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PRESIDENTIAL ADDRESS

Congress President: PROFESSOR S. N. BOSE

THE CLASSICAL DETERMINISM AND THE QUANTUM THEORY

I WOULD like to present before you certain aspects of modern physics and draw your attention to the profound changes in the principle of scientific explanation of natural phenomena brought about by the quantum theory. The last fifty years record remarkable discoveries. These discoveries have their repercussions in the realm of ideas. Fifty years ago the belief in causality and determination was absolute. To-day physicists have gained knowledge but lost their faith. To understand properly the significance of such a profound change it will be necessary to discuss briefly how it all came about. Classical physics had begun with the study of astronomy. Physicists had taken the equations of celestial mechanics as their model of a universal law. Since matter had resolved into a conglomeration of particles, the ideal scheme was to explain all phenomena in terms of their motions and interactions. It was only necessary to set up a proper set of equations, and to take account of all possible mutual interactions. If the mass, position, and velocity of all the particles were known at any instant, these equations would theoretically enable the physicist to predict the position and motion of every particle at any other subsequent moment.

The phenomena of light did not at first fit into this simple scheme. With the discovery of the electron as a universal constituent of matter, the electromagnetic theory of Maxwell was converted into an electronic theory by Lorentz. To the dynamical laws were added the electromagnetic equations and the two together apparently gave an exact and ideal formulation of the laws of causality. It was more or less a matter of faith to maintain that if it were possible for us to obtain all the necessary data by delicate observations, universal laws would enable us to follow each individual molecule in this intricate labyrinth and we should find in each case an exact fulfilment of the laws and agreement with observation. The above in brief forms an expression of faith of a classical physicist. We see that it involves as necessary consequences, belief in continuity, in the possibility of space-time description of all changes and in the existence of universal laws independent of observers which inexorably determine the course of future events and the fate of the material world for all times.

II

The development of the quantum theory has raised fundamental issues. Facts have been discovered which demonstrate the breakdown of the fundamental equations which justified our belief in determinism A critical examination of the way in which physical measurements are made has shown the impossibility of measuring accurately all the quantities necessary for a space-time description of the motion of the corpuscles

Experiments reveal either the corpuscular or the wave nature for the photon or the electron according to the circumstances of the case, and present us with an apparently impossible task of fusing two contradictory characters into one sensible image. The only solution suggested has been a renunciation of space-time representation of atomic phenomena and with it our belief in causality and determinism.

Let me briefly recapitulate the facts. In 1900 Planck discovered the quantum of action while studying the conditions of equilibrium between matter and the radiation field Apparently interchange of energy took place in discrete units whose magnitude depended on h and the frequency of the radiation emitted or absorbed by matter. Photo-electric emission had similar disquieting features Einstein, therefore, suggested a discrete structure of the radiation field in which energy existed in quanta instead of being continuously distributed in space as required by the wave-theory. This light-quantum, however, is not the old light-corpuscle of Newton. The rich experimental materials supporting the wave-theory preclude that possibility altogether. Moreover the fundamental relation, $E = h\nu$, and $p = hk$, connecting energy and momentum of the photon with the frequency ν and the vector wave number k, makes a direct reference to idealised plane wave so foreign to the old idea of a corpuscle. Soon afterwards Bohr postulated the existence of radiationless stationary states of atoms and showed how it led to a simple explanation of the atomic spectra. The extreme simplicity of the proposed structure and its striking success in correlating a multitude of experimental facts at once revealed the inadequacy of the ordinary laws of mechanics and electro-dynamics in explaining the remarkable stability of the atoms.

The new ideas found application in different branches of physics. Discontinuous quantum processes furnished solutions to many puzzles. Suitably modified, the theory furnished a reasonable explanation of the periodic classification of elements and thermal behaviour of substances at low temperature. There was, however, one striking feature. It was apparently impossible to characterise the details of the actual transition processes from one stationary state to another, that is, to visualise it as a continuous sequence of changes determined by any law as yet undiscovered. It became clear that the dynamical laws as well as the laws of electromagnetism failed to account for atomic processes. New laws had to be sought out compatible with the quantum theory capable at the same time of explaining the rich experimental materials of classical physics. Bohr and his pupils utilised for a time a correspondence principle, guessing correct laws for atomic processes from analogy with the results of the classical theory. In every case these appeared as statistical laws concerned with the probabilities of transition between the various atomic states. Einstein tackled the problem of the equilibrium of matter and radiation on the basis of certain hypotheses regarding the probabilities of transition between the various states by absorption and emission. A derivation of the Planck Law was obtained by Bose by a suitable modification of the methods of classical statistics. Heisenberg finally arrived at a satisfactory solution and discovered his matrix-mechanics and a general method for all atomic problems. Dirac and Schrödinger also published simultaneously their independent solutions. Though clothed in apparently dissimilar mathematical symbols, the three theories gave identical results and have now come to be looked upon as different formalisms expressing the same statistical laws.

