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First Fifty Years (1900-1950) of Physiology in India

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Abstract

In British Colonial India, following the European System of Medicine, the teaching of Physiology was introduced first in Sanskrit School and Calcutta Madrasha both in Calcutta (Kolkata) in 1826 and by the Medical College, Kolkata in 1835. In Calcutta, Medical College, Physiology was taught as an introductory subject of Medicine. The study of Physiology as a basic science under faculty of science was introduced first in the country by the University of Calcutta in early part of the 20th century in undergraduate General and Honours courses in the Presidency College. Since then progress of physiology, its emergence in the post–graduate course of the University of Calcutta, establishment of 'The Physiological Society of India' by eminent medical and non-medical persons to fulfill the growing need of the days and publication of the '*Indian Journal of Physiology and Allied Sciences*' in the pre-independent India have been discussed. In the following section, attempt has been made to stock the scientific studies in the domain of basic physiology as recorded in the Scientific Journals during the first 50 years counting back from 1955 i.e., during the initial phases of development of physiology in India. The different studies have been classified under different categories for presenting the heterogeneous assay of materials on the basic topic of physiological sciences in the country. In addition certain relevant aspects have been mentioned without which this write up would remain incomplete.

Key words: Physiology, Physiological Societies, Presidency College, University of Calcutta

1. Emergence of physiology as a discipline in India

The term physiology originated from a Greek root 'Physiologikos' meaning discourse of natural knowledge. It was introduced by the French Physician, Jean Fernel in 1552, since then physiology deals with normal functioning of the body.

In 19th century CE, under the influence of great Greek and Roman Civilizations, the idea to originate and develop 'Physiology' as an important branch of the then modern science emerged. For the colonial British rule in India, following the European system of medicine, the teaching of physiology was introduced in Sanskrit School, Calcutta and Calcutta Madrasha in 1826 followed by in the Medical College, Calcutta, where physiology was taught as an introductory subject of medicine in 1835.

The study of physiology as a basic science outside the domain of Medical Colleges was introduced in the country by the University of Calcutta. The idea of studying Physiology as basic science under the faculty of science was conceived by S C Mahalanobis who got his B. Sc. (Hons.) degree in Physiology from Edinburgh University, UK followed by his research work at Edinburgh Royal College of Physician and admitted to the Fellowship of Royal Society of Edinburgh (FRSE) in 1898 as his recognition and appointed as interim

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Professor and Head of the Department of Physiology at Cardiff University, UK. He was also offered the full Professor of Physiology at Bristol University, but he did not join to that post and returned to India.

The training and experience he gained while in UK motivated Mahalanobis to meet Sir John Woodburns, the then Lt. Governor of Bengal and apprised him about the importance of the subject - Physiology, as an important subject of Biological sciences. Accordingly, in the latter part of 1900 CE, he joined in the Provincial Bengal Education Service (Imperial Education Service) and was posted in Presidency College, Calcutta, as Professor and Head of the Department of Biology (Physiology and Botany combined).

In 1901 – 1902, B. Sc. course was instituted and the subject of Biology was separated into Physiology, Zoology and Botany under the new regulation of the University of Calcutta and teaching of Physiology was started in Intermediate Science (I. Sc), B. Sc. (Pass/ General) and B. Sc. (Hons) classes. The first passed out candidate in B. Sc. (Hons) Physiology from the Presidency College was one and it was in the year 1904 and the number gradually increased and in 1950 it was only sixteen (16). In addition to Presidency College, the undergraduate Honours Courses started in the University College of Science, University of Calcutta considering its demand.

The teaching of Physiology as basic science both at undergraduate and post graduate levels has been introduced first in India by the University of Calcutta and it is still in the progress. No universities in India other than University of Calcutta introduced this subject till 1950 and even after that. After 1960, certain Universities in West Bengal had introduced the subject only at undergraduate level. Presently many universities in West Bengal and Tripura University (Central University) have introduced the subject both at UG and PG levels.

The Post-Graduate course in Physiology of the University of Calcutta commenced in 1911 at Presidency College since the Post-Graduate Department of Physiology of the University was housed there and the first batch post-graduate student came out only in 1913 and the number of student was only one. However, full fledged Post Graduate Department of Physiology with regular faculty under the University of Calcutta has been established at its campus of Rajabazar Science College in 1937, in addition to the Post Graduate Department of Physiology at Presidency College under an affiliated College of the University.

The topic covered in the Physiology syllabus of both Undergraduate and Post-Graduate courses included: cardiovascular physiology, respiratory physiology, blood and tissue fluids, skin, body temperature, digestive system, metabolism, enzymes, nutrition, biophysics, excretion, endocrine, reproduction, nervous system, special senses and nerve muscle physiology. Any of the following special papers have to opt each student in their final year Post-Graduate class – Biochemistry, Biophysics, Hormones, Nutrition and Dietetics and Comparative Physiology. The practical papers were based on experiments on Histology, Biochemistry and Experimental Physiology. The syllabus was subject to alteration from time and time.

Employments taken by post-Graduate Physiology students after passing M. Sc. were teaching, research, private practice and others are shown in Table 1.

The table as mentioned is from a monograph prepared and published by the then faculties of the University of Calcutta [Department of Physiology, Calcutta University: Departmental activities (1909 – 1971), University College of Science & Technology, 92, Acharyya Prafulla Chandra Road, Calcutta – 9, India pp 1-46 (Published in 1972)].

Table 1. Employments taken by Post-Graduate Physiology Students after passing M.Sc.

	Years 1913-23	Years 1924-33	Years 1934-43	Years 1944-53
M.B.B.S., M.Sc. engaged in teaching of physiology and research	8	7	7	14
M.B.B.S., M.Sc. engaged in research	-	-	-	4
M.B.B.S., M.Sc. engaged in private practice and business	4	9	6	4
M.Sc. engaged in research only	-	3	5	16
M.Sc. engaged in teaching and research	4	6	8	18
M.Sc. engaged in teaching only	4	4	4	10
M.Sc. gone abroad for higher studies	5	5	7	30
M.Sc. attached with non-academic job (business, law, administrative etc.)	16	23	16	21

In the mentioned table, the students as shown were of Calcutta University because during that period no University other than University of Calcutta used to teach physiology as basic science under the Faculty of Science. The type of jobs choosen by the then pass out PG students (with other additional degrees) of the department at an interval of about 10 years has been shown.

1.1 Research Degree

D. Phil (Sc) was initiated in the University of Calcutta in 1952 and in that year there were two recipients of the degree from the Department of Physiology, University College of Science, University of Calcutta. Quite a large number of students of Physiology have also obtained D. Phil (Sc) and D. Sc. degrees from other institutes.

