The results are tabulated on the next page.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT.

Experiment IX

Subject	Average Respiration				Absorption of O_2 in volume per cent.			Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average	1st Attempt	2nd Attempt	Average
A_1	...	...	...	...	5·17	5·57	5·37	4·50	5·11	4·81
B_1	...	...	...	...	4·83	5·71	5·27	3·94	4·00	3·97
C_1	...	...	...	...	2·96	2·86	2·91	2·90	3·10	3·00
D_1	...	...	...	...	3·90	4·80	4·35	4·15	4·25	4·20
E_1	...	...	...	...	4·51	3·51	4·01	3·98	3·04	3·51

Total 21·91 **Total 19·49**

Final Average 4·38 **Final Average 3·90**

EXPERIMENT X

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentages of O_2 absorption and CO_2 elimination in a Pranayamic round of 7″ Pûraka and 7″ Rechaka, with no Kumbhaka between them. The other object was to compare these percentages with other similar percentages secured with Pranayamic rounds of longer time units, with a view to see whether the longer time units had an advantage over these, so far as the absorption of O_2 and the elimination of CO_2 were concerned.

PREPARATION OF THE SUBJECTS AND THE APPARATUS :—

The subjects and the apparatus in this experiment were the same as in the previous experiment, the subjects being prepared in the same fashion as before.

THE EXPERIMENT PROPER :—

In the case of each subject a Pûraka of 7″ was followed by a Rechaka of 7 seconds. The expired air was collected in a rubber bag as was done in the previous experiment. Out of this a sample of 100 c.c. was analyzed for finding out percentages of O_2 absorption and CO_2 elimination.

Each subject was examined twice. The results are tabulated on the next page.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT.

Experiment X

Subject	Period of Pûraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prânâyâma in seconds	Absorption of O_2 in volume per cent.			Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average	1st Attempt	2nd Attempt	Average
A_1	7	0	7	14	7·21	5·16	6·19	5·85	5·81	5·83
B_1	7	0	7	14	6·09	5·88	5·99	5·00	5·26	5·13
C_1	7	0	7	14	4·77	4·20	4·49	4·70	3·90	4·30
D_1	7	0	7	14	6·49	6·04	6·27	5·50	5·41	5·46
E_1	7	0	7	14	6·00	5·47	5·74	5·45	5·28	5·37

Total 28·68 **Total 26·09**

Final Average 5·74 **Final Average 5·22**

EXPERIMENT XI

OBJECTS OF THE EXPERIMENT:—

One of the objects of the experiment was to determine the percentages of O_2 absorption and CO_2 elimination in a Pranayamic round of 7″ Pûraka and 14″ Rechaka, with no Kumbhaka between them. The second object was to compare these percentages with other similar percentages secured with Pranayamic rounds of shorter or longer time units, with a view to see whether the longer time units had an advantage over the shorter units, so far as O_2 absorption and CO_2 elimination were concerned.

PREPARATION OF THE SUBJECTS AND THE APPARATUS :—

The same as in the last two experiments.

THE EXPERIMENT PROPER :—

In the case of each subject a Pûraka of 7″ was followed by a Rechaka of 14 seconds. As in the last experiment the expired air was collected in a rubber bag and a sample of it measuring 100 c.c. was analyzed. Each subject made two attempts. The results are tabulated on the next page.

REMARKS :—

The Pranayamic round of the last experiment was of 14″ whereas the same was of 21″ in the present experiment. The percentage of CO_2 elimination in the last experiment was 5.22. Had this percentage increased in proportion to the increase in the time unit, the CO_2 elimination percentage in the present experiment would have been 7.83. Actually it is only 5.38. Hence we clearly see that a longer time unit in Prâṇâyâma is not an advantage so far as the elimination of CO_2 is concerned. The same can be said about the absorption of O_2. In the last experiment with 14″ Pranayamic round the percentage of O_2 absorption was 5.74. Had this percentage increased in proportion to the increase in time unit, we would have had 8.61 per cent. of O_2 absorption in the present experiment. Actually it is only 6.43.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT.

Experiment XI

Subject	Period of Pûraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prânâyâma in seconds	Absorption of O_2 in volume per cent.			Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average	1st Attempt	2nd Attempt	Average
A_1	7	0	14	21	5·96	5·07	5·52	5·00	4·90	4·95
B_1	7	0	14	21	6·48	7·64	7·06	5·20	5·60	5·40
C_1	7	0	14	21	6·16	5·68	5·92	5·60	5·40	5·50
D_1	7	0	14	21	7·28	6·48	6·88	5·80	5·40	5·60
E_1	7	0	14	21	7·17	6·37	6·77	5·51	5·40	5·46
						Total	32·15		Total	26·91
						Final Average	6·43		Final Average	5·38

EXPERIMENT XII

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentages of O_2 absorption and CO_2 elimination in a Pranayamic round of 7″ Pûraka, 7″ Kumbhaka and 14″ Rechaka. The other object was to compare these percentages with similar percentages secured with a Pranayamic round of the same time unit, but without Kumbhaka, the period of Kumbhaka being added to Rechaka for lengthening it, with a view to see whether Kumbhaka had a special value so far as the absorption of O_2 or the elimination of CO_2 was concerned.

PREPARATION OF THE SUBJECTS AND THE APPARATUS :—

The same as before.

THE EXPERIMENT PROPER :—

Each subject had a Pranayamic round of 7″ Pûraka, 7″ Kumbhaka and 14″ Rechaka. The expired air was collected in a rubber bag as before. A sample measuring 100 c.c. was analyzed. Each subject made two attempts. The results are tabulated on the next page.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT.

Experiment XII

Subject	Period of Pûraka in seconds	Period of Kum-bhaka in seconds	Period of Rechaka in seconds	Total Period of Prâṇâ-yâma in seconds	Absorption of O_2 in volume per cent.			Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average	1st Attempt	2nd Attempt	Average
A_1	7	7	14	28	7·65	6·50	7·08	5·99	5·20	5·60
B_1	7	7	14	28	6·58	8·95	7·77	5·50	7·03	6·27
C_1	7	7	14	28	5·77	5·44	5·61	5·80	5·64	5·72
D_1	7	7	14	28	7·54	7·57	7·56	6·30	6·00	6·15
E_1	7	7	14	28	7·17	7·13	7·15	5·74	5·83	5·79
						Total	35·17		Total	29·53
						Final Average	7·03		Final Average	5·91

EXPERIMENT XIII

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentages of O_2 absorption and CO_2 elimination in a Pranayamic round of 7″ Pûraka and 21″ Rechaka, with no Kumbhaka between them. The other object was the same as the second object of the last experiment.

PREPARATION OF THE SUBJECTS AND THE APPARATUS :—

The same as before.

THE EXPERIMENT PROPER :—

This was done exactly as the last experiment with the following change. Instead of 7″ Kumbhaka and 14″ Rechaka, the subjects had 21″ Rechaka only, without any Kumbhaka at all. Each subject was examined twice. The results are tabulated on the next page.

REMARKS[1] :—

A comparison of the results of this experiment and the last, clearly shows that Kumbhaka has no special value, so far as O_2 absorption and CO_2 elimination are concerned. In the last experiment the percentage of O_2 absorption was 7.03 whereas in the present experiment it is 6.94. The last experiment has, indeed, an advantage of .09 per cent. over the present one. But the difference is so small that we cannot claim any special advantage for Kumbhaka in the absorption of O_2. Similar is the case of CO_2 elimination. In the last experiment its percentage was 5.91 whereas in the present experiment it is 5.69. Thus there is an advantage of .22 per cent. in the last experiment. But this too is such a trifle that Kumbhaka cannot be given any special value for CO_2 elimination.

1 For a detailed discussion on these remarks we refer our readers to the *Introduction* of these experiments.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT.

Experiment XIII

Subject	Period of Pûraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prâṇâyâma in seconds	Absorption of O_2 in volume per cent.			Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average	1st Attempt	2nd Attempt	Average
A_1	7	0	21	28	7·17	6·07	6·62	5·60	5·94	5·77
B_1	7	0	21	28	7·06	8·12	7·59	4·88	4·92	4·90
C_1	7	0	21	28	6·03	6·20	6·12	5·76	5·60	5·68
D_1	7	0	21	28	7·77	7·03	7·40	6·63	5·53	6·08
E_1	7	0	21	28	7·18	6·74	6·96	5·81	6·19	6·00
						Total	34·69		Total	28·43
						Final Average	6·94		Final Average	5·69

EXPERIMENT XIV

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentages of O_2 absorption and CO_2 elimination in a Pranayamic round of 7″ Pûraka, 14″ Kumbhaka and 14″ Rechaka. The other object was to compare these percentages with similar percentages secured with a Pranayamic round of the same time unit, but without Kumbhaka, the period of Kumbhaka being added to Rechaka for lengthening it, with a view to see whether Kumbhaka had a special value so far as O_2 absorption and CO_2 elimination were concerned.

PREPARATION OF THE SUBJECTS AND THE APPARATUS :—

The same as before.

THE EXPERIMENT PROPER :—

Each subject went through a round of Pranayama consisting of 7″ Pûraka, 14″ Kumbhaka and 14″ Rechaka. The expired air was collected, and a sample of it analyzed as before. Two attempts were made by each subject. The results are tabulated on the next page.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT.

Experiment XIV

Subject	Period of Pûraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prâṇâyâma in seconds	Absorption of O_2 in volume per cent. 1st Attempt	Absorption of O_2 in volume per cent. 2nd Attempt	Absorption of O_2 in volume per cent. Average	Elimination of CO_2 in volume per cent. 1st Attempt	Elimination of CO_2 in volume per cent. 2nd Attempt	Elimination of CO_2 in volume per cent. Average
A_1	7	14	14	35	7·58	7·63	7·61	5·90	6·16	6·03
B_1	7	14	14	35	8·60	7·98	8·29	6·10	5·70	5·90
C_1	7	14	14	35	5·90	6·07	5·99	6·44	6·10	6·27
D_1	7	14	14	35	7·48	7·97	7·73	5·78	6·20	5·99
E_1	7	14	14	35	7·47	8·69	8·08	5·80	6·31	6·06
						Total	37·70		Total	30·25
						Final Average	7·54		Final Average	6·05

Experiment XV

OBJECTS OF THE EXPERIMENT :—

One of the objects of this experiment was to determine the percentages of O_2 absorption and CO_2 elimination in a Pranayamic round of 7″ Pûraka and 28″ Rechaka with no Kumbhaka between them. The second object was the same as the second object of the last experiment.

PREPARATION OF THE SUBJECTS AND THE APPARATUS :—

The same as before.

THE EXPERIMENT PROPER :—

This was done exactly as the last experiment with the following difference. Instead of 14″ Kumbhaka and 14″ Rechaka, the subjects had 28″ Rechaka only, without any Kumbhaka at all. Each subject was examined twice. The results are tabulated on the next page.

REMARKS :—

On comparison of the results of this and the last experiments, we find that the percentage of O_2 absorption is higher in this experiment than in the last. This, therefore, confirms the conclusion that Kumbhaka has no special value in O_2 absorption. Further, so far as CO_2 elimination is concerned, we find that the percentage arrived at in the last experiment is higher by .1 per cent. only. This advantage is so trifling that we can again safely say that Kumbhaka has no special value in CO_2 elimination also.

ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PERCENT

Experiment XV

Subject	Period of Pûraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prâṇâyama in seconds	Absorption of O_2 in volume per cent.			Elimination of CO_2 in volume per cent.		
					1st Attempt	2nd Attempt	Average	1st Attempt	2nd Attempt	Average
A_1	7	0	28	35	6·91	7·27	7·09	6·06	5·60	5·83
B_1	7	0	28	35	8·67	6·93	7·80	6·42	5·30	5·86
C_1	7	0	28	35	7·40	6·95	7·18	5·90	6·30	6·10
D_1	7	0	28	35	8·00	8·12	8·06	5·80	6·06	5·93
E_1	7	0	28	35	7·60	7·98	7·79	6·06	5·95	6·01
						Total	37·92		Total	29·73
						Final Average	7·58		Final Average	5·95

AVERAGE ABSORPTION OF O_2 AND ELIMINATION OF CO_2 IN VOLUME PER CENT. IN DIFFERENT PRÂṆÂYÂMÂS

Experiment	Period of Pûraka in seconds	Period of Kumbhaka in seconds	Period of Rechaka in seconds	Total Period of Prâṇâyâma in seconds	Average Absorption of O_2 in volume per cent.	Average Elimination of CO_2 in volume per cent.
IX	AVERAGE	RESPIRATION	AVERAGE	RESPIRATION	4·38	3·90
X	7	0	7	14	5·74	5·22
XI	7	0.	14	21	6·43	5·38
XII	7	7	14	28	7·03	5·91
XIII	7	0	21	28	6·94	5·69
XIV	7	14	14	35	7·54	6·05
XV	7	0	28	35	7·58	5·95

N. B.—The Director of the Kaivalyadhâma entreats every man of means to show his active sympathy for the Âśrama.

The Popular Section

N. B.—Instruction in Yogic culture higher as well as lower will be given gratis at the Âśrama to everyone that earnestly seeks it.

BHASTRIKÂ

THE NAME :—

By this time our readers have become familiar with the meaning of the word Prâṇâyâma.[1] They have also seen that Svâtmârâma Sûri, the reputed author of *Haṭha-Pradîpikâ*, recognizes eight[2] varieties of Prâṇâyâma of which Bhastrikâ is one. A reference has already been made to the meaning[3] of the word Bhastrikâ and also to the technique[4] of it. In this article we shall study this Prâṇâyâma at some length.

In Saṅskṛita Bhastrikâ means *bellows*. This Prâṇâyâma is called Bhastrikâ because it is characterized by incessant and quick expulsions of breath in all its varieties,[5] imitating the actively hissing bellows of a village smith. Whether in these expulsions both the nostrils are used as in the first two varieties, or only one nostril is used as in the last two varieties, is all immaterial, quick succession of forceful expirations is the most prominent feature of every type of Bhastrikâ. Hence[6] the name.

THE TECHNIQUE :—

Those of our readers that may have made themselves thoroughly familiar with the technique of Ujjâyî

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1 Vide Vol. III, pp. 258-59. 2 Vide Vol. III, p. 260.

3 Vide foot-note 2, p. 172 of this volume. 4 Vide p. 163-64 of this volume.

5 There are as many as four varieties of this Prâṇâyâma. We are going to notice all of them in this article.

6 Svâtmârâma Sûri says :—

पुनर्विरेचयेत्तद्वत्पूरयेच्च पुनः पुनः ।
यथैव लोहकारेण भस्त्रा वेगेन चाल्यते ॥ H. P., II 61
तथैव स्वशरीरस्थं चालयेत्पवनं धिया ।
... ... ॥ H. P., II 62

[One should exhale again so also inhale again, doing the same repeatedly. Just as a blacksmith works his bellows actively, so should one move his physical breath with speed and attention.]

and Kapâlabhâti, will find almost nothing new to learn in the technique of Bhastrikâ, at least so far as the first two varieties are concerned. We shall presently see why this is so.

First Variety[1] :—The first part of this variety is completely identical with the exercise of Kapâlabhâti as it is described in the second number of this volume. The breathing is entirely abdominal, the ribs being raised and kept up in that condition by the continued contraction of the intercostals. Both the nostrils are used for forceful and quick expulsions of breath that follow one another in rapid succession. Inhalations are passive being brought about by the relaxation of the abdominal muscles. In fact this part of Bhastrikâ is nothing more than the practice of Kapâlabhâti.

After a number of exhalations, this number[2] being determined by the strength of the individual practising Prâṇâyâma, deepest possible Pûraka is made as in the case of Ujjâyî. Air is inhaled through both the nostrils and the abdominal muscles are kept controlled. Only the partial closure of the glottis and the consequent frictional sound produced in inspiration are to be avoided. The glottis is to be kept fully open. The air is to be drawn in by *slowly* expanding the chest. The passage of the inspired air through the nose and throat is to be so gentle, that no friction is caused in any part of the respiratory tract. It is desirable that the process of Pûraka should cover at least eight seconds.

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1 This is the type of Bhastrikâ traditionally handed down to the Director of the *Kaivalyadhâma* and daily practised by the Sâdhakas of the Âśrama. The author of *Gheraṇḍa-Saṁhitâ* recommends this variety to the students of Yoga. Vide Lesson V 75-77.

2 In *Gheraṇḍa-Saṁhitâ* only twenty expulsions of breath have been advised. In the cultural and curative work done in the Âśrama, we have found that the measures of Kapâlabhâti and Bhastrikâ agree with each other with wonderful accuracy. Also read the *General Hints* given at the end of this article.

Pûraka is followed by Kumbhaka. The inspired air is retained by completely closing the glottis and by securing Jâlandhara-Bandha. The closing of the nostrils with the fingers as in Ujjâyî is necessary. In fact Kumbhaka in Bhastrika is to be practised exactly as Kumbhaka in Ujjâyî, the two Kumbhakas being thoroughly identical in every detail, including the control of the abdominal muscles.

Rechaka follows Kumbhaka. Except for the partial opening of the glottis and the resulting soft sound of a low pitch, Rechaka in Bhastrikâ is quite similar to Rechaka in Ujjâyî. As in Pûraka so in Rechaka, Bhastrikâ requires the glottis to be thoroughly open, so that the returning air from the lungs may smoothly glide by. We have already studied the technique of Rechaka in Ujjâyî. In Bhastrikâ the same steps are taken to start and to complete Rechaka. First the hold on the nostrils is removed,[1] then Jâlandhara-Bandha is unlocked, afterwards the glottis is thrown open, and lastly by a simultaneous contraction of the chest and abdomen the air is slowly sent out of the recoiling lungs.

The Pûraka and Rechaka that respectively and immediately precede and follow Kumbhaka in Bhastrikâ Prâṇâyâma, differ from those Pûrakas and Rechakas which succeed each other without the interruption of Kumbhaka and which form the first part of this exercise corresponding to the practice of Kapâlabhâti. Inhalations and exhalations that successively follow each other are shallow, but the inhalation and exhalation that immediately precedes and follows Kumbhaka are made the deepest possible of their type.

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1 As will be stated later on the right hand removed from the nose is again to be placed on the right knee.

We shall now sum up this description of a single round of Bhastrikâ which consists of two parts, the first being exactly similar to Kapâlabhâti and the second roughly similar to Ujjâyî. The student begins with quick expulsions of breath following one another in rapid succession. When the necessary number of expulsions is done, the last expulsion is followed by deepest possible inhalation. After retaining his breath till he could do it comfortably, he exhales as deeply as possible. The end of this deep Rechaka completes one round of Bhastrikâ.

A few normal breaths for rest and the student is again ready for another round of this Prâṇâyâma.

Regarding the relative measures of Pûraka, Kumbhaka and Rechaka forming the second part of Bhastrikâ Prâṇâyâma, and the absolute measure of Kumbhaka therein, what we have said in the article on Ujjâyî also holds good here.

The author of *Gheraṇḍa-Saṁhitâ* recommends three rounds of Bhastrikâ for a man to keep himself fit. In our Âśrama we follow this very recommendation and find that an average man of health can keep up his health for practising three rounds of Bhastrikâ daily.[1]

Second Variety[2] :—We shall consider this variety in its two parts separately. Starting with the first part which corresponds to Kapâlabhâti, we notice that there is a difference in the arrangement of the glottis during respiration. The glottis is to be slightly contracted so that a frictional sound is produced while breath is ex-

1 This is not to be interpreted to mean that an average man of health can always find himself fit simply for practising three rounds of Bhastrikâ every day. What our statement means is this. In a well-balanced scheme of Yogic exercises, three rounds of Bhastrikâ form a suitable item. Such a scheme was published in *Yoga-Mîmâṅsâ* a few years ago and is to be found in Vol. II, on p. 286. The scheme is being practised all over India by several Yogic culturists at the recommendation of the Âśrama.

2 This variety is recommended by the author of *Haṭha-Pradîpikâ*.

pelled or taken in, but no substantial obstruction is offered to the passage of the air.[1] This slight contraction of the glottis once secured is to be maintained throughout this part of the exercise. Except for this difference, the first part of this type of Bhastrikâ is completely identical with Kapâlabhâti.[2]

The measure[3] of expirations in the first part of this

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1 Read foot-note on p. 168 of this volume and the paragraph to which it is appended.

2 In making this statement, we have followed the text of *Haṭha-Pradîpikâ* and not its commentary by Brahmânanda. The commentator is of opinion that even in the first part of this exercise only one nostril is to be used as will be described in the third and fourth varieties, and not both. We positively know that there are traditions in Southern India which conform to the descriptions of the third and fourth varieties of Bhastrikâ as noticed here and as recommended by Brahmânanda in his commentary. But this does not mean that his interpretation of the original text is correct. We shall give our reasons in brief for our difference of opinion.

The original text relating to inhalation and exhalation in the first part of Bhastrikâ runs as follows :—

मुखं संयम्य यत्नेन प्राणं घ्राणेन **रेचयेत्** ॥ H. P., II 59.

वेगेन पूरयेचापि ... ... ॥ H. P., II 60.

[Shut up your mouth. Make a forced expiration through the *nose* and then quickly inhale.]

Here the singular number of the word घ्राणेन has given an opportunity to the commentator to get support from the original text for his varieties of Bhastrikâ—the third and the fourth—which alone he recognizes. He explains घ्राणेन as घ्राणस्यैकतरेण रन्ध्रेण । [through one hole in the nose]. Now Svâtmârâma Sûri whenever he has to make a reference to *one* nostril or to both the nostrils either to be used alternately, invariably gives specific instructions to that effect. As any such instructions are absent here, we have to take घ्राणेन to mean *through the nose, that is, through both the nostrils.* The singular number of घ्राणेन need not present any difficulty, as Brahmânanda himself has explained that word elsewhere as *through both the nostrils.* In commenting upon घ्राणेनैव occurring in Lesson II 53, he writes as follows : घ्राणेनैव नासिकयैवेत्यनेनोभाभ्यां नासापुटाभ्यां रेचकः कार्य इत्युक्तम् ।

So we find that the original text describes the second variety of Bhastrikâ, but the commentator tries to find in that text descriptions of the third and fourth varieties, simply because he advocates the latter two and does not favour the former.

There are additional arguments in support of the view we have taken. But we abstain from quoting them here.

3 Svâtmârâma Sûri does not define this measure by putting a numerical restriction upon it. He is of opinion that the bodily strength of an individual should determine his or her measure in every case. He says :—

यदा श्रमो भवेद्देहे ... ... । H. P., II 62.

[When the physical frame is fatigued (the second part should start).]

variety agrees *in toto* with the measure of expirations in the corresponding part of the preceding variety. With the last expulsion of breath the second part begins.