I have mentioned that the photon gave a simple explanation of many of the properties of radiation and thereby presented its corpuscular aspect while the well-known properties of interference and superposibility brought out its wave character. That the same dual nature may exist in all material corpuscles was first imagined by De Broglie. His phase-waves found quick experimental verification, and raised a similar problem of the real nature of the corpuscle. The formulation of wave-mechanics by Schrödinger, once raised a hope that by a radical modification of our usual ideas about the corpuscle it might be possible to re-establish the law of causality and classical determinism. Subsequent developments have shown such hopes to be illusory. His waves are mathematical fictions utilising the multidimensional representation of a phase-space and are just as incapable of explaining the individuality of the electron, as the photon is incapable of explaining the superposibility of the field. The true meaning of his equations appears in their statistical interpretation.

III

The adherents of the quantum theory interpret the equations in a peculiar way. They maintain that these equations make statements about the behaviour of a simple atom and nothing more than a calculation of the probabilities of transition between its different states is ever possible. There is nothing incomprehensible about such a statistical law even if it relates to the behaviour of a single particle. But a follower of determinism will interpret such statements as betraying imperfect knowledge, either of the attendant circumstances or of the elementary laws. We may record the throws when a certain die is cast a large number of times and arrive at a statistical law which will tell us how many times out of a thousand it will fall on a certain side. But if we can take into account the exact location of its centre of gravity, all the circumstances of the throw, the initial velocity, the resistance of the table and the air and every other peculiarity that may affect it, there can be no question of chance, because each time we can reckon where the die will stop and know in what position it will rest. It is the assertion of the impossibility of even conceiving such elementary determining laws for the atomic system that is disconcerting to the classical physicist.

Von Neumann has analysed the statistical interpretation of the quantum mechanical laws and claims to have demonstrated that the results of the quantum theory cannot be regarded as obtainable from exact causal laws by a process of averaging. He asserts definitely that a causal explanation of quantum mechanics is not possible without an essential modification or sacrifice of some parts of the existing theory.

Böhr has recently analysed the situation and asserted that we cannot hope any future development of the theory will ever allow a return to a description of the atomic phenomena more conformable to the ideal of causality. He points out the importance of the searching analysis of the theory of observation made by Heisenberg, whereby he has arrived at his famous principle of indeterminacy. According to it, it is never possible for us to determine the simultaneous values of momentum, and positional co-ordinates of any system with an accuracy greater than what is compatible with the inequality

$$\Delta p \, \Delta q > \frac{h}{4\pi}.$$

This natural limitation does not affect the physics of bodies of finite size but makes space-time descriptions of corpuscles and photons impossible. When we proceed to study the behaviour of the elementary particles, our instruments of measurement have an essential influence on the final results. We have also to concede that the contributions of the instrument and the object, are not separately computable from the results as they are interpreted in a classical way with the usual ideas of co-ordinate and momentum accepting thereby a lack of control of all action and reaction of object and instrument due to quantum effects.

It is in this imperative necessity of describing all our knowledge with the usual classical ideas, that Böhr seeks an explanation of the apparently irreconcilable behaviour of corpuscles and radiation in different experiments. For example, if we set our experiments in such a fashion as to determine accurately the space-time co-ordinates, the same arrangement cannot be simultaneously used to calculate the energy momentum relations accurately; when our arrangements have pushed the accuracy of determining the positional co-ordinates to its utmost limit, the results evidently will be capable only of a corpuscular representation. If, on the other hand, our aim is to determine momentum and energy with the utmost accuracy, the necessary apparatus will not allow us any determination of positional co-ordinates and the results we obtain can be understood only in terms of the imagery of wave-motion. The apparently contradictory nature of our conclusions is to be explained by the fact, that every measurement has an individual character of its own. The quantum theory does not allow us to separate rigorously the contribution of the object and the instrument and as such the sum total of our knowledge gained in individual cases cannot be synthesised to give a consistent picture of the object of our study which enables us to predict with certainty its behaviour in any particular situation. We are thus doomed to have only statistical laws for these elementary particles and any further development is not likely to affect these general conclusions.