1.2 The Physiological Society of India

Considering the need of the days, the Physiologists (both medical and non-medical) of the country were feeling the need for the further promotion of teaching and research on the subject in the country, and set up an independent organization of the Physiologists and allied scientists that ultimately emerged in July 1934 as 'The Physiological Society of India'. The founder members and office bearers of the first Executive Committee were the following

Prof. S C Mahalanobis, B.Sc. F.R.S.E.,	President
Sir Nilratan Sircar, M.A., M.D., LL.D., D.C.L.,	Vice President
Sir Kedar Nath Das, F.R.C.S., F.R.C.O.G.,	do
Sir U N Brahmachari, M.A., M.D., Ph.D.,	do
Dr. Bidhan Chandra Roy, B.A., M.D., M.R.C.P., F.R.C.S.,	do
Dr. H E C Wilson, M.D., D.Sc., M.B., Ch.B.,	do
Prof. Nibaran Chandra Bhattarcharya, B.Sc., M.A.,	Secretary
Prof. N M Basu, M.Sc.,	do
Dr. B B Sarkar, D.Sc., F.R.S.E.,	Treasurer
Dr. P M Brahmachari, M.Sc., M.B.B.S., M.D., P.R.S.,	Asst. Secretary
Dr. S M Banerjee, M.Sc., M.B.B.S.,	Member
Dr. S K Sen, M.Sc., M.B.B.S., L.M., D.T.M., D.P.H.	do
Dr. H N Mokherjee, M.B.B.S.,	do
Dr. B C Guha D.Sc.,	do
Dr. M M Datta, D.Sc., M.B.B.S.,	do
Dr. B B Chatterjee, M.Sc., M.B.B.S.,	do
Dr. J N Dutta, B.Sc., M.B.B.S.,	do
Capt. P Dey, M.D.,	do
Shri P B Sen, M.Sc., P.R.S.,	do
Lt.Col. A C McGilChrist, I.M.S.,	do
Dr. B Ahmed, M.Sc., Ph.D.,	do
Dr. Satinath Bagchi, M.D.,	do
Shri. G N Bera, M.Sc.	do
Shri. Pratul Chandra Gupta. M.Sc.,	do
Dr. J N Moitra, M.Sc., M.B.B.S.,	do
Shri. D N Mullick, M.Sc.,	do
Shri. S C Sen, M.Sc.,	do

The rules and regulations of the Society were constituted by the first Executive Committee and were duly adopted at its Second General Meeting on 26th day of September, 1934. The Society is adhered to the International Union of Physiological Sciences (IUPS), the Federation of Asian and Oceania Physiological Sciences (FAOPS), Federation of Indian Physiological Society (FIPS) and the newly formed South Asian Association of Physiologists (SAAP). The Physiological Society of India is registered under Act XXI of 1960.

Though the Society initially started functioning in Calcutta, in course of two decades it became an all India organization of physiologists and allied scientists. The most significant achievement of the Society was to initiate the publication of '*The Indian Journal of Physiology and Allied Sciences*' that was published first time in January, 1947, just about six months before India became politically independent. Since then the journal is published regularly in the months of January, April, July and October every year. The first issue of the journal consisted of forty five pages and included five original articles and an encouraging letter of Prof. A V Hill, the then Secretary of 'The Royal Society of England', UK and also a honorary member of the Physiological Society of India wrote on 10th October, 1945 to hear the plan to found the journal that 'the journal will play a valuable part in encouraging the development of these science in India.'. He also wrote 'By setting and maintaining that high standard Indian Journal of Physiology and Allied Sciences will be able to do a real service both to science and to India'.

In addition to the publication of journal, the Society publishes Laboratory Note Books on Biochemistry, Histology and Experimental Physiology Practical for the undergraduate degree course study. Further, in recognition of the work to scientists, the Society has introduced oration, young scientist's awards, etc. Every year society organizes 'Annual Conferences' in different parts of the country, scientific meetings, foundation day celebration etc. The society has members throughout the country and abroad.

2. Research in basic Physiology in India during the first-half of twentieth Century

Physiology has no independent existence unlike the other disciplines of science such as physics, chemistry etc in India in the first half of the twentieth century; this is because the teaching and research in physics, chemistry etc. in colleges and universities started much earlier than that of the biological sciences rather physiological (human) sciences under basic science faculty or in other words when these subjects have already achieved dependency, then physiology has started emerging when the teaching of the subject was initiated in few medical colleges and as a distinct non-medical discipline in University College of Science, University of Calcutta. Around that time, because of inadequate resources and extensive teaching load of the faculties in-depth work could not be done. The research work so far done during the period remains scattered in different medical journals for the lack of any publication medium of the subject. Emphasis was given on scientific research in different frontiers of Physiology before Indian independence in 1947 and thereafter.

In the following section emphasis has been given on collection of materials as far as practicable on the research which were in progress during that period in the country in Physiology that were published in journals of allied sciences mentioned under subheadings.

In this background as many as 180 titles of research articles in Physiological science have been included. It should not be considered to be a complete record as many important contributors might have been overlooked. The review as discussed represents the chronicles of certain

events of the Physiological sciences in India. The progress of biological sciences in India has been much slower than the 'Physico-chemical sciences' and this is more appropriate in the area 'Physiological sciences' rather than other areas of biological sciences such as Agriculture, Botany etc. Indian Physiology during the period apparently based on research spirit and methodology of the western schools of thought and adopting the newer and more refined instrumentation techniques in experimental studies in the laboratory. The topic of the researchers along with brief outline of those works based on bibliographic references is discussed below.

2.1 Nervous System

The influence of cerebral cortex, hypothalamus, limbic system and other parts of central nervous system on behavior and autonomic function was the object of investigation of Anand and his coworkers (1951a, 1951b). Based on extensive studies, the hypothalamic control of food intake in rats, cats and monkeys was established; they located a 'feeding centre' in the lateral hypothalamus, and 'satiety centre' in the medial hypothalamus. They also tried to initiate a method of permanent implantation of electrodes for stimulation and recording of action potentials of various areas in the central nervous system of conscious animals for several studies.

Interesting studies have been made by Indian scientists on problems related to mechanoreceptors and neurohormones. Anand (1952) showed that stimulation of the vagus nerve markedly inhibited the frog heart especially when the temperature of the heart was high. Fluid withdrawn from the heart chamber after vagal stimulation at high temperature produced a stimulating effect on a second frog heart. This stimulation is due to liberation of acetyl choline in small amounts. The relationship between the temperature difference and the difference in the amount of acetyl choline liberated is linear, and the relationship between the deviation of stimulation and the difference in amount of acetyl choline liberated per degree difference in temperature is hyperbolic. Basir (1940) observed that stimulation of the vagus and the splanchnic nerves decreased the backward flow of the perfusion fluid in the spleen of the dog.