The second part of this variety is similar to the second part of the first variety except in one detail. Here the deep inhalation and exhalation which respectively precedes and follows Kumbhaka are done through one nostril only instead of through both the nostrils as in the previous case. The nostril to be used for inhalation is always the right, whereas that to be used for exhalation is invariably the opposite one. Thus after the last expulsion of breath completing the first part of the exercise, deepest possible inspiration is made through the right nostril. Breath is retained according to the technique given in the first variety and then it is driven out, the expiration again being as thorough as possible. Needless to say that in this part of the practice the right hand[1] will all along be on the nose to regulate the passage of air. With deepest exhalation after Kumbhaka one round is finished. In order to be ready for the next round, the right hand is returned to its original position on the knee and a few normal breaths are taken.

Under the second variety, we have described only those features which distinguish it from the first. As all other features are entirely identical, for understanding them we refer our readers to what has been said about them under the first variety.

Third Variety :— Here again it is desirable to consider the variety in two parts, the first part corresponding to Kapâlabhâti and the second corresponding to Ujjâyî. The only difference in Kapâlabhâti and the first part of

1 For the exact position of the hand and use of fingers read the general instruction given in Vol, III, on pp. 276–77.

the third variety is that in Kapâlabhâti both the nostrils are used for the expulsion of breath, but in this variety of Bhastrikâ only one nostril is used. Naturally the other nostril is to be kept closed, this closing being effected by the fingers arranged as in the case of Ujjâyî. According to Brahmânanda for every odd round of Bhastrikâ the right nostril is to be used and for every even round the other. Thus breath will be expelled after the fashion of Kapâlabhâti through the right nostril in the first, third, fifth and every succeeding odd round of this Prâṇâyâma; whereas the expirations will be done through the left nostril in the second, fourth, sixth and every even round that follows.

The second part of this variety corresponds exactly with the second part of the last variety, with only one exception. In the second variety the deep inspirations and expirations immediately preceding and following Kumbhaka are invariably done through the right and the left nostrils respectively. But in the third variety the deep inhalation is to be done through the right nostril in every odd round and through the left nostril in every even round, the deep exhalation being effected invariably through the opposite nostril. Thus in the first, third, fifth and every succeeding odd round, the right nostril will be used for deep inhalation and the left for the deep exhalation, of course after the intermediate Kumbhaka. But in the second, fourth, sixth and every even round that follows, the left nostril will be used for deep inspiration and the opposite one for deep expiration.

In short the technique of the third variety can be described as follows. Incessant respirations are started through the right nostril, keeping closed the left. When the necessary[1] number of respirations is gone through,

1 What number is necessary will be presently stated.

deep inspiration is made through the same nostril. After retaining breath according to one's measure, it is fully expelled through the left nostril. This completes the first round. The second round commences with forceful expirations as in Kapâlabhâti, using for this work the same nostril that was used for the last deep expiration, namely, the left. After due respirations, deep inspiration is made through that very nostril. Breath is retained and let out thoroughly through the right nostril. This completes the second round. Thereafter every odd round resembles the first and every even round resembles the second.

As throughout this exercise, in the first as well as in the second part of it, either one or both the nostrils are required to be kept closed, the right hand is always kept on the nose but the left hand is allowed to be on the knee. The fixing up of the chest, the play of the abdominal muscles and the arrangement of the glottis, thoroughly conform to the technique of the first variety.

Regarding the number of expulsions constituting the first part of every round and the total number of rounds that an individual should perform every day, what we have said in this connection in the first variety also applies to this variety.[1]

Fourth Variety :— In this variety the second part is the same as in the third; but the first part differs. Here the first part resembles the second part with two points of difference. In the first part, there is no Kumbhaka and breathing is not deep. Otherwise the two parts are exactly similar. Thus if a particular nostril is used for inspiration, the opposite is used for expiration as is always done in the second part. In simple words the technique may be put down as follows.

1 Also read the *General Hints* given at the end of this article.

Quick inspiration through the right nostril is immediately followed by quick expiration through the left nostril. This chain of incessant inspirations and expirations is prolonged till the individual feels healthily fatigued. That constitutes the first part of the first round. This is followed by the deepest possible inspiration through the right nostril, the necessary retention of breath and the final expiration through the left nostril, which completes the second part of that round and also the round itself. Then the second round commences with quick inspirations through the left[1] nostril, and expirations through the right. In the second part, Pûraka is done through the same nostril as in the first part, that is, through the left, and after due Kumbhaka, Rechaka is done through the right nostril.

As in the last variety so in this, the first round is a model for every succeeding odd rounds and the second for every succeeding even rounds.

What we have said about the measures of the first three varieties applies to this type of Bhastrikâ also.

If we examine all the varieties of Bhastrikâ we find that the first part consists of a quick succession of Rechakas and Pûrakas as in Kapâlabhâti and the other part consists of deep Pûraka, Kumbhaka and deep Rechaka as in Ujjâyî. That is why we have said that Bhastrikâ is equal to Kapâlabhâti plus Ujjâyî.

Kapâlabhâti plays such a prominent part in Bhastrikâ that whatever we have said[2] regarding Âsana appropriate to Kapâlabhâti applies to this exercise also. Thus a physical culturist should practise Bhastrikâ while sitting

1 The same through which Rechaka of the previous round was done.

2 See the opening paragraphs of the technique of Kapâlabhâti in the second number of this volume.

and a spiritual culturist should always take the Lotus Pose throughout the practice of this Prâṇâyâma. While sitting in Padmâsana whether the hands are to be folded as is required by the technique of that posture or whether they are to rest on the knees forming what is called Jn'âna-Mudrâ, is left to the choice of the individual. It must be noted, however, that throughout the third and the fourth varieties and during the second part of the first and the second varieties, the right hand has to manage the nostrils and cannot keep company with the left which invariably enjoys the privileged position of resting either on the knee or on the heels arranged in front of the abdomen. The two Bandhas, namely, Mûla and Jâlandhara have a place in the technique of this Prâṇâyâma as they form a part of Padmâsana. As regards the former we might at once say that instructions given for its formation etc., in Kapâlabhâti apply *in toto* to the case of Bhastrikâ. We have, however, pointed out that Jâlandhara-Bandha has no place in Kapâlabhâti for obvious reasons. The case of Bhastrikâ stands on a different footing. Being a Prâṇâyâma, it requires the use of the Chin-Lock at the time of Kumbhaka. It is to be remembered, however, that Mûla may be maintained throughout the succession of different rounds, but Jâlandhara is to be used at the time of Kumbhaka only, otherwise the neck is to be kept erect.

For knowing the place, seat, time etc., suitable to the practice of Bhastrikâ, we refer our readers to the article on Prâṇâyâma in Vol. III.

CONCENTRATION :—

Concentration to be practised in Bhastrikâ does not differ from the one recommended under Kapâlabhâti for both the types of Yogic culture, spiritual as well as physical.

GENERAL HINTS :—

Something has already been said under each variety of Bhastrikâ regarding its average measure. The following discussion is intended to make this question of measure clearer to the readers and to suggest progressive arrangements for their choice.

We have laid down the following equation :—

Ujjâyî plus Kapâlabhâti is equal to Bhastrikâ. Does it mean that the exercise of Bhastrikâ can singly replace the two exercises of Ujjâyî and Kapâlabhâti ? Yes, theoretically it can; but in practice it is not desirable to do so. We shall consider the cases of physical and spiritual culturists separately.

In our discussion on Ujjâyî, we have advised a physical culturist to avoid Kumbhaka at least in the beginning. The same advice holds good even in regard to Bhastrikâ. So a beginner when he starts with Bhastrikâ as a measure of physical culture, starts without Kumbhaka and will have eleven expulsions of breath followed by one deep inspiration and one deep expiration. Of these he will have three rounds. Thus in all there will be thirty-three expirations of Kapâlabhâti type and three deep inspirations and expirations of the Ujjâyî type, speaking roughly. These very inspirations and expirations can again be arranged in four rounds : three rounds of Kapâlabhâti of eleven expulsions each and one round of Ujjâyî of three breaths each. Now our experience has taught us that the three rounds of Bhastrikâ put a greater strain on the system than the three rounds of Kapâlabhâti and one round of Ujjâyî put together. This statement may not appeal to one who examines these exercises on a smaller scale, but when they are compared on a larger scale the truth of it becomes at once evident.

Further our readers may recall what has been stated in the last but one paragraph of the article on Kapâlabhâti in the second number of this volume. There we have said that as a breathing exercise Kapâlabhâti is less innocent than Ujjâyî. But if Kapâlabhâti is less innocent than Ujjâyî, Bhastrikâ is much less innocent that way. Hence we should strongly advise a beginner first to start with lessons in Ujjâyî alone. When he is practised to it a little and finds the same comfortable, he should add Kapâlabhâti to his programme of the Yogic exercises. He might think of practising Bhastrikâ, only when he becomes capable of taking up Kumbhaka. Here again we would advise a cautious arrangement. The three rounds of Kapâlabhâti may give place to three rounds of Bhastrikâ to begin with. Afterwards as the practice develops, the first part of Bhastrikâ may be broken up into convenient groups of sixty, forty, thirty and twenty each, every group being followed by the second part. Thus each round of Bhastrikâ will be broken up into 2, 3, 4 and ultimately into six rounds. While laying down the measure of Kapâlabhâti, we have recommended six rounds of it as the maximum for any physical culturist. Now if each round of Kapâlabhâti is substituted by six rounds of Bhastrikâ, the total number of Bhastrikâ rounds amounts to thirty-six. We are sure this is more than sufficient for the needs of any student of physical culture.

When the rounds of Bhastrikâ in the daily scheme of exercises exceed nine, it is desirable that the rounds of Ujjâyî are proportionately lessened. And when the maximum of thirty-six rounds is attained in Bhastrikâ, Ujjâyî is dropped altogether.[1]

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1 What has been said in this and the preceding paragraphs is intended to give the readers a general idea regarding the adjustment of breathing exercises. It is not meant to lay down any hard and fast rules. It may be pointed out here again, that Bhastrikâ with twenty expirations is recommended by the author of *Gheraṇḍa-Saṁhitâ*.

The needs of a spiritual culturist are always greater than those of a physical culturist, so far as the Yogic exercises of spiritual value are concerned. Bhastrikâ is emphatically an exercise of that nature. Hence Yogic students of spiritual culture require a larger measure of Bhastrikâ than the one that is recommended above.

In discussing the spiritual measure of Kapâlabhâti, we have advised three rounds of three minutes each. Now when a spiritual student takes to Bhastrikâ, he should progressively break up these three rounds into six rounds each, so that the total number of Bhastrikâ rounds would be eighteen at a sitting. If the student stands in need of a larger dose of Bhastrikâ for the day, he should not subdivide the eighteen rounds any more ; but should add to these rounds or should have a larger number of sittings in the day. In arranging for this extra dose of Bhastrikâ students should never fail to consult an expert whom they have chosen as their guide.

Out of the eight varieties of Prâṇâyâma, Bhastrikâ has been mentioned as peculiarly capable of rousing the spiritual force. This Prâṇâyâma best prepares the mind for Pratyâhâra, Dhâraṇâ, etc. It is a wonderful exercise for lifting the individual above his flesh, and for bringing him face to face with the serene spiritual light. Practise Bhastrikâ religiously for a few months and the ecstatic joys of a Yogin are yours. Do not allow your enthusiasm to get the better of your reason, however, ever remembering the cautions pronounced at the end of the articles on Ujjâyî[1] and Kapâlabhâti.[2]

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1 Vide Vol. III, p. 275. 2 Vide Vol. IV, p. 161.