It is clear that a complete acceptance of all the above conclusions would mean a complete break with the ancient accepted principles of scientific explanation. Causality and the universal laws are to be thrown simultaneously overboard. These assertions are so revolutionary that, no wonder, they have forced physicists to opposing camps. There are some who look upon causality as an indispensable postulate for all scientific activities. The inability to apply it consistently because of the limitations of the present state of human knowledge would not justify a total denial of its existence. Granted that physics has outgrown the stage of a mechanistic formulation of the principle, they assert that it is now the task of the scientists to seek for a better formulation. Others of the opposing camp look upon old determinism as an inhuman conception, not only because it sets up an impossible ideal, but also as it forces man to a fatalistic attitude which regards humanity as inanimate automata in the hands on an iron law of causation. For them the new theory has humanised physics The quantum statistical conception of determinism nestles closer to reality and substitutes a graspable truth for an inaccessible ideal. The theory has brought hope and inspired activity. It constitutes a tremendous step towards the understanding of nature. The features of the present theory may not all be familiar but use will remove the initial prejudice We are not to impose our reason and philosophy on nature. Our philosophy and our logic evolve and adjust themselves more and more to reality.

In spite of the striking success of the new theory, its provisional character is often frankly admitted. The field theory is as yet in an unsatisfactory state. In spite of strong optimism, difficulties do not gradually dissolve and disappear. They are relegated to a lumber room, whence the menace of an ultimate divergence of all solutions neutralises much of the convincing force of imposing mathematical symbols. Nor is the problem of matter and radiation solved by the theory of complementary characters. Also we hear already of the limitations of the new theory encountered in its application to nuclear problems.

The quantum theory is frankly utilitarian in its outlook; but is the ideal of a universal theory completely overthrown by the penetrating criticism of the nature of physical measurements?

Bohr has stressed the unique character of all physical measurements. We try to synthesise their results and we get probabilities to reckon with instead of certainties. But how does the formalism $\frac{h}{2\pi i}\frac{\partial\psi}{\partial t} = H\psi$ emerge as a certain law? The wider the generalisation, the less becomes the content. A universal law would be totally devoid of it. It may nevertheless unfold unsuspected harmonies in the realm of concept. More than ever now, physics does need such a generalisation to bring order in its domain of ideas. M. A. G.

CHEMISTRY

President Dr. R. C. Ray, D.Sc., F.I.C.

SOME ASPECTS OF MODERN INORGANIC CHEMISTRY

THERE are many who think that there is no future for inorganic chemistry, except in its application to industry It is generally assumed that inorganic chemistry has progressed as far as it could with the tools at hand. The discovery of the inert gases of the atmosphere by Ramsay and his co-workers and practically all the missing elements seems to have added the last chapter to inorganic chemistry; and one may really wonder what is there left to be done. The accumulated treasures, no doubt, seem marvellous, but as each year rolls by we find ourselves, like Balboa, looking down from the mountain top, beholding an infinite and beautiful expanse, yet unfathomed The vista continues to widen, and new problems, new theories, new view-points loom large before us.

The possibility of compound formation by the inert gas was first suggested by Villiard, who found that crystalline hydrates were formed when the inert gases admixed with water, were cooled under pressure. The structure of these hexahydrates would seem to be similar to that of the co-ordination compounds of the cobaltamine type. The recent work of Nikitin in U.S.S.R., have established the formation of $Rn.2C_6H_5OH$ and $Xe.2C_6H_5OH$ corresponding to $H_2S.2C_6H_5OH$ or $HCl.2C_6H_5OH$. Booth and Wilson have also obtained and studied the formation of $A.6BF_3$. The formation of these co-ordination compounds of inert gases opens up an interesting field of research, and a considerable amount of work still remains to be done in this direction. The formation of such compounds by the higher atomic weight inert gases is permitted also by theoretical considerations, which indicate besides that the other lighter inert gases may also form compounds after excitation. Thus while Helium does not form co-ordination compounds of the type mentioned, it is apparently capable of combining with mercury in presence of electric glow discharge at low pressures. The formation of several other helides such as WHe_2, etc, by the reaction of excited He atoms, has also been reported.