2.2 Cardiovascular System

2.2.1 Blood pressure

Relating to factors influencing blood pressure, Mathur and Tandon (1952) found that the femoral branchings showed a greater sensitivity in the arterial pathways of the dogs to electrical stimulation. Later on they showed that stimulation at the site of origin of Profunda Femeris in dogs resulted in fall of blood pressure.

2.2.2 Heart

Investigations have been made on cardiac activities under certain physiological/ and non-physiological conditions. Using ECG or direct kymographic recordings all these studies were conducted; besides *in situ* and isolated hearts, usual heart-lung preparations or its modification have been used (Gavindan Nayar, 1953). The action of some physiological substances was studied on the heart of anasthesized fish. Indistinct P wave and downward T wave were noted in ECG recordings. In case of malnutrition, a definite increase of QT intervals has been shown and this could be reduced after treatment with high protein diet (Gopalan et al, 1955).

2.3 Respiratory System

The pattern of respiration, vital capacity and exchange of respiratory gases are the aspects on which investigation have been done. In 1954, Singh *et al* noted that there was variation in relative potencies of two nasal passages at different times of the day even in normal healthy individuals and there was no detectable or evident rhythm or pattern in these changes. Several workers

determined the vital capacity of human subjects of different ages, sex and class (Reddy and Shastri, 1944; Bhatia, 1929; Krishnan and Vareed, 1932a; De and De, 1939), body surface and height (Bhatia, 1929) from different parts of India and the result varied from 2180 to 3096 ml.

In 172 young healthy male medical students aged 18-29 years, the vital capacity per sq. meter of body surface was found to be 3000 ml (Telang and Bhagwat, 1941); while Krishnan and Vareed (1932b) found average vital capacity 2.93 liters i.e., 1.85 liters/ meter^2 and 17.5 c.c. per centimeter of standing height of 103 medical students of 18-29 years . Ramaswami *et al* (1954) determined the oxygen requirement for a new form of muscular exercise (*Baithaks*) and found that an optimum rate existed almost identical with one found by Dickinson in his ergonomic work.

To oxygenate blood of man and animals by extra-pulmonary route has also been attempted. At body temperature only a very small percent of the total O_2 requirement can be given. Singh (1935) administrated intravenously large amount of oxygen under increased atmospheric pressure in dog and man with success.

2.4 Gastrointestinal System

2.4.1 Salivary Secretion

The human parotid saliva had 6-8 times more saccharogenic activity than mixed saliva and did not differently hydrolyze soluble starch and starch amylum (Basir and Ramabhardan, 1937). They also reported the occurrence of acetyl choline in human saliva. Greval and Mukherjee (1950) noted that the isogen content of saliva from Indian subjects in Calcutta was found to be poor and most of the saliva samples were unsuitable for neutralizing corresponding isonine in sera from Rh-iso-immunised subjects. However no correlation could be suggested between diet and complexion of the subjects and the isogen content of saliva.

2.4.2 Gastric Secretion

Mangalik *et al.* (1942) performed gastric analysis with alcohol test - meal in persons residing in the United Provinces; the average fasting stomach contents were 30ml in 90% of the cases. The people of this province showed higher initial and maximum acidity as compared to those in Bengal and Madras. There was no significant difference in acid response amongst population due to difference in diet or religious practice.

A reflex augmentation of bile formation in dog was found by stimulating the central end of one vagus with the other vagus intact, and the stimulation of the sympathetic nerve supply of the liver was found to decrease the bile formation (Tanturi and Ivy, 1938).

2.5 Unstriated Muscle

Various aspects of physiology of unstriated muscle have been studied by Singh and his co-workers. They have reported that cooling might cause contraction as well as relaxation under different conditions (Singh 1944). They characterized different types of inhibition and contraction of unstriated muscles (Singh and Singh, 1949). It is noted that change of temperature at certain rate produced both chronic and phasic contraction probably by sensitizing the muscle to ions outside the muscle fibers; such contractions may be due to direct action on the contractile mechanism (Singh and Singh, 1952). The muscle reacted in saline solution in which all sodium (Na) had been replaced with potassium (K) (Singh and Singh, 1947).

In smooth muscles, blood vessels in dogs and guinea pigs are shown to be relaxed by K and contracted in presence of Na, cholesterol and Ca (Singh and Singh, 1955a). Singh and Singh (1955 b), found that frog's stomach reacted like a normal muscle and showed action potentials in complete absence of any electrolyte in the external medium (e.g. pure sugar cane).

Unstriated muscle responds to continuous stimulation by accommodation. This is due to the development of an inhibitory state. The muscle further responds to continuous inhibition by accommodation, so that the inhibition may disappear eventually. This is for the development of an excitatory state, as excitatory ions facilitate accommodation to inhibition (Singh and Singh, 1952).

Acetylcholine caused contraction and adrenaline caused relaxation (Singh and Singh, 1950). Small concentration of adrenaline was shown to increase the excitability of muscle to electrical stimulation and decreased it in large concentrations (Singh, 1940). Adrenaline inhibition in striated muscle may be preceded by a contraction; this shows that such inhibition is due to adaptation to excitation (Singh and Singh, 1952).

The inhibitory effect of adrenaline could be converted into a stimulatory one by a number of substances that decreased adaptation to excitation (cyanide, thiocyanate) or increased adaptation to inhibition (e.g. eserine). Many other substances were studied to modify the effect of adrenaline (Singh and Singh, 1947; Singh and Singh, 1949).

Unstriated muscle that had been killed by heat has been suggested to be a suitable preparation for the study of effects of substances on the contractile mechanism (Singh and Singh, 1954a; Singh and Singh, 1954b). Some proteolytic enzymes relax these muscles by unfolding the polypeptide chains or causing denaturation of proteins (Singh and Singh, 1955). Hydrochloric acid also produced relaxation (Singh and Singh, 1955).

In unstriated muscle, neuromuscular transmission is an electrochemical event, the primary response being produced by the action potential and this is tonically maintained by the secretion of acetylcholine (Singh and Singh, 1947).

2.6 Blood and Body Fluid

In their book '*Haematological Techniques*', Napier and Dasgupta (1945) reported the normal values of heamoglobin content, red cell count, leukocyte count and the different corpuscular value of the different male and female population of Calcutta and other parts of India. The plasma and blood volumes of 50 Indian males from Calcutta zone found to be 47.7 and 83.1ml/kg and 1.591 and 2.770 ml/sq.m. body surface respectively (Chaudhuri *et al.,* 1951). Plasma volume of children with malnutrition has also been studied (Chakravarty *et al.,* 1953; Gopalan *et al.*, 1953; Venkatachalam *et al.*, 1952). A diminution of blood and plasma volumes in effective circulation and an increase in hematocrit values were observed during hypothermia (Mukherjee and Sen, 1954).