PHYSIOLOGICAL AND SPIRITUAL VALUES OF PRÂṆÂYÂMA[1]

THE physiology of normal respiration was described in the second, third and fourth numbers of Volume III of this journal. In the same volume, in numbers three and four, we studied two meditative poses, namely, Svastika and Sama, in addition to two others, namely, Siddha and Padma, which were studied in the third number of Volume II. These four Âsanas are very appropriate to Prâṇâyâma. The most important general features which are common to all Pranayamic practices were discussed at some length in the article on Prâṇâyâma in Volume III. Separate articles on Ujjâyî and Kapâlabhâti have appeared in numbers three and four of Volume III and the second number of Volume IV respectively. In this number an article on Bhastrikâ has been published in this very *Section*. In the present article we wish to evaluate Prâṇâyâma from the physiological and spiritual points of view. First we shall ascertain its physiological value and then the spiritual.

The physiological value of an exercise depends upon its capacity to confer health upon the person practising it. The greater the degree of health an exercise is calculated to induce, the more valuable it will be. But what is health? Health may be defined as the harmonious functioning of the different systems working in the human body. The principal systems are the nervous, the endocrine, the respiratory, the circulatory and the digestive. Out of these the nervous and the endocrine are of supreme importance, but even they have to depend upon the other systems enumerated above. We shall

1 We have tried to write this article in as popular a language as the subject allowed it. We have not, however, sacrificed scientific accuracy; but as a result of our attempt to make things simple many statements have remained scientifically incomplete. To give one example out of many, in our discussion about the organs of elimination we have made no reference to the skin which is, perhaps, as important as the other three organs which have been mentioned therein. Our readers are, therefore, requested not to expect scientific completeness in this general article on Prâṇâyâma.

now proceed to see how many and in what way and to what degree, Prâṇâyâma is able to influence these systems and secure their efficient and harmonious working. But before we do this we shall make a brief reference to the functions of the different systems under discussion.

Starting with the nervous system, we may compare it to a big power house generating electricity and the network of wires that distributes it to the different machines in a factory. The brain is the power house. The nerves starting from the brain itself, the spinal cord which is the tail of the brain and the different individual nerves that arise from the spinal cord, all of these represent the electric wires in the factory of the human body. In a regular factory every piece of machinery is set in motion by the electric current carried across the wires from the power house. Similarly, in the factory of the human body all physical movements depend upon the impulses carried across the nerves from the brain. Let the power house go out of order or let there be obstruction in the current of electricity flowing across the wires, the whole machinery will come to a standstill. Similarly if the brain is deranged or the nerves are so degenerated as not to convey the impulses, physical movements will stop. The effects of this cessation of physical movements have a deeper meaning than an ordinary reader can imagine. Our digestion, our blood circulation and even our respiration is controlled and carried on by the nervous impulses brought to the organs responsible for these functions, from the brain. In case the nervous impulses do not start or having started do not reach their destination, all life processes will stop, and even the spark of life may become extinct. Such is the supreme importance of the nervous system.

Now in the illustration of the power house taken in the previous paragraph, granting that the power house does generate electricity, and the wires do conduct that electricity to their terminals, if the current of electricity is not of sufficient

strength, the machinery supplied by that electricity will not move. For the necessary movement the electric current must be of the required strength. In the machinery of the human body this strength of the current depends upon the secretions of what are called the endocrine glands. The whole nervous mechanism may be in perfect order, and yet if the endocrine secretions are not available in the necessary quantity and of the necessary quality, the strength of the nerve impulse and the nerves themselves later on will degenerate. Consequently physical movements and the life processes will become dull and languid. Let us take one of these glands for illustration, say the thyroid. This is the most popularly known endocrine gland, although the sex glands both in males and females, the pituitary body etc., are of no less importance. Remove the thyroid from a healthy person and his eyes begin to be pale, his cheeks begin to sink, his muscles begin to be flabby or lean, his hair begin to turn gray and he becomes a prey to premature old age. Restore the thyroid and the man begins to show all the signs of youthful enthusiasm. Symptoms of old age are gone, the fellow begins to walk erect, things brighten and life again becomes a pleasure. Thus it will be seen that the endocrine system stands on the same level of physiological importance as the nervous system.

Study of human physiology clearly indicates that these two systems of infinite importance in the human organism have to depend upon the circulatory system for getting the necessary blood supply and upon the respiratory and the digestive systems for getting the blood of the necessary quality. The circulatory system consists of the heart, the arteries, the veins and the capillaries. It is the duty of this system to take the blood to every tissue in the human body. The nerves and the endocrine glands, if they are starved for want of the necessary blood supply, will degenerate in their functions. The result will be what has been stated in the last two paragraphs.

It is, however, of no practical use to have the circulatory system in an efficient condition, if the quality of the blood that is being circulated through it is not rich. If the blood is loaded with toxins, the efficiency of the circulatory system will be of little consequence. So the quality of the blood must be kept rich, and for this human physiology has to depend upon the respiratory and the digestive systems.

In order that the blood may be rich in quality, it must carry the necessary quantity of oxygen with it and also contain elements of nutrition for the tissues. The blood gets oxygen from the air inhaled and the elements of nutrition from the absorption of food-stuffs and drinks. The quantity of oxygen the blood can carry, will mainly depend upon the efficiency of the respiratory system. With defective respiration the absorption of oxygen into the blood will be insufficient and the tissues supplied by the blood deficient in oxygen will be starved. So also one may use rich food-stuffs and luxuriant drinks, but if the digestive apparatus is not in order, there will be little digestion and absorption and most of the stuff will be wasted, with the result that the blood will contain very small elements of nutrition. Thus we see that the respiratory and the digestive systems must work efficiently if the blood supply is to be constantly kept rich in quality.

A defective working of the respiratory and digestive systems not only keeps the blood poorer in quality for want of oxygen and nutritive elements, but it loads the blood with waste matter which is poisonous. We shall explain this point further. Carbon dioxide is constantly manufactured in the body. The efficiently working circulatory system carries this poisonous gas to the lungs and there gets rid of it. But if the efficiency of this system suffers, this waste matter accumulates in the different tissues and there produces toxic effects. Similarly food-stuffs leave a very large wastage. It is for the bowels to throw it out. The smaller the degree of digestion and

absorption of food and drink, the larger is the wastage. And if the bowels which are anatomically included in the digestive tube, do not work efficiently, this waste matter remains lodged in the colon or even in the small intestine for several days, giving rise to highly dangerous toxins. These toxins get into the current of the blood through the walls of the bowels and poison the blood ; and the poisonous blood being circulated throughout the body, leads to the degeneration of the whole organism.

We have seen in the previous paragraph how the lungs and the bowels act as organs of elimination. The kidneys are also organs of the same type. Some of the waste products which are poisonous in nature, are driven out of the human organism with the urine. If the kidneys do not function satisfactorily these poisonous substances are held back and find a resting place especially in the different joints of the human body. People suffering from gout have invariably defective kidneys. Thus it is clear that the blood in order to be rich in quality has to depend upon the respiratory and the digestive systems and in order to be free from toxic elements, it has to depend upon the organs of elimination. In this way we have studied some of the broadest features of the most important physiological systems upon the harmonious functioning of which, human health depends. We shall now proceed to examine how Prâṇâyâma helps the efficient functioning of these systems.

Starting with the organs of elimination, we find that the bowels and the kidneys are situated in the abdomen and the lungs in the chest. In normal respiration the alternate rise and fall of the diaphragm and the alternate contraction and relaxation of the abdominal muscles, give constant movement and gentle massage to the bowels and the kidneys. During Prâṇâyâma in both inspiration and expiration as well as in retention of breath, this movement and massage are greatly

accentuated. If there be any congestion it is relieved for the pressure exerted. The nerves and muscles which control the functions of the bowels and the kidneys are all toned up. Thus the bowels and the kidneys derive benefit not only during the time that Prâṇâyâma is being practised, but even for the remaining part of the day. The nerves and muscles once toned up continue to maintain that tone for a considerably long time. The bowels and the kidneys rendered healthier for Prâṇâyâma carry on their functions of elimination more effectively.

The same is the case with the lungs. As we have seen in the article on respiration, healthy respiration depends upon strong respiratory muscles and good elasticity of the lungs. On the physical side Prâṇâyâma is a culture of these muscles and the lungs. By opening out the chest to its fullest extent several times a day and by putting the lungs on a stretch to the utmost possible extent, these organs are best educated to perform their functions satisfactorily. As in the case of bowels and kidneys so in the case of the lungs the training given to them for a short time prepares them for an efficient working during the remaining part of the day. Thus Prâṇâyâma is a very valuable exercise for the organs of elimination.

Organs of digestion and absorption do not stand on a different level so far as the effects of Prâṇâyâma on them are concerned. The stomach, the pancreas and the liver which play a very prominent part in the digestion of food and drink, are all exercised in Prâṇâyâma, for the massage given to them by the diaphragm and the abdominal muscles. In a very large number of people who are dyspeptic and constipated, the liver becomes habitually congested and consequently faulty in function. For relieving this congestion Prâṇâyâma is an excellent exercise. An unhealthy pancreas gets very good stimulus and correction for Pranayamic exercises. In our clinical experience we have noticed a number of cases being

effectively relieved of their gastric disorders, mainly as the result of Prâṇâyâma. With a perfectly functioning digestive system, absorption also becomes perfect, and the blood is enriched with the necessary nutritive elements.

A liberal supply of oxygen to the circulating blood current is of supreme importance for the health of an individual. This supply is effectively improved by means of Prâṇâyâma. The scope of this article does not allow us to enter into physiological details. We refer our readers to the volumes of *Yoga-Mîmâṅsâ* for evidence that conclusively proves the statements that we are presently going to make.

Prâṇâyâma performed according to the technique described in *Yoga-Mîmâṅsâ* is capable of improving the oxygen supply of the blood as no other exercise is. This is not because during the process of Prâṇâyâma an individual absorbs a larger quantity of oxygen, but because of the training of the respiratory system which helps the individual for twenty-four hours. The impression that an individual absorbs larger quantities of oxygen in Prâṇâyâma is merely a superstition. We shall explain how. Any Prâṇâyâma worth the name should have every round of it to cover at least one minute. Now an average person inhales in one minute about 7,000 c.c. of air during normal inspiration. The same individual during Prâṇâyâma will inhale at the most 3,700 c.c. in one minute. The total intake of air being far smaller in Prâṇâyâma the absorption of oxygen is consequently smaller. In the *Scientific Section* we have conclusively proved on the strength of experimental evidence that the degree of absorption of oxygen does not vary in proportion to the time for which breath is retained. For this reason even when breath is held even for half a minute, the increase in the absorption of oxygen over the normal absorption is not considerable. Thus it will be clear that the idea that an individual absorbs larger quantities of oxygen during Prâṇâyâma is a myth.

Where then is the advantage of practising Prâṇâyâma for enriching the blood with oxygen? The answer to this question is as follows. Even when temporarily during the process of Prâṇâyâma an individual absorbs smaller quantities of oxygen, the Pranayamic exercises so train the respiratory apparatus that during the remaining part of the day respiration is carried on most efficiently and larger quantities of oxygen are absorbed throughout the day, than they ordinarily would be.

In our article[1] on Ujjâyî, we have recommended four rounds of it in a minute. This recommendation is for people who practise only Rechaka and Pûraka. For ordinary purposes of physical culture this is sufficient. It is to be noted that when four rounds of Ujjâyî are performed in a minute, the quantity of oxygen absorbed even during the Pranayamic process is much larger than in ordinary respiration. Again the training of the respiratory apparatus by means of having four rounds of Ujjâyî in a minute, is sufficient for all practical purposes of physical culture.