During the last thirty years, considerable progress has been made in the chemistry of Boron and its compounds, but a large amount of work still remains to be done, before adequate answers could be found for many questions which remain unanswered. The study of hydroborons and borohydrates has raised new problems about the nature of the chemical bond. Six hydrides of Boron are now known and the recent work of Schlesinger and his school have advanced our knowledge about these highly unstable and greatly reactive substances. Two of these very interesting types of compound are borine carbonyl and the metalloborohydrides. The former is somewhat similar to volatile metal carbonyls. The metallic borohydrides are generally prepared by the action of diborane on the alkyl compounds of the corresponding metals. Lithium borohydride is a definitely salt-like substance and has been given the formula $Li^+ BH^-_4$, but the beryllium borohydride BeB_2H_8 is a highly volatile solid, and aluminium borohydride AlB_3H_{12} is a still more volatile liquid. The gradation of properties from the relatively high melting non-volatile and polar lithium borohydride to the low-melting, highly volatile and almost non-polar aluminium borohydride is very striking; while the properties of aluminium borohydride approach those of diborane itself, the properties of beryllium borohydride are intermediate between those of corresponding lithium and aluminium compounds.

The mechanism of hydrolysis of magnesium boride has been studied by Ray and co-workers with interesting results. Contrary to what has been generally supposed, no boric acid or magnesium borate is formed in the hydrolysis of magnesium boride by water or dilute acids, but $H_3B_6(Mg.OH)_3$ and $Mg_4B_2(OH)_2$. The aqueous extract is a strongly reducing solution containing $H_6B_2O_2$. This compound exists in 2 isomeric forms α and β, the most important difference between these being that while a molecule of the α-compound loses 4 atoms of hydrogen when treated with an acid, the β-compound yields only 2 atoms of hydrogen per molecule. The constitution of these isomeric borohydrates provides a very interesting study on the nature of chemical bonds, particularly considering that it is now generally admitted that any chemical bond is not the resultant of a pair of electrons nor even of all the electrons associated with the pair of bonded atoms, but of all the electronic forces in the molecule. It seems that the solution of the mystery of the nature of the chemical bond lies hidden in the chemistry of the inert gases and that of boron.

While the constitution and structure of most organic compounds have been worked out, analytically as well as synthetically, the same thing cannot be said about many inorganic compounds. For instance our knowledge about the metallic hydrides is still incomplete. It is well known that some rare-earth metals, zirconium, tantalum and titanium, form a class of hydrogen compounds in which there does not exist an exact stoichiometric relationship between the metal and the hydrogen atoms, and these are generally regarded as interstitial compounds. Some of these "hydrides", however, possess high values for their heats of formation, suggesting that there can be little difference in the nature of the chemical bond in a substance such as zirconium hydride, $ZrH_{1.98}$ (heat of formation = 38,900 cals.) and barium hydride, BaH_2 (heat of formation = 40,960 cals.) It is one of the puzzling features of this group of substances.

The list of topics can, of course, be made much larger and may well include fields of other investigations in which both experimental methods and relevant theories are still lacking. It is clear, however, from what has already been said, that there has probably never been a time when the prospects of inorganic chemistry were so promising as they are to-day.

M. A. G.

BOTANY

President: Dr. T. S. Sabnis

PROGRESS OF BOTANY WITH SPECIAL REFERENCE TO ECONOMIC PLANTS

THE science of plant breeding and genetics has played a dominant role in the creation of better crops. Mendel's laws of heredity gave impetus all over the world to apply them for the benefit of evolving varieties with desirable traits. The present-day sugar-beet with its trebled sugar content, Marquis wheat, Yeomen I and Yeomen II and Howard's Pusa varieties of wheat which are the best yielding strains, are the outcome of intensive work on breeding. Cytology has recently come to play an important part in plant breeding; desirable gene combinations have been made possible by a cytological study of the different varieties of plants and this study has helped further to induce fertility in sterile hybrids which is a source of setback in plant breeding. The potentiality of inducing polyploidy does not merely end in inducing fertility but a further application of this phenomenon has resulted in plants like tomato and maize with increased nutritive content.