The mean red cell diameter of a group of healthy British soldiers stayed in Wellington, 6000 ft above the sea level and a group of healthy Indians living in Coimbatore 1350ft above the sea level of South India were measured and found to be 7.135µ and 7.0779µ respectively. It was suggested that the altitude might have some influence on the red cell diameter (Radhakrishna and Narsimha, 1942). Ramalingaswami and Venkatachalam (1950) determined the number of RBC and WBC, hemoglobin, haematocrit and corpuscular constant of 100 healthy adult men residing in Coonoor, Wellington and Ootacamund. However, no appreciable difference in the mean RBC count and hemoglobin value from those recorded in other parts of India at sea level. An increase in mean RBC volume was found. The hematological response of a group of Indian troops at moderately high altitude in extreme cold environment has been investigated and suggested that the non-responsiveness of the red cells and hemoglobin content on change of altitude might be related to the low protein and high carbohydrate diet (Mookerjee and Ghosh, 1951).

Napier and Mazumdar (1938) analyzed the hematological findings in 57 anemic pregnant garden coolies and noted that these women as a whole had a low level of hemoglobin associated with a small amount red cell. Ghosh et.al (1948) reported the hematological findings in normal pregnant females of Calcutta. The haemoglobin curve was studied and observed that there was a steady increase with age from 11.5 gm at 5 years to about 13.5 gm at 16 years (Napier and Dasgupta, 1940). Ramamurti (1955) determined the haemoglobin values in Rajasthan students and found it to be high as compared to Western standards and pointed out the better character of the diet in respect to iron. Sankaran and Rajagopal (1938) also estimated hemoglobin content of girls of South India. Greval et al (1939) described a technique of typing the blood groups and reported the findings in 300 Indian in Calcutta.

2.7 Endocrinology

In hypo- and hyperthyroidism, alteration in the gonadal physiology occurs. Therefore, thiourea administration promoted formation of ovarian cysts in the female and partial inhibition of spermatogenesis and subnormal level of androgen production in the male rat (Kar and Sur, 1953). The basic mechanism seemed to operate through a 'shift' towards and enhanced TSH production under conditions of hypothyroidism with a concomitant lowering of endogenous gonadotrophins. The latter hormone was found to have a thyrotropic action and it was suggested that this was provoked by increase in TSH production by a similar 'shift" of endogenous gonadotrophins (Kar et.al, 1955).

Testosterone propionate therapy ameliorated or prevented the adverse effect of hypothyroidism on the gonads of rats depending on dose (Kar and Sur, 1953; Kar et.al. 1955). The action probably mediated through alteration of thyroid physiology and secondarily through a restoration of TSH-GTH gonadal relationship.

2.8 Thyroid-adrenal-pituitary

In thiourea induced hypothyroidism, adrenocortical atrophy occurs presumably through decrease of ACTH secretion. Such adrenal could be stimulated further by ACTH or testosterone propionate (Kar et al, 1955). The steroid hormone probably could correct the defect by pituitary stimulation of ACTH (Roy et al, 1953).

Conversely, hypothyroidism produced by injecting thyroxine caused profound atrophy of the testes of young rats; both the spermatogenic and androgenic functions were affected (Roy et al, 1953*)*. It was suggested that normal gonadal activity was largely dependent 'an optimal ratio' of the level of thyroid hormone to that of gonadotrophins; any inbalance in this ratio would result in defective gonadal function. The results obtained in the ovary of rat given thyroxine and gonadotrophin jointly is an interesting pointer in this respect (Kar et al, 1954).

2.9 Protein Hormones

Karkun *et al*. (1953) reported that intermedin, unlike ACTH, failed to increase the adrenal weight in intact mice. In hypophysectomised rats, the said hormone could not arrest the decrease of adrenal weight following hypophysectomy (Karkun *et al*, 1954). Prolonged administration of ACTH was shown to provoke hyperplasia and hypertrophy of the pituitary cells producing intermedin (Karkun *et al*, 1954a). These cells show characteristics changes indicating increased synthesis of proteins, presumably intermedin (Karkun et.al, 1954b).

Intermedin administratin to frogs (*Rana tigrina*) at frequent intervals so as to keep the animals continuously dark for a month, promoted the development of fresh pigmentary pitches in certain areas (e.g. snout) of the animal (Karkun and Mukherjee,1953). Lerner et al (1954) reported that in Addison's disease, Cushing's syndrome and pregnancy etc. MSH titer in blood is believed to

be elevated. In extension of this observation to human skin, methods were developed to isolate the pigment cells either singly or in a state of continuity (Shukla et.al, 1953).

2.10 Basal Metabolism

Rajagopal (1938) compared BMR in 26 Indians and 20 European males and found it to be 8% lower in the Indians. Sokhey and Malandkar (1939) showed that BMR of 60 normal Indian males to lie between -7% and -9.5% by the Aub-Du-Bois standard. It has been suggested this low value of BMR was due to very low protein content of the usual Indian diet and not for racial or climatic factors.

The BMR was found low in adult males of Bombay as compared to the Westerns, while the cretatinine coefficient remained practically similar (Niyogi et al, 1931).They also reported that BMR of 35 boys (11-16 years) from Bombay was lower than Mayo Clinic and Du-Bois standard by 16.8% and 15.9% respectively and 5% lower than Harris and Benedict standards.

3. Biochemistry / Nutrition

In India, malnutrition, a major problem has attracted the attention of numerous scientists. Various Indian food stuffs were analysed for their contents of carbohydrate, protein, fat, vitamis and minerals and estimation of their food values. Biochemistry of various disorders have been the subject of a large number of investigations , while others have estimated various biochemical constants in Indian health and their changes in diseases.

3.1 Milk

The biological values for milk of goat, cow and buffalo have been determined (Mitra and Mitra, 1942). Ananta Krishnan and Lahiri (1942) reported that the casein of ass milk contains a higher percentage of phosphorus and arginine-N than in the casein of milk of other mammalian species. Mani et.al (1955) determined the biological value of the proteins of the curd and was found lower than that of milk; while digestibility coefficient of 'khoa' proteins was lower to other milk products.

Soybean milk substance was investigated by Desikachar *et al.* (1948). Vegetable milk was prepared by admixture of 56% soybean, 24% ground nut, 20% ragi malt and required amount of Vanslyke and Bosworth salt mixture. Karnani *et al.* (1948) fortified soybean milk with calcium and found its percentage of utilization for growing rats to 82 – 87%. These workers did not find any significant difference between this milk and cow's milk in regard to this calcium availability for growing children.

The common diet is much imbalance and is of poor nutritive value in many parts of India. The nutritive value of milk as a supplement to these diets was determined (Aykroyd and Krishnan, 1936). Krishnan and Mitra (1938), Mitchel (1924) and Swaminathan (1937a), found that milk proteins have a high biological value and growth promoting effect. Rajagopala and Balkrishnan (1955) remarked that curd provides more favourable conditions for bacterial synthesis of vitamin B1 than milk by virtue of its influence on colony forming organism.