With the efficient functioning of the organs of digestion, elimination and respiration, the quality of the blood remains satisfactory. Now this blood is to be distributed to the different tissues of the body. This is the duty of the circulatory system and especially of the heart. It has been admitted even by the Western scientists that practices in deep breathing exercise a gentle massage on the heart. We have carefully studied the pressure changes that are produced roundabout the heart in Prâṇâyâma. And we are happy to note that the technique of Prâṇâyâma as it is given in Yoga, establishes conditions much more favourable for this massage, than the conditions secured in the Western type of deep breathing. For the elucidation of this point we refer our readers to the article on the pressure changes in Prâṇâyâma.[2] Now the heart which is the principal organ of circulation being made healthier for Prâṇâyâma, the whole circulatory system works satisfactorily.

1 Vide Vol. III, Nos. 3-4. 2 Vide Vol. IV, number one.

But the matter does not end there. In Bhastrikâ, especially in its part which corresponds to Kapâlabhâti, vibrations start and spread themselves to nearly every tissue in the human organism, the arteries, the veins and the capillaries included. Thus the whole circulatory system is exercised and massaged during Prâṇâyâma and is prepared for efficient functioning.

Next we come to the nervous and the endocrine systems. The rich quality of the blood and its satisfactory distribution to all the nerves and glands ensure their health. During Prâṇâyâma especially during Bhastrikâ, the circulation of the blood becomes very rapid and the quality of the blood is also rendered very rich.[1] This richer and more liberal blood supply brought to the endocrine glands makes them healthier. The same is the case with the brain, the spinal cord, the cranial and the spinal nerves and the sympathetic.

The advantage derived from a richer and more liberal blood supply is not the only advantage the nervous system gets from Prâṇâyâma. The nerves are directly exercised. During Pûraka the diaphragm is contracted and lowered and the abdominal muscles are kept controlled, that is, slightly contracted. The combined action of the diaphragm and the abdominal muscles pulls up the lower part of the spinal column. If Jâlandhara-Bandha is practised the upper part of the spinal column is also pulled up. This pulling up of the vertebral column as a whole, gives exercise to the sympathetic and the roots of the spinal nerves.

Limitations of this article do not allow us even to make a passing reference to the exercise of the brain by the Pranayamic processes. Suffice it to say that the whole nervous system is very finely exercised by the practice of Prâṇâyâma. Thus the nervous and the endocrine systems which are of supreme importance in the human physiology and also the respiratory the circulatory and the digestive systems upon which the health

1 Evidence on this point has already been collected in our laboratory and will in due course of time, appear in the pages of this journal.

of the first two systems depends, are all simultaneously exercised in Prâṇâyâma. Every round either of Ujjâyî or Bhastrikâ makes the organism healthier. In fact the Yogic seers of ancient India looked upon Prâṇâyâma as the one exercise that could make every life process supremely healthy. Some of them were so enthusiastic in their optimism about the physiological efficiency of Prâṇâyâma that they ruled out all other exercises for securing the health of the human body. From our own experience we can safely say that no physical exercise can even have one hundredth of the efficacy of Prâṇâyâma. In fact Prâṇâyâma is not only the control of the different physiological functions but it is the control of the very life processes that vitalize the human organism.

* * * * *

The spiritual value of Prâṇâyâma is none the less inferior. People fail to understand how a physical process could lead to spiritual development. To-day we have not got sufficient *laboratory* evidence to convince those that are prejudiced against Yoga. But we can surely offer a few remarks on this point which will appeal to people who have an impartial but sympathetic attitude towards Yoga. Students of endocrinology are coming to the conclusion that the endocrine glands are capable of influencing not only the physiology but also the psychology of an individual. The most optimistic of them feel that they could change criminals into saints by means of treating endocrine glands. Personally we do not know how far this optimism is justifiable. In fact orthodox scientists do not accept everything that endocrinology has to say. But even they cannot deny the fact that the endocrine glands materially influence the psychology of a person.

Hypothetically we are satisfied that particular nerve centres have got influence on human psychology similar to the influence of the glands of internal secretion. That these centres of the human nervous system could be effectively worked upon and made to experience extraordinary impulses and vibrations, is a fact of every day experience for practical

students of Yoga. It is our fond hope that a day will arise when these impulses and vibrations could be demonstrated objectively in the laboratory of the *Kaivalyadhâma* and their influence on human psychology could be scientifically established. The day may come when it will. To-day we will explain how the different centres are worked upon through the physiology of Prâṇâyâma. As the scope of this article does not allow us to enter into details, we will give here merely a broad outline of our explanation.

A reference has already been made to the pulling up of the spinal column in Prâṇâyâma. By means of different Bandhas introduced in the technique of Prâṇâyâma, that pull is made to exercise very considerable tension upon the spine from the bottom to the highest point in it. This tension gives strong peripheral stimulus to the whole nervous system.

In the first number of this volume we have discussed the intra-thoracic and intra-pulmonic pressure changes in Prâṇâyâma. The intra-abdominal pressures also undergo considerable changes in Pranayamic exercises. It can be easily proved that all the three types of pressures referred to just now, are rendered extremely high during Prâṇâyâma practised with the three Bandhas, Mûla, Uḍḍiyâna and Jâlandhara. This high pressure gives peripheral stimulus to the different nerve plexuses situated in the abdomen and the thorax.

Again we are hypothetically satisfied that the practice of Prâṇâyâma introduces high pressures both in the central canal of the spinal cord and the ventricles of the brain. These pressures centrally stimulate the whole nervous system. Owing to these central and peripheral stimuli, the human consciousness begins to be internalized and supersensuous perceptions begin to be possible. Worlds subtler and still subtler begin to be opened out in proportion to the consciousness itself getting more and more refined, till at last the individual consciousness merges into the cosmic and the individual becomes one with the Infinite.

Figs. XXXVII-XXXVIII

Vakrâsana or the Twisted Pose.

(The upper picture illustrates the Right Spinal Twist whereas the lower one illustrates the Left Spinal Twist)

VAKRÂSANA

or

THE TWISTED POSE

THE NAME :—

The pose is called Vakrâsana because in taking it, the spinal column is twisted. In Sanskṛita Vakra means *twisted*. Vakrâsana is only a simplification of Ardha-Matsyendrâsana and has been introduced in Yogic culture by us as an easier exercise preparatory to that pose.

THE TECHNIQUE :—

To begin with, the student takes his seat stretching out his legs so as to keep them close together. Then he raises one of his knees, say the right, and withdraws his foot till it rests by the side of his left knee. Next he places his right hand behind his back without much twisting his trunk. Thereafter the left arm is passed round the right knee from outside and the left palm is placed on the ground. In doing this the student pushes the right knee as far to the left as possible, all the while trying to twist his trunk to the right as best as he can. The knee is, however, kept firmly in its position, offering good resistance to the opposite arm. The last part of the technique is gone through when the student turns his face to the right, till his chin finds itself coming exactly over the right shoulder. This secures a complete twist to the right for the spinal column. Fig. XXXVII illustrates the right spinal twist.

Instead of starting with the right knee the student can start with the left and obtain the left vertebral twist. Fig. XXXVIII illustrates the left spinal twist.

The right and left twists put together should not take more than three minutes as the maximum time devoted to them.

UḌḌIYÂNA-BANDHA OR THE RAISING OF THE DIAPHRAGM

UḌḌIYÂNA is an exercise of the diaphragm and the ribs. When expressed in a popular[1] language its technique may be described as follows.

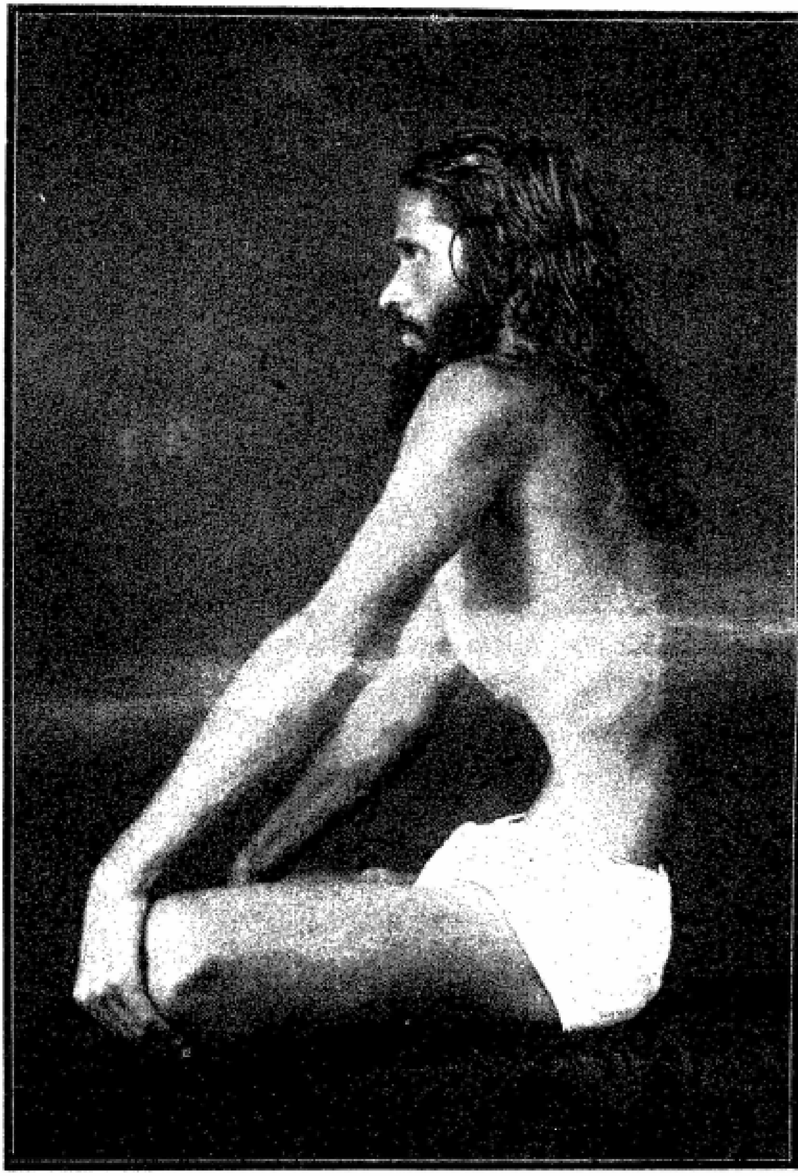
As this Bandha is practised either in sitting or in standing, the student poses himself as shown in Fig. XXXIX and the following, respectively. In these pictures, hands are shown to be resting either on the knees or on the thighs. This position of the hands enables them to be firmly pressed against their support and thus to fix up the muscles of the neck and the shoulders. Having taken this posture the student secures the deepest possible expiration by vigorously contracting the front muscles of the abdomen. The chest also stands contracted. While the breath is held out, the muscles of the neck and the shoulders are fixed up by firmly pressing the hands either against the knees or against the thighs as the case may be. Then a vigorous mock inhalation is attempted by raising the ribs and by not allowing the air to flow into the lungs. Simultaneously the front abdominal muscles are completely relaxed.

The fixing up of the neck and shoulders, the vigorous mock inhalation preceded by the deepest possible exhalation, and the simultaneous relaxation of the contracted front abdominal muscles, these three actions complete the technique of Uḍḍiyâna. Automatically[2] the diaphragm will rise up and

1 This Bandha has been subjected by us to a very large number of X-ray and other experiments many of which have already appeared in *Yoga-Mîmâṅsâ*. Hence we are in a position to give a detailed scientific description of its technique. Looking to the popular character of this *Section*, however, we have sketched its technique in the simplest terms possible.