The discovery of ecotypes or biotypes in a species has provided a larger arena for the breeder. It has been possible to evolve newer and better-yielding forms by a close study of the variations in the ecotypes and has a great application both for improving agricultural and forestry plants. The findings of Clements and his co-workers regarding the growth of plants in relation to their environmental factors, that qualitatively water is the most important and that quantitatively light and nutrients, is of immense help particularly in the improvement of grasslands and forage crops.

Photoperiodism and vernalization have given wonderful results particularly in the U.S.A. and Russia The finding that the general effect of shortened illumination resulted in an earlier production of flowers, has become a boon to synchronising the flowering period of widely divergent varieties. This has a very important possibility of cross-fertilising them under normal conditions. Such a result has already been achieved by crossing Egyptian cotton with low boll with several South American cottons with large bolls but of short day and perennial habit. 'Light' treatment is finding use in India in the improvement of potato. Lysenko subjected certain seeds to various temperature treatments and found that the vegetative stage was greatly reduced and the flowering stage commenced very early. This finding has resulted in many varieties of winter wheats yielding good crop, which without vernalization would not ear when sown in spring.

Economy in time and energy of raising fresh plants has been made possible by the application of growth hormones. Contributions from the Boyce Thompson Institute and the investigations of Zimmermann and Hithhcock have opened up the possibility of employing the application of growth hormones on a commercial scale particularly for the rooting of cuttings which prove difficult and seedlings which are too delicate and suffer considerable mortality in early stages. It is of particular interest to note that when seeds are treated with the hormones obtained from Rhizopus and Yeast, the reproductive phase of such plants commenced earlier, much in the same manner in the case of vernalized seeds.

The role of secondary elements like boron, manganese, etc., is shown to be of vital importance for successful growth and fructification. And this has helped to combat certain deficiency diseases also. Soil-less culture is finding popularity but its success depends upon much spadework which is still to be done. Breeding has again played a major part in evolving varieties resistant to certain diseases. Particularly in America and Canada great success has been achieved in breeding rust and smut-resistant individuals from existing varieties.

B. G. L. S.

ZOOLOGY AND ENTOMOLOGY

President: DR. VISHWA NATH

THE GOLGI APPARATUS

IN his Presidential Address to the Section of Zoology and Entomology Dr. Vishwa Nath has given a summary of the present position of the Golgi Apparatus, incorporating some of his own views regarding the form and function of this cytoplasmic structure. A very large number of papers have appeared since 1898 when first this apparatus was discovered by Golgi and to-day, we are able, to a certain extent, to marshal the great array of facts and observations that have accumulated about the form, composition and function of this body. It is now known that the Golgi apparatus is found in every type of animal cell (and in most plant cells) and instead of being artefacts as they were once believed to be, they are real and living bodies in the cell. But their form, however, is subject to great variation, depending, mostly, on the technique employed; and here, Dr. Nath holds the belief very fixedly and vehemently that they are spherical granules and never of any other form. All other forms,—networks, dictyosomes, batonettes and rods are, according to him, artefacts, a conclusion which he has arrived at from an examination of a variety of cells. In chemical composition, the Golgi bodies are fats linked with proteins. The protein probably occupies the outermost layer of the Golgi sphere. In comparison with mitochondria the Golgi bodies have relatively less protein than lipoids and also their specific gravity is less than that of mitochondria as shown by experiments with the centrifuge.

The function of the Golgi bodies is also manifold. They give rise to the acrosome in sperm formation, to fat in oogenesis and to secretory granules in gland cells. But the exact method of formation of these bodies is a subject of controversy. Dr. Nath holds the view that in all the three cases a direct transformation of the Golgi apparatus into the products takes place, while the majority of workers are of opinion that they are products of secretion of the Golgi apparatus. There appears to be a close relation between the Golgi bodies and the mitochondria as the recent work of Hirsch has shown and it is possible that the Golgi pre-substance which is the primordial Golgi material in the cell is the contribution by the mitochondria and probably also the nucleus and cytoplasm.

There really does not seem to be much use in debating at great length and with much heat the problem of the exact form of the Golgi apparatus or the precise manner in which the products are formed by it. Would it not be better to realise that this "most protean of all cytoplasmic inclusions" is, like the living protoplasm of which it forms part, capable of varied manifestations, expressing itself in a hundred forms, all different but all designed to the same end, of fulfilling their destiny?

B. R. S.

MEDICAL AND VETERINARY RESEARCH