3.2 Carbohydrate

McCarrison (1928) and Aykroyd (1932) have the early contribution in the chemistry and analysis of different Indian cereal foods. The chemical composition of cereals and millets were studied while Aykroyd *et al.* (1940) studied the effect of para-boiling and milling on the nutritive value of rice as well as the influence of different cooking methods and the effects of aging on cooking quality of cereals.

In a comparative study of the nutritive values of millet and wheat no significant difference

was noted. Aykroyd and Krishnan (1936) showed that tapioca like other tubers were extremely protein deficient and to make theses into a suitable supplementary food, skimmed milk, egg or other good animal proteins should be added. They also found when lactose was fed along with ground nut oil, the survival time was significantly longer in both sexes of rats.

Phytin phosphorous (P) content of rice grain and bran was affected during mould deterioration. This effect was more significant at higher humidity of storage atmosphere. All the rice-infesting fungi exhibited dextrinase and amylase activities on the synthetic media. Proteolytic and lipase activity also exhibited by these fungi (Ghosh 1951).

Giri (1938) reported on the phytin P content of legumes, cereals and nuts. It has also been reported that unpolished rice contains maximum amount of phytic acid phosphorous, rats were able to utilize only 57% of calcium in the diet. With increasing degree of polishing from 7-14%, the availability of calcium (Ca) increased from 90.5 – 93.9% respectively. Polishing did not significantly affect P utilization. Greatest intake of Ca and P was found to improve growth due to rice diet (Sathe et.al 1952).

A comparative study on availability of Ca and P in some common Indian cereals was investigated by Giri (1940). In experimental rats, the test cereals (forming more than 70% of the diet) constituted the main source of Ca and P. The percent availability of Ca and P was found by Giri to be 64 and 58 in Ragi, 89 and 74 in Cambu, 84 and 67 in Cholam respectively and that of P to be 64 in polished rice. Basu *et al.* (1939) found that rice and wheat diets kept the subjects in positive P balance. Increased intake of protein appeared to have no effect on Ca metabolism in adults.

3.3 Protein

Biological values of the protein of 27 common Indian foods was determined, that included cereals, pulses, nuts and oil seeds, vegetables and skimmed milk protein (Swaminathan, 1938; Saha and Guha, 1939). Saha and Guha (1940) investigated the available iron in different varieties of fish. De and Basu (1938) observed appreciable supplementary relationship between proteins of Rohu fish and protein of the pulses (*Lathyrus sativa*) and lentil. They also found that tyrosine and the tryptophan contents of proteins of both hilsa and rohu fish.

The important vegetable sources of protein food grown in India are pulses viz. Bengal gram, green gram, black gram, red gram, dried peas, lentil and khesari which are used widely; the prevalence of one or more in the diet of a particular region depends on their availability in the area and on the traditional food habits. Studies on their chemical composition, digestibility and biological values have indicated that the protein content varies from 22 – 30% (Basu and Mukherjee, 1936; Desai *et al.*, 1932; Swamminathan, 1937b). The biological values of these proteins were near about 50. Some of the seeds of *Lathyrus Sp*., have been found to contain toxins in them (Bhagwat, 1946; Shourie, 1945) that produced lathyrism in man or in experimental animals while other investigators (Mc Carrison, 1927; Lewis *et al.*, 1948) could not produced such disease in experimental animals by feeding these seeds. The role of pulses in supplying eventual mineral requirements has been studied by Goswami and Basu (1938) and Chaudhury and Basu (1939) and their importance as a source of vitamins when taken raw or in the germinated form has been recorded by Swaminathan (1942a; 1942b) and Narasinga and Bhagwat (1942). Esh and Som (1952) found that the protein content of various Indian pulses varied from 21.6 – 31.7%, *Lathyrus sativas* having the highest content. *Cicer arietinum* had the highest fat content. However, there was no significant difference on the total mineral contents of these pulses. Digestibility of various pulse protein content varied widely (average value 90%). Their biological and growth

promoting value and effect of heat processing etc. also studied. Methionine, cystine, tryptophan in four type of grams and dried peas were determined and compared them with those of egg protein (Esh and Som, 1952).

An inhibitor found in soybean responsible for the low biological value of its protein has been documented by many investigators. Germination of soybean resulted in an increase in methionine availability, inspite of the presence of inhibitor intact (Desikachar and De, 1950). Viswanatha and De (1951) observed that autoclaving of germinated beans resulted in maximum availability of methionine which was later shown in *in vitro* experiments to be due to fastest rate of release of these sulfur amino acid. They further reported that soya inhibitor was an antiproteinase of trypsin only, which has no influence on the peptidase fraction of the enzyme. Ganguly and De (1947) found that inhibitor extracted from soy protein has got the same growth promoting efficiency as the autoclaved soy protein.

3.4 Fat

The nutritive value of Indian vegetable foods and fish liver oils was determined by Acharya *et al.* (1942) and Acharya *et al.* (1943). The digestibility of natural fats, oils and hydrogenated oils was studied by Basu and Nath (1946). Hassan Ahmed and Ram Chand (1950) found that the blood pressure was increased if the ghee was consumed after heating though Reichert and Polenske constants were decreased.

3.5 Vitamins

3.5.1 Vitamin A

The carotene content of about 80 food stuff was determined by De (1935) using the then modified sprectrographic method. Further the stability of the pigment in a number of vegetable food stuffs under different conditions of storage and cooking has also been investigated (De, 1936). Sadana and Ahmed (1949) observed an increase of the carotinoid pigments in mango during the time of ripening. It was noted that α-carotene increased at a greater rate than any other pigment. Carotenoid pigments of leafy and non-leafy vegetables have also been determined by Sadna and Ahmad (1947). Vitamin A content has been estimated in various food stuffs e.g., mangoes (Guha and Chakraverty, 1933) human, cow, goat and buffalo milk (De, 1935).

Distribution of body iodine was studied in albino rats receiving large oral doses of vitamin A. In hypervitaminosis A, protein-bound iodine was decreased in liver and thyroid, and increased in serum, pituitary and skeletal muscle (Sadhu and Truscott, 1948). In vitamin A deficiency, there occurred lesions in peripheral nerves of rabbits; after addition of carotene to the diet the developed lesions remained unchanged, however further progress of degeneration of nerves arrested and also prevent the development of lesions that not already developed (Radhakrishnan Rao, 1940).

The blood level of vitamin A in male and female medical students of Lahore was 91 and 76 IU/ 100 ml respectively and found that the level of vitamin A was inversely related to leucocyte count (Khanna and Hassan, 1947). Aykroyd and Krishnan (1936) observed high incidence of Bitot spots and other positive eye changes associated with vitamin A deficiency among children in labour camps in South India.