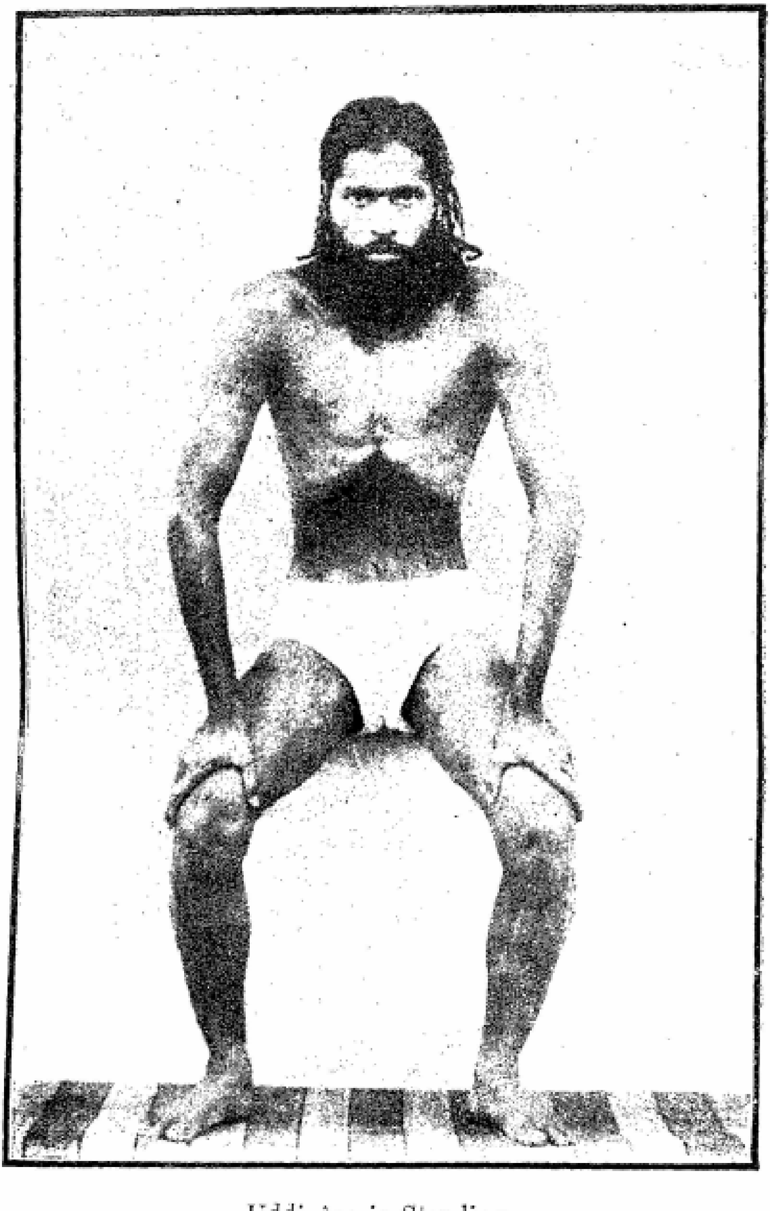
2 The pressure changes in the chest and abdomen which are responsible for this automatic abdominal depression, have been detailed in this journal, in places too numerous to be quoted here. Zealous students of Yogic physiology may read the *Scientific Sections* of Vols. III & IV.

Fig. XXXIX



Uḍḍiyâna in Sitting.

Fig. XL



Uḍḍiyâna in Standing.

the abdomen will undergo a pronounced depression, producing the concave appearance shown in Fig. XXXIX and the following. A slight forward bent of the trunk will be helpful in securing greater abdominal concavity. This position is required to be maintained throughout the exercise of Uḍḍiyâna.

When the student finds that he can no longer hold his breath out comfortably, he relaxes his neck and shoulders, lets go the ribs and slowly starts inhalation, allowing the abdominal depression to be effaced gradually. When inhalation is completed, one round of the Uḍḍiyâna exercise is finished.

Uḍḍiyâna means *rising up* and Bandha means *contraction of particular anatomical parts.* This exercise is called Uḍḍiyâna-Bandha because the muscular contractions described above enable the spiritual force[1] to rise up. Anatomically this Bandha may be called Uḍḍiyâna because it raises the diaphragm.

CULTURAL & THERAPEUTICAL ADVANTAGES :—

Uḍḍiyâna is a very fine exercise for the abdomen. Its therapeutical value against constipation, dyspepsia, liver troubles etc., is very great. Its spiritual worth is greater still.

CAUTION :—

People suffering from circulatory or serious abdominal troubles should not take to this exercise on their own responsibility.

1 This force is locked up in the lower region of the abdomen. Uḍḍiyâna is one of the different exercises capable of letting loose this force and making it to travel upward along the spine.

NAULI OR THE ISOLATION AND ROLLING MANIPULATION OF THE ABDOMINAL RECTI

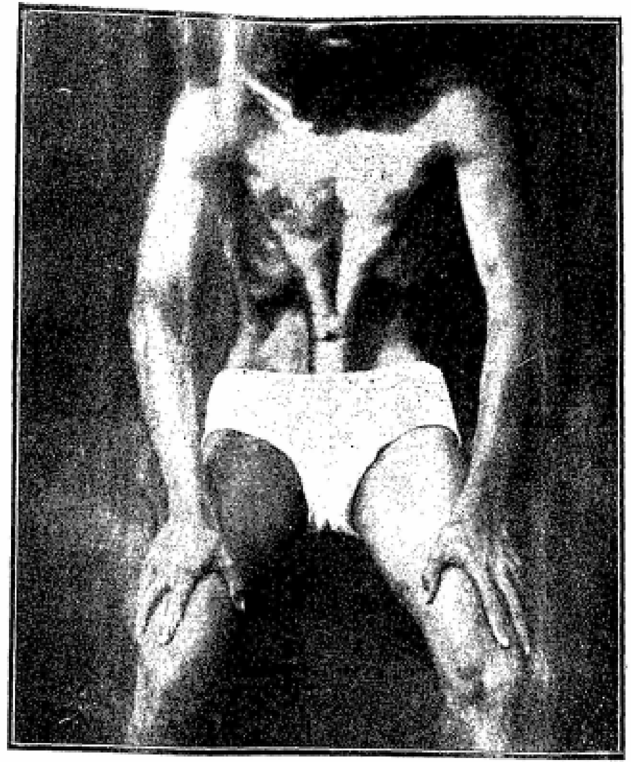
NAULI is an abdominal exercise. Its principal feature is the isolation and rolling manipulation of the abdominal recti. Generally it is practised in standing, although its practice in a squatting position is required at the time of Basti—Yogic flushing of the colon.

The way to Nauli lies through Uḍḍiyâna. In fact Nauli may be equated to Uḍḍiyâna plus the isolation and rolling manipulation of the recti. What it means is this. While practising Nauli the student has to go through the whole technique of Uḍḍiyâna; and then while maintaining Uḍḍiyâna, has to isolate the abdominal recti and roll them from right to left and from left to right, clockwise and counter-clockwise.

For securing Uḍḍiyâna, as we have already seen, the student has first to fix up his neck and shoulders and then to try mock inhalation preceded by the deepest possible expiration. Simultaneously with this he has to relax completely all the muscles that go to form the front portion of the abdominal wall. For practising Nauli the position thus secured is to be treated as a preparatory position.

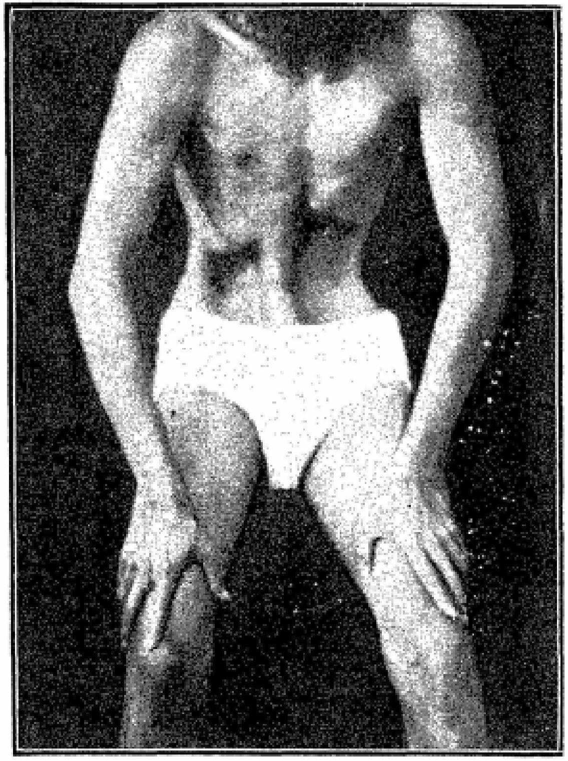
While maintaining Uḍḍiyâna the student repeatedly gives a forward and downward push to the abdominal point just above the pubic bone. This is the point where the two recti originate. A push at this point brings about contraction of these muscles while it leaves the other muscles of the front abdominal wall in a relaxed condition. An idea of the nature of this push can be had by imitating the straining of the constipated people when going to stool. The only difference in that straining and this push is as follows. In straining the whole pressure is exerted downward whereas in this push it is exerted forward as well as downward. Repeated attempts at

Fig. XLI



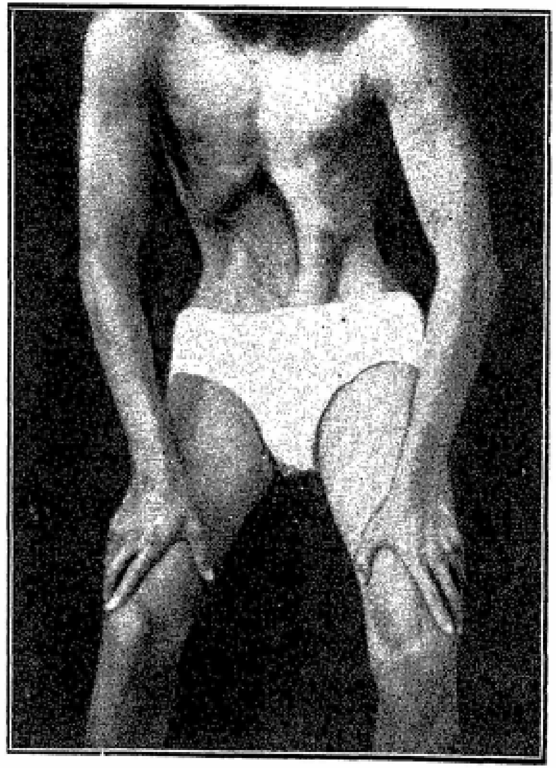
Nauli-Madhyama or the Central Aspect of Nauli.

Fig. XLII



Dakshiṇa Nauli or the Right Aspect of Nauli.

Fig. XLIII



Vâma Nauli or the Left Aspect of Nauli.

pushing out the point above the pubic bone, will isolate the recti from the adjoining muscles, because these muscles will be kept in a relaxed condition whereas the recti will be contracted. In every case of muscular isolation, the isolated muscle is contracted while the neighbouring muscles stand relaxed and inactive.

Once the two recti are isolated at the origin, the isolation will be almost automatically completed right up to the points where they are attached to the ribs above. Of course the push must continue all along. When the process of isolation is completed, the recti will stand side by side vertically crossing the abdomen as shown in Fig. XLI. This is called *Nauli-Madhyama* or the Central Aspect of Nauli.