3.5.2 Vitamin B complex

The components of vitamin B complex have been estimated in various Indian food stuffs. Human milk was found less potent among all those milk. Vitamin B_1 (Thiamine) and vitamin B_2 (Riboflavin) of certain common food stuffs of Bengal along with their protein, Ca, Fe, P contents have been estimated by Ghosh and Guha (1933). Guha and Chakravorty (1933) determined vitamin B_2 content in the extracts of liver and kidneys of

different animals. Ox and buffalo kidney extract contained 67 and 87 units of vitamin B_2 respectively per 100 gm of tissue. Fowl liver also proved to be a good source. Swaminathan and Aykroyod (1940) estimated the niacin content of wheat, rice and millet. It was observed that raw milled rice loses 60% niacin by washing where as paraboiled rice losses only 12% (Swaminathan, 1941) when Bhagvat and Devi (1944) studied the nature of anti vitamin B factors present in ragi rice polishing, green grass etc. Swaminathan (1942b) described a modified method for the estimation of niacin and nicotinamide in biological materials.

In *in vivo*, tryptophane is converted to niacin through intermediary stages but in rat liver slices and homogenates (*in vitro* studies) tryptophane transforms to quinolinic acid and not to nicotinic acid (Henderson and Ramasarma, 1949) and thus the excretion of quinolinic acid increased markedly during tryptophan treatment and then rapidly returned to original level.

The motor function of bowel in avitaminosis B and in starved animals was determined (Chatterjee, 1935); the amplitude, number and intensity of the intestinal contractions were diminished in both the conditions. In addition the response to pilocaprine, atropine, nicotine and $BaCl_2$ were also decreased. Sankaran and Krishnan (1936) studied the heart rate in vitamin B and C deficiency and they found that pigeons on polished rice diet and rats on vitamin B_1 deficient diet developed bradycardia.

Effects of various factors of vitamin B complex in normal and deficient man and animals have been investigated by different workers. De (1955) observed that thiamine hydrochloride added in different doses inhibited the human serum cholinesterase activity. Subrahmanyan (1954) studied trytophane-sparing effect of nicotinic acid and found that addition of nicotinic acid increased the biological value of a diet containing L-tryptophane as the limiting essential amino acid, in amounts slightly less than the minimum requirement.

Sarma (1950) observed that gammexane, 90% pure γ-isomer of hexachlorocyclohexane, inhibited the growth of the rice moth larvae (*Corcyra cephalonica St*) at a concentration of 2 mg percent inositol. Marked accumulation of cholesterol in the tissues of gammaexane fed larvae was found, and this was mobilized on feeding the larvae with inositol. These experiments indicated that inositol, a constituent of phospholipid – present in the outer layer of cereals including rice grain membrane rich in thiamine or Vitamin B1 (McHenery and Patterson, 1944) has a definite influence either on the synthesis or the metabolism of cholesterol. Sachdev (1955) found that vitamin B_{12} failed to prevent fatty livers induced by pancreatic duct ligation in rats.

3.5.3 Vitamin C

Studies have been conducted to determine the vitamin C content of various fruits and food stuffs. Wats and White (1931) estimated vitamin C in Pumelos (*Citrus decumana*), pineapples (*Bromelia ananas*), orange, lemon and banana and found that these were poor in vitamin C. Vitamin C in pulses, tomatoes, mangoes and bananas (Wats and Eyles, 1932) and in several food stuffs (Rangathan, 1935) have also been estimated . Guha and Ghosh (1934) observed an increase of vitamin C in *Phaseolus mungo* during germination. Rudra (1936) found vitamin C was more concentrated in the skin of fruits and vegetables than in the inner edible portions. Guha and Pal (1936) measured the ascorbigen content of a number of vegetables and animal foods. Birch *et al* (1933) developed a micromethod for estimating the hexuronic acid contents of food.

Dhopeshworkar and Magar (1950) found ascorbic acid was more stable in canned guavas as compared to canned potatoes and pineapple.

The presence of SH-compounds was found to protect ascorbic acid from oxidation in *Neera* from Date palm juice at 37°C. Guha and Ghosh (1934) observed isolated liver tissues of rats, rabbits and pigeons were able to synthesize ascorbic acids from mannose in vitro while those of guinea pig and monkeys failed to do so.

Ram Sri and Giri (1949) studied the influence of vitamin C on phosphorylase. Banerjee (1944) studied the interrelationship between ascorbic acid metabolism and the insulin content of β-cells of islets of Langerhans. Giri and Doctor (1938) demonstrated the application of a pyrophosphate- trichloroacetic acid mixture in the determination of vitamin C analysis of plant materials and animal tissues, and in the preparation of stable aqueous solutions of vitamin C and found Indian goose berries to be the richest source of vitamin C.

Harris and Ray (1933) found that vitamin C is normally excreted in urine. The amount was found to be 30-33mg/ day; while Ahmed (1936) found reduction of vitamin C excretion in a high protein diet with an increased ingestion of vitamin C. Chakraborty and Roy (1936) noted high ascorbic acid excretion in urine on high meat as well as high fat diets.

Roy *et.al.* (1946) observed the stimulating effect of chloretone on ascorbic acid excretion by rats were largely reduced in thiamine or riboflavin deficiency; while Ray and Basu (1940) determined that 66 mg of this vitamin was needed to meet its daily requirement for persons living on Bengali diet. Chakravarty and De (1948) observed its daily requirement for saturation to vary from 1.6 to 2 mg/kg body weight.

Banerjee and Guha (1939) studied the intradermal test of Rotter for vitamin C status of the individual. However Banerjee and Elvehjem (1945) could not agree with the claim of Wolly that glucoascorbic acid is an antivitamin of ascorbic acid.

Shourie and Giri (1940) investigated the protective action of the tissues of scorbutic and normal guinea pigs against oxidation of vitamin C and found no significant difference between them. Harris and Ray (1933) observed the loss of vitamin C in the suprarenals of guinea pigs in scurvey. Chakravarti and Banerjee (1955) studied the importance of dehydroascorbic acid index in determining the prognosis of diseases. They also observed the decrease in ascorbic acid and –SH groups of plasma with concomitant rise of dehydroascorbic acid in patient suffering from various infective diseases and studied the relationship between the rise of plasma dehydroascorbic acid and function of adrenal cortex in such infectious diseases.

3.5.4 Vitamin D

Dikshit and Ranganathan (1950) measured the vitamin D content of butter and ghee and found the non- saponifiable fractions to have a lower figure for vitamin D than the whole untreated sample. Chitre and Patwardhan (1938) studied the effect of vitamin D - hypervitaminiosis on calcium (Ca) and phosphate (P) content in bones and excretion of nitrogen, Ca and P in rats. Further Sukhatankar *et.al* (1945) have shown that ionic products of calcium and phosphates are influenced by the state of vitamin D nutrition.