Very often people fail to hit the exact point against which the pushing business is to proceed. In that case the whole abdomen is pushed out, the recti and other muscles as well. Nor is there any contraction secured. This error is to be studiously avoided. The whole attention is to be concentrated on the point just above the pubic bone. As soon as the student sees that he has not hit the right point, the push should be abandoned there and then, and a fresh attempt should be made in the right direction. Patience is sure to achieve success.

Nauli-Madhyama is only the first part of the whole exercise of Nauli. But there should be no hurry to proceed to the next part of it, unless and until full mastery over this part is obtained. The following tests may be applied to see whether real mastery over Nauli-Madhyama has been secured. (*i*) The isolation must be complete. The isolation may be known to be thorough only when thin contracted recti stand out very prominently, projecting themselves from the remaining part of the abdomen that comparatively sinks very deep under the ribs. (*ii*) The isolation must be easy. That is there should

be absolutely no labour required to bring out the recti, nor to withdraw them. Their projection and retraction must become possible several times in the same exhalation with the greatest facility. (*iii*) The isolation must be painless. Some thin people who happen to have cultivated good muscles in their youth, can stand the first two tests in practising Nauli-Madhyama ; but because of some intestinal disorders find the practice painful. Such persons should not try Nauli at all, till they get rid of the pain by some other means.

We particularly insist upon one's mastering Nauli-Madhyama because upon it mainly depends the efficiency one would get in the practice of Nauli as a whole. Not only this, but the success in Basti and Vajrolî also directly depends upon one's control over Nauli-Madhyama.

The next step in the practice of Nauli is to keep contracted and isolated the right and the left rectus alternately, while the left and right rectus along with the neighbouring muscles stand relaxed. When the right rectus alone is contracted and rolled off to the extreme right, it is called *Dakshiṇa Nauli* Again when the left rectus alone is contracted and rolled off to the extreme left, it is called *Vâma Nauli.* Figs. XLII and XLIII illustrate Dakshiṇa and Vâma Nauli respectively.[1]

We shall now proceed to see how this is done. While maintaining Nauli-Madhyama the student bends forward evenly over his thighs. Now if he wants to practise Dakshiṇa Nauli, he bends forward still further on the right-hand side, but stands a little erect on the left side. So also he gives his whole trunk a little lateral bend to the right. This sideward and forward bending makes the right rectus still more contracted and pushes it to the right side of the abdomen. Simultane-

1 Because of photographic requirements in all the illustrations of Nauli given here, the figure is shown with the head erect. In practice the head should hang down, so that the student can observe his abdominal work and concentrate upon the contracting muscles.

ously the straightening of the left side allows the left rectus to be relaxed, of course this relaxation being brought about by a conscious effort of the will.

If the student wants to practise Vâma Nauli, after securing Nauli-Madhyama he bends forward still further on the left and also gives a lateral bent to his trunk on that side. Side by side the right half of the trunk is held a little more erect. An effort is made to relax the right rectus. These operations will succeed in keeping the left rectus contracted and getting it rolled off to the left of the abdomen.

When the student gets full control of these three aspects of Nauli, he becomes ready for the final operations of rolling the recti clockwise and counter-clockwise several times over without a break in motion. These rolling manipulations alone go by the name of Nauli strictly speaking.

This performance depends upon a very cordial co-operation between the two recti. The two muscles are made to maintain a vertical wave across the abdomen that travels from left to right and from right to left so quickly that it becomes impossible even for an expert eye to follow its progress from point to point. Let us see how this is done.

Starting from Nauli-Madhyama, the left rectus is rolled off to the extreme left and the right rectus is kept relaxed. When the left rectus reaches the extreme left, it is relaxed there and then and simultaneously the right rectus is projected on the extreme right of the abdomen. From there it is rolled to the middle where it begins to disappear (because it is relaxed), and its place is taken by the fully contracted left rectus which carries on the wave of contraction to the extreme left, thus completing one round of Nauli. Several such rounds are taken in one exhalation. All the manipulations of the recti done in one exhalation constitute what we in our literature call one turn.

Similar wave of contraction can be made to travel from left to right also.

The maximum number of turns an average man of health can take in his daily practice of Nauli is seven. There is no harm if a strong man takes even as many as twenty-one turns of the exercise every day.

Nauli is strictly to be practised with an empty stomach.

Limitations :—

1 People on the wrong side of forty should not attempt this exercise unless they are advised by an expert.

2 People suspected of tuberculosis of the abdomen should never attempt Nauli on their own responsibility.

3 Sufferers from chronic appendicitis should avoid this exercise, if it is not recommended by an expert.

4 People suffering from high blood pressure should never take to Nauli.

5 The exercise is not available to boys and girls before the age of puberty.

CULTURAL ADVANTAGES :—

Best exercise for preserving and promoting the health of all the abdominal viscera.

THERAPEUTICAL ADVANTAGES :—

(*i*) An excellent remedy against dyspepsia and constipation.

(*ii*) Can correct faulty liver, spleen, pancreas and the kidneys.

(*iii*) Can overcome ovarian insufficiency.

(*iv*) Can stop painful menstruation under particular circumstances.

CULTURAL AND THERAPEUTICAL ADVANTAGES OF ÂSANAS

ŚALABHÂSANA OR THE LOCUST POSE

Cultural Advantages :—

Śalabhâsana is a fine exercise for the pelvis and the abdomen.

Therapeutical Advantages :—

Read what has been said in this regard under Bhujañgâsana.

ARDHA-ŚALABHÂSANA OR THE HALF LOCUST POSE

Cultural & Therapeutical Advantages :—

Ardha-Śalabhâsana gives the same advantages as Śalabhâsana. In the former case, one derives them only on a humbler scale.

DHANURÂSANA OR THE BOW POSE

Cultural Advantages :—

It will be readily seen that this posture is a combination of the two exercises, Bhujañgâsana and Śalabhâsana. Naturally it claims the advantages of both, though on a humbler scale. The intra-abdominal pressure here is not as great as in Śalabhâsana, because, even with full inspiration, the diaphragm does not press upon the abdominal viscera as tightly in this practice as in Śalabhâsana. The deep muscles of the back are exercised much better in Bhujañgâsana than in this pose ; because there they are *mainly* responsible for the backward curve of the trunk, whereas in this pose their work is largely done by the hands and legs tugging at each other. Again the wave of contraction and relaxation travelling up and down the spinal column, and which forms the principal

feature of Bhujañgâsana, is missed here. This pose has, however, a special advantage which cannot be had of the two preceding Âsanas that are combined in it. The two recti as well as the other muscles of the abdomen that flex the hip-joints, are more fully stretched in this pose, than in the other two. This is due to raising backward simultaneously both the trunk and the thighs.

Therapeutical Advantages :—

For therapeutical advantages read what is said in this regard under Bhujañgâsana.

ARDHA-MATSYENDRÂSANA OR THE HALF MATSYENDRA POSE

Cultural Advantages :—

If the spinal column is to be maintained in the best of health, it must be trained to execute all the movements through which it is capable of going. The natural movements of the spine may be of six varieties: forward and backward bents, side bents to the right and left, the left twist and the right twist. In practising Sarvâñgâsana, Halâsana, Paśchimatâna and Yoga-Mudrâ we educate the spine in forward bents. The training of backward bents is given to the vertebral column in Matsyâsana, Bhujañgâsana, Śalabhâsana and Dhanurâsana. Ardha-Matsyendrâsana in one pose gives the two side twists with the greatest efficacy and as such has a very great cultural value. This pose also secures the side bents for the spine, although not on a large scale. Hence every scheme for the culture of the spine must find a prominent place for Ardha-Matsyendrâsana and must co-ordinate it with the backward and forward movements of the spinal column.

Therapeutical Advantages :—

As a curative measure Ardha-Matsyendrâsana can be effectively prescribed against constipation and dyspepsia.

Against enlarged and congested liver and spleen and inactive kidneys, it could be practised with advantage. The best therapeutical use to which this Âsana could be put, is to co-ordinate it with other Âsanas or Yogic exercises that may be indicated in the case of a particular patient.

VAKRÂSANA OR THE TWISTED POSE

Cultural & Therapeutical Advantages :—

Vakrâsana is Ardha-Matsyendrâsana simplified. As such it claims all the advantages of the latter pose, although they are available in this Âsana on a moderate scale.

SIṀHÂSANA OR THE LION POSE

Cultural Advantages :—

The pose by itself has not got much physical value, nor has it got any spiritual value also. So it need not be maintained for any considerable time. A maximum of three minutes has already been prescribed in its technique. Its great physical and therapeutical importance when practised with the *Tongue-Lock* in rapid succession, has been discussed under Jihvâ-Bandha.

It is to be remembered, however, that the Âsana is a very valuable exercise as a preparation for the three Bandhas: Uḍḍiyâna, Mûla and Jâlandhara, even when by itself it is not of much consequence either physically or spiritually. The mere widely throwing open of the jaws and the drawing out of the tongue make the muscles of the neck elastic, thus facilitating the formation of the *Chin-Lock*. The attempt at Jâlandhara-Bandha, the pressure on the knees exerted through the hands, the bracing up of the spine and the throwing out of the chest, all put together, give a sort of control over the abdominal recti, thus preparing the student for Uḍḍiyâna. Again lifting up the buttocks with a view to hold the spine

erect and sit lightly on the heels, tends to the contraction of such pelvic muscles as facilitate the practice of Mûla-Bandha. Thus it will be seen that Simhâsana is a fine exercise preparatory to the three Bandhas.

For Therapeutical Advantages read under Jihvâ-Bandha.

VAJRÂSANA OR THE PELVIC POSE

Cultural & Therapeutical Advantages :—

Vajrâsana is principally a meditative pose. Its physical advantages are not considerable.

SUPTA-VAJRÂSANA OR THE SUPINE PELVIC POSE

Cultural Advantages :—

The abdominal recti are fully stretched and the bowels and other abdominal viscera are considerably stimulated, the effects on the pelvic organs being greatly pronounced.

Therapeutical Advantages :—

Supta-Vajrâsana is a very good remedy for constipation.

PAŚCHIMATÂNA OR THE POSTERIOR-STRETCHING POSE

Cultural Advantages :—

Paśchimatâna is a fine stretching exercise. Nearly all the posterior muscles of the body and particularly the hamstring muscles at the back of the knees are relaxed and fully stretched. The pose is also of great importance in the culture of the abdomen. The front abdominal muscles are vigorously contracted which ensures better health and functioning for them. Nerves supplying the pelvic organs and arising from the lumbosacral region are toned up because of the exercise of the lumbosacral part of the spine and the consequent richer blood supply brought to that part.

Paśchimatâna is known to have considerable spiritual significance. It has been found to enable a student of spiritual culture to listen to Anâhata Dhvani or the *subtle sound.* It is also understood to rouse the spiritual force called Kuṇḍalinî. For spiritual purposes, however, the Âsana has to be practised daily for upwards of an hour according to the needs and the capacity of the individual practising it.

Therapeutical Advantages :—

Paśchimatâna builds a powerful abdomen and is found to be a good remedy against constipation and dyspepsia. It may be prescribed with advantage against seminal weakness and also against the possibility of a recurrence of sciatica.

The measure of Paśchimatâna has to be judiciously adjusted. When maintained for a long time, it promotes constipation instead of relieving it. So if the Âsana must be practised across a good length of time either for physical or spiritual advantages, it should always be accompanied by Uḍḍiyâna which can be repeated several times while Paśchimatâna is being maintained. Habitually constipated people should avoid practising Paśchimatâna for anything more than three minutes a day.