3.5.5 Minerals and Electrolytes

Requirement of minerals and electrolytes has been the subject of investigations by the then many investigators. De (1949) estimated the minimum requirements of copper and magnesium to be 2.02 mg and 2.74 mg/day respectively in 7 normal adults with rice and wheat in diet, while Ganguly and Chatterjee (1950) determined copper content in normal urine and faces of Mohamedan, Anglo-Indian, European and Hindu widows from Calcutta area to be 2.64-2.72 mg/kg in faeces and 0.031-0.033 mg/l in urine. In Hindu male and female (not widow), these values were much lower.

Iron intake of normal male adults with three typical Indian diets was studied and observed that minimum daily requirement of iron for normal individual to be 9 mg; the average iron content of sweat has been found to be 0.13 mg per day (De, 1950). De (1950) also studied the metabolism of iron with typical Indian diet and found the saturation requirement to be between 8mg-9mg / day.

Chopra *et.al* (1940) observed the pH of sweat of healthy Indians to be 4.6 to 5.9 and the chloride content varied from 0.073-0.805%, the ammonia N from 10.9 mg to 34.2 mg% and the urea N from 10.4 mg- 61.5 mg %. However in hot and humid monsoon season in Calcutta in general, a progressive increase in concentration of sweat was observed with duration of exercise.

Sadasivan (1950b) showed that assimilation of phosphorus and sulphur in the intestine was affected by zinc. In another study, Sadasivan (1950c) reported the influence of manganese on metabolism was just the opposite to zinc. There appears no evidence of a lipotrophic activity of manganese under those experimental conditions.

4. Deficiency Disorders

Deficiency of certain dietary factors has been described in the previous sections. In addition, disorders which involve deficiency of multiple dietetic factors and which need treatment with their combination are presented below.

Malnutrition due to gross dietary deficiency was the important problem of the country as evident by the studies in the school children (Daver, 1950) and in factory workers (Demello *et al*, 1950). A survey in factory workers in Bombay (now Mumbai) revealed that more than 50 % of adult males suffered from anaemia. Similarly surveys carried out among the families of agricultural labours in Sagar district showed similar condition (Roy, 1950).

Different types of Indian diets were investigated to measure the total protein content to study whether these diets could provide the minimum protein requirement for normal individual health (Basu and Bask, 1935). South Indian diet has also been mentioned to be poor in its nutritive values and as such attempts have been made to supplement. The nutritive value of rice diet of the poorer classes in south India could be improved by the addition of basic calcium and phosphate. The improvement was evidenced by greater increase in weight, better length of body and femur due to more efficient calcification of bone. The calcium content of the blood was greater in the group receiving the supplement than in the other group, the reverse being observed in the case of phosphorus (Singh and Pal, 1938).

Giri and Shourie (1939) showed that serum phosphtase activity of rats fed on a poor south – Indian diet was higher than that or rats receiving the same ration supplemented with calcium lactate. Addition of extra fat to the basal diet was found to increase the serum phosphatase activity. However Krishnamurthy and Subhramanium (1949) found that calcium and vitamins at sub optimal levels given to rats fed with poor south Indian diets help to breed successfully but did not improve their capacity for lactation; incorporation of tamarine and chilli in proportions improved the growth rate and general health of animals.

Karambelkar et.al (1950) observed the effect of feeding animal proteins on the urinary nitrogen of adult human volunteers. Patwardhan *et.al* (1949) observed that low nitrogen excretion in Indian adults was not due to (i) the low protein intake or (ii) to the lower digestibility of vegetables proteins. Further, on increasing the proportion of animal protein from 11 to 46 %, the total urinary nitrogen increased in all subjects.

Radhakrishna Rao (1937) observed the nature of 'phrynoderma' and suggested that it was a manifestation of nutritional deficiency

particularly of vitamin A. He treated 2 cases of phrynoderma by high concentration of vitamin A. Iodine numbers of serum fatty acids were found to be significantly lowered in these cases (Menon et. al., 1950).

Several vitamins and amino acids have been found to influence fat metabolism and their deficiencies have been shown to cause fatty infiltration in liver. Tulpule and Patwardhan (1950) observed low iodine number of fatty acids of liver and kidney in fat and pyridoxine deficient rats and indicated that pyridoxine may help in the transport of fatty acids from liver.

Rao *et.al* (1950) reported on the curative effects at choline and methionine on experimentally produced hepatic lesions in rats on high fat diets; while Sadasivan (1950) studied the effects of choline on general metabolism of rats. Supplementation at 100 mg % of diet had a distinct sparing action on nitrogen, phosphorus and sulphur but a higher level of choline reversed this even though fat contents of liver were identical at both levels. Mukherjee and Guha (1938) showed that choline at 500 mg/kg failed to prevent acute fatty infiltration of liver in rabbit injected with a small dose of anterior pituitary extract though a change in iodine number of fatty acid was observed. Dietary protein did not appear any influence on the cystine and methionine content of the liver protein in rats (Sahasrabudhe and Lakshinarayan, 1951).

In this review article just the outline of the work of different investigators has been presented as far as practicable in the languages / symbols as used in the original article. Attempt has been made to highlight certain studies which are found comprehensive to author.

In the foregoing discussion, the origin and development of the subject physiology in the first fifty years along with the research activities during the period has been narrated however certain relevant points are stated below without which this write up would remain incomplete.

5. Physiology is the mother for most biology and allied subjects

Physiology deals with overall functioning of the different systems of human body to understand the entire life process as a whole based on physico-chemical principles from which its different branches have been emerged in a truncated way as biochemistry, biophysics, microbiology, immunology, bioengineering, bioenergetics, neurobiology, nutrition and dietetics, sports physiology and medicine, genetics, even today's biotechnology – wherein physiology remains as mother. This has been further evidenced by emergence of the pass out scholars of physiology as eminent biochemist, biophysicist, microbiologist, molecular biologist, neurobiologist, immunologist, biotechnologist in national and international scenario indicating their equal rather more proficiency in different fields than the scholars of any other branches of biological sciences.

6. Basic Physiology/Medical Physiology – challenges

Physiology as basic science is taught at undergraduate level (B.Sc Hons.) where in the duration of the course is for a period of complete three years while physiology under medical science is taught at preclinical level in the first year (MBBS) as preclinical subject for a period of one year in two semesters.

The syllabus in both the course are almost similar in content however the topics taught under basic science is in more detailed with the structural and functional aspects of the different systems along with mechanism of action to create an opportunity to know its different fields and generates an interest in research. The syllabus further facilitate to perform experiments designed either primarily for the study of physiological phenomena or for the assessment of function, analyze and interpret experimental data critically, distinguish between normal and abnormal data

derived as results and observations in the laboratory. In medical science it deals with structural and functional aspects to cover whole system physiology. The approach of the syllabus is to study more on applied physiology related to clinics and learn about human physiology experiments and clinical examinations of normal subjects which helps to develop their ability to understand para clinical and clinical subjects.

Certain topics viz. biostatistics, work physiology & ergonomics, sports physiology, social physiology, nutrition and dietetics etc. are additionally included in basic physiology syllabus.

The practical manual is based on hard core histology, experimental physiology, biochemistry, microbiology and immunology and human physiology at undergraduate levels in basic physiology syllabus ; further at undergraduate B.Sc.(Hons.) level the subject is taught as major subject with any two subsidiary subjects like Zoology/Botany/Chemistry/Physics/ Mathematics/ Molecular biology etc. while under medical science faculty the subject is taught with other two important major subjects like Anatomy and Biochemistry within a short span of one year.

In postgraduate level the duration of course are quite different - two years (in basic physiology) and three years (in medical physiology) respectively; in basic physiology all the advanced aspects of physiology are taught with any of the special papers as microbiology & immunology, endocrinology & reproductive physiology, biochemistry, nutrition & dietetics, environmental physiology, work physiology & ergonomics, sports physiology etc. The students have to prepare a project paper based on the topic of opted special paper. However under medical sciences, it is a self studied course, to develop self teaching skill the post-graduate students have to teach their under graduates peers and also submit a thesis paper.

In overall the tenure of the entire course in basic physiology is for 5 years and in medical physiology it is for 4 years only, the exposure of the students of basic physiology is more towards classical and advances aspects with hands on training in hard core practical physiology to generate research interest but in medical physiology to develop ability in para clinical and clinical subjects.

Graduates of this course from basic physiology department of Calcutta University contributed to elevate the standard of other allied Departments in research as well as teaching in the country at large.

The pass out students of this Department not only served as faculties in the subject of other Universities but also in the departments of allied subjects like Biochemistry, Psychology, Nutrition and Dietetics, Home Science, Microbiology, Neuroscience, Biotechnology, Pharmacology etc., as well as in medical colleges including AIIMS, veterinary colleges; as scientists in ICMR funded national research institutes, DST (Govt. of India), CSIR, different state Government funded research institutions, Defence Research Development Organisations (DRDO), Indian Council of Medical Research (ICMR) of the country with great repute. The service of the physiologists has not only restricted to scientific activities but also as administrative heads, policy makers of those scientific organizations having immense contributions.

7. Contributions of the physiologists to Industry, Defense (DIPAS)

The importance of basic physiology is now being well recognized in different industries as physiologists are recruited to reduce occupational health hazards, as faculties in Indian Institutes of Technologies (IITs), Institute of Design and Occupational Health for better design of man-used tools and machines, and to ensure safety and security. Basic physiologists are recruited in large numbers in Defence Research & Development Organizations (DRDO) to enhance efficiency,

performance and safety of the soldiers who have been working in adverse climatic conditions like extreme cold and hypobaric situations at high altitude, in space, deserts and even under water at sea.

8. Importance/Relevance of the subject in global arena

Considering the inherent strength of physiology as natural science 'Nobel Prize' is awarded every year since the inception Nobel Award Committee in 1900 in Physiology or Medicine giving both the subjects equal emphasis. Accordingly in Indian Science Congress Association (ISCA)'Physiology' has been introduced as independent Section since 1936 in addition to Medical and Veterinary Science Section. However just a decade ago Physiology Section has been merged with Medical Science and renamed as 'Medical Science (including Physiology) Section' in spite of the strong opposition from physiology community of the country. Reconsideration in this important aspect needs attention of the Executive and General Council members of ISCA as well as the Government.

9. Present state of the subject

The foundation followed by the development that have had in the first half of the century remain continued in the latter years up till now as the number of universities where physiology is taught as basic science at post graduate levels increased from one to six including one Central university and two post graduate colleges, the uptake of students at PG level increased from 20 to about 250 every year, the syllabus have been thoroughly revised from time to time considering the development of the subject and need of the hour, a number of new special papers have been introduced, the number of students enrolled every year for Ph.D. programme in Physiology is about one hundred

10. The state of the parent Physiology Department at the Calcutta University

The parent Department still located in the Science College campus at Rashbehari Siskha Prangan (Raja Bazar) of the University of Calcutta where it has been established. The intake of students every year is 40 and the student teacher ratio is 7:1, having nine special papers in different aspects, have ten well developed dedicated research laboratories in addition to six general laboratories. The number of annual publications on an average of the Department is about fifty in peer reviewed journals. A good number of students qualified them every year for National Eligibility Test (NET). DST (Govt. of India), DBT (Govt. of India), CSIR, ICMR UGC and other national and state Government level agencies provide funds to faculties to pursue research in basic physiology in varied aspects.

11. Why did not this subject flourish further

In spite of its immense potentiality as basic science, the subject has not been flourished as much as has been expected because more than the 100 years old subject is yet to get UGC's recognition like other subjects of biological sciences, students of physiology having M.Sc. and Ph.D. degree under basic science faculty are not eligible to be faculty in Medical Colleges of the country as was earlier (33 percent reservation provision for nonmedical candidates) as per existing Medical Council of India's regulations , and there is no Government level organisation for the promotion of physiological sciences in the country like 'Physiological Survey of India' as exists in other allied subjects . Further the invisible demarcation between nonmedical and medical physiologists of the country may not be ruled out in further progress and development of physiology in the latter years.

There is however an unfortunate tendency to include departments of Physiology, Botany and

Zoology clubbing them under a single department of Biological Science, even today which is detrimental for the development of Physiology in Indian Universities.

12. Inclusion of work in the Review

The review entitled 'First fifty years of physiology in India' literary a historical scientific review comprised of two sections – in the first section, the initiation, growth and development of physiology as basic science in India have been narrated while in the next part the research in physiological sciences in India during the first half of 20th century (1900 – 1955) without giving any consideration to the scientists who were from either basic physiology or medical physiology or any allied branches but their work have been considered only on the basis of the subject topic.

As a result, the contribution of the physiologists whose work are of immense importance and recognised internationally but in the latter half of the 20th century (i.e.,published as article in peer reviewed journal after 1955) have not been considered . This is not for ignorance of the author but as per title of the article as well as instruction of the journal.

Acknowledgement

My close association with the Physiological Society of India for a long time has inspired me to prepare this write-up wherein the information about the inception of the subject 'Physiology' in British Colonial India followed by its gradual development in terms of teaching and research during the first half of Twentieth Century came from the records of the Society as well as from the resourceful library of the Department of Physiology, University of Calcutta with which I am attached for a long time as a Faculty Member. The book *Progress of Physiology: Fifty years of Science in Indi*a edited by Mukherjee and Pradhan (1963) and published by Indian Science Congress Association is also a source to prepare this write-up. For the preparation of this manuscript the cooperation received from Dr. Arijit Chakraborty and Dr. Suvendu Ghosh is gratefully acknowledged.

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