MAYÛRÂSANA OR THE PEACOCK POSE

Cultural Advantages :—

Mayûrâsana partially checks the flow of the abdominal aorta and thus diverts a liberal blood supply to the digestive organs, rendering them more healthy. These organs are further toned up by the increase in the intra-abdominal pressure which Mayûrâsana causes in its practice.

Therapeutical Advantages :—

Mayûrâsana is a very good measure against ptosis of the abdominal organs and against dyspepsia. Its usefulness, how-

ever, is limited, because in advanced cases of dyspepsia the patient becomes too weak to undergo the strain which this Âsana necessarily involves.

ŚAVÂSANA OR THE DEAD POSE

Cultural Advantages :—

(*i*) Muscles work more efficiently because of their relaxation.

(*ii*) Venous blood circulation is promoted throughout the body and thus fatigue is relieved.

Therapeutical Advantages :—

(*i*) Śavâsana is helpful in reducing high blood pressure.

(*ii*) It can considerably overcome neurasthenia.

YOGA-MUDRÂ OR THE SYMBOL OF YOGA

Cultural Advantages :—

Yoga-Mudrâ builds a powerful abdominal wall, helps the abdominal organs to be kept in their proper places, and tones up the nervous system in general and the lumbosacral nerves in particular. Spiritually its prolonged practice helps to rouse the Kuṇḍalinî.

Therapeutical Advantages :—

The cecum and the pelvic loop are usual seats of bad constipation. In this practice the left heel presses against the cecum and the right against the pelvic loop. This pressure when slowly, steadily and repeatedly applied, has power to stimulate these parts to action; and thus to reduce constipation. Yoga-Mudrâ relieves constipation also by replacing the displaced abdominal viscera.

Yoga-Mudrâ has also been found useful in overcoming seminal weakness.

JIHVÂ-BANDHA OR THE TONGUE-LOCK

Cultural Advantages :—

(*i*) Muscles of the neck are exercised and the blood circulation therein is improved.

(*ii*) Cervical nerves and ganglia are rendered healthier.

(*iii*) Pharynx and larynx are exercised and their health promoted.

(*iv*) The thyroid is rendered healthier.

(*v*) The auditory apparatus is made more efficient.

(*vi*) Salivary glands function more satisfactorily.

Therapeutical Advantages :—

(*i*) Congestion in the pharynx is removed.

(*ii*) Tonsilitis of certain types is checked.

(*iii*) Deafness due to the thickening of the drum of the ear is relieved.

N. B.—The Cultural and Therapeutical Advantages mentioned above, can best be obtained from Jihvâ-Bandha when it is made to alternate with Simhâsana.

VIPARÎTA KARAṆÎ OR THE INVERTED ACTION

Cultural & Therapeutical Advantages :—

In Haṭha-Yoga the *Inverted Action* is looked upon as the most important practice capable of developing supreme vitality. It is said to be so wonderfully effective that it would rejuvinate an old body in six months. We do not propose any examination of these claims here. One thing is certain. The practice combines, though on a humbler scale, all the advantages of Śirshâsana and Sarvâñgâsana, and as such must have great influence upon the vital forces in the body. All the cautions, however, that are given to the students of Sarvâñgâsana, are also to be given to the students of this practice.

NOTES ON CHRONIC CONSTIPATION

ITS CAUSES AND CURE

(*By M. N. Parandekar*, M. B., B. S.)

CHRONIC constipation is a scourge brought on by the so called modern civilization. No doubt the excessive amount of nervous strain and the hurry-scurry of modern life play an important part in upsetting the regular smooth working of the human organism ; but still a certain amount of this upsetting can be attributed to a faulty mode of living.

When once the regular working of the system is deranged, a number of symptoms begin to appear, first of which is irregularity in the movement of bowels resulting in either constipation or diarrhœa. If nervous strain and wrong way of living continue for a long time, constipation or diarrhœa becomes a chronic complaint ; and then follow a host of other disorders such as dyspepsia, insomnia and so on.

It is very difficult to give an exact definition of constipation. Certain people having only one motion regularly in a week, may be quite healthy, so also others whose bowels move twice or thrice every day. There are still others occupying various grades in between these two extremes but all these may be considered quite healthy so long as they do not have any complaints. For practical purposes one can be said to be constipated if one's bowels do not open at least once in forty-eight hours and if one is thereby suffering from some sort of bodily discomfort such as loss of appetite, headache, lack of concentration, etc.

There are another sort of people who also can be said to be constipated, but to whom the above definition is not quite applicable. They go to privy twice or thrice, open their bowels, but still complain that they are not satisfied with the motions. After each motion they feel that some fæcal residue

has still remained. This feeling gives them a sort of uneasiness. Such a complaint is mostly due to the inability of the colon to evacuate its contents completely owing to the weakness of its musculature.

Below I have tried to give in a summary form the causes of constipation and its cure. In doing this I have discussed the question of diet. It should, however, be noted that it is quite impossible to set a fixed diet which will suit each and every person. Individual variations as regards taste, habits, digestive power etc., have to be taken into consideration in forming one's dietary. Nevertheless the main principles mentioned below should not be overlooked.

Causes of Constipation

1. Dietary faults.

   (*i*) Taking less food than is required or taking more food than is required.

   (*ii*) Taking unsuitable food, that is, food which upsets digestion.

   (*iii*) Eating too often.

   (*iv*) Taking food devoid of roughage. (By roughage I mean substances like vegetable cellulose, bran, cocoanut etc., which are not completely digested and hence form a large amount of undigestible residue in the bowels).

   (*v*) Excess of rice in diet—especially of polished rice.

   (*vi*) Excess of spices, chillies or such other condiments.

   (*vii*) Excess of ghee, butter and oils.

   (*viii*) Eating concentrated food-stuffs very often such as: Halva, Khava or Mava, Basundi, etc.

   (*ix*) Excess of water or any other liquid in the meals,

   (*x*) Insufficient intake of water.

(*xi*) Not taking lemons or such other fruits containing organic acids.

(*xii*) Deficiency of mineral salts that are available in fruits and vegetables and in well and spring waters.

(*xiii*) Deficiency of vitamins in diet.

2. Sedentary life—not taking any exercise.
3. Neglect to respond immediately to nature's call for easing oneself.
4. Failure to form a regular habit of visiting the privy once or twice daily.
5. Addiction to tea, coffee and cold drinks.
6. Tobacco—eating or smoking in excess.
7. Constant use of drastic purgative drugs.
8. Faulty posture.

To Cure Constipation

1. Correct all dietary faults.

(*i*), (*ii*) Take a sufficient quantity of food suiting your palate and stomach.

(*iii*) Eat nothing in between the two or three regular meals.

(*Note*—A meal does not necessarily mean a dish of cooked cereals. A meal may consist purely of milk or of milk and fruits. It is always advisable to have a variety in the different meals.)

(*iv*) Take green leafy vegetables, a bit of cocoanut, and bread prepared without removing the bran from the flour. A small dish of raw diet may also be tried.[1]

[1] Taking of roughage or indigestible matter is not advisable for persons whose colon musculature is very weak and for those who have any ulceration, irritation or pain in the bowels.

(*v*) Reduce the amount of rice—especially all rice that is thoroughly polished.

(*vi*) Avoid spices and chillies as much as possible. They may be taken in moderate amount, but certainly not to such an extent as to irritate the stomach and the bowels.

(*vii*) Take ghee and oils moderately. Butter may be preferred to ghee.

(*viii*) Take sweetmeats only occasionally. Although a certain amount of sugar in the dietary helps to promote the intestinal peristalsis, still excess of cane sugar is often harmful. Some persons may find it advantageous altogether to stop taking cane sugar. Honey and even some sweet fruits will be found more beneficial than cane sugar.

(*ix*), (*x*) Take a glass of water on rising in the morning and also enough water in between the meals. Not more than a glass of water (or any other liquid) should be taken with each meal. Some people may find it agreeable not to drink any water during meals, but to take it after half to one hour.

(*xi*) Take lemons, tamarind, red mangoes (Kokam or Amsul) and other fresh fruits containing organic acids which help to relieve constipation.

(*xii*) Pure well or spring water is not available in cities and hence if constipation persists in spite of other measures to cure it, it may be taken for granted that certain mineral salts are wanting in the drinking water. Under such circumstances medicinal salts may be taken in small amounts only to supply the deficiency and not to cause any purgative action.

(*xiii*) Take sufficient amount of vitamins. These will be taken if the following are included in the diet in suitable proportion—

(*a*) Butter and green vegetables. (*Vit. A*).

(*b*) Bran—whole meal bread, peas, etc. (*Vit. B*).

(*c*) Lemons, onions, tomatoes, germinated seeds, milk and buttermilk, and other fresh fruits. (*Vit. C*).

(*d*) Dried cocoanuts. (*Vit. D*).[1]

(*e*) Nuts and vegetable oils such as sesame oil, peanut oil, olive oil, cocoanut oil, etc. (*Vit. E*).

2. Take exercise regularly. Abdominal exercises are preferable and Yogic exercises will be found to be very efficacious. Breathing exercises help a good deal to move the bowels and the exercises of Uḍḍiyâna and Nauli give a good massage to the bowels and help to improve their tone. Strengthening the abdominal muscles and toning up the bowels is an absolutely essential measure for obtaining permanent relief from constipation.

3. Attend to nature's call immediately.

4. Form a regular habit of visiting the privy once or twice daily. Give full time for the bowels to act. Do not hurry. Do not strain.

5, 6. Avoid tea, coffee, cold drinks and smoking or eating tobacco.

7. Do not take purgatives very often. An occasional mild laxative once or twice in a month may be taken ; but it may not be necessary if the above measures are strictly followed. Very

1 Sun's rays (*ultra-violet rays of the solar spectrum*) are an excellent source of *Vitamin D*, and one may obtain a sufficient amount of it by bathing in the sun, morning and evening, for at least ten to fifteen minutes.

chronic and obstinate cases of constipation may require the use of a drug or an enema, *only in the beginning of their treatment.* The best drugs are senna or sonamukhi, cascara and alaoes which should be taken in moderate doses only and the dose gradually reduced and finally given up as soon as a regular habit is established with the help of exercises and other hygienic measures. If recourse is taken to a daily enema, it should be taken in the morning, the amount of water should be gradually reduced and then finally given up after the establishment of a regular habit. Constipated people of the second variety mentioned above, will derive more benefit from the daily use of an enema.

(*Note*— When taking a daily enema the water should be absolutely plain without any irritating drugs in it and its temperature should be moderately tepid.)

8. Always maintain an erect posture so as not to compress the digestive organs.

9. Follow all other rules of hygiene.

The following additional measures may be found beneficial in some cases.

(*a*) The juice of half a lemon and a pinch of common salt to be added to the morning glass of water.

(*b*) Two tea-spoonfuls of sesame or olive oil to be taken just before each meal.

(*c*) A table-spoonful of liquid paraffin to be taken at bed-time.

(*d*) An occasional fast once a week or fortnight will also be found beneficial. Sufficient amount of water should be taken during the fasting period.

Following diseases, especially in their chronic condition, can be effectively treated by the Yogic methods :

1. *Constipation.*
2. *Dyspepsia.*
3. *Headache.*
4. *Piles.*
5. *Heart-disease (functional).*
6. *Neuralgia.*
7. *Diabetes.*
8. *Hysteria.*
9. *Consumption.*
10. *Obesity.*
11. *Sterility (certain types).*
12. *Impotence.*
13. *Appendicitis, &c.*

Therapeutical advice is given gratis at the Âśrama to patients coming for consultation.

Arrangements have been made under the supervision of the Âśrama for patients to stay on payment of actual expenses, Rs. 45/- per mensem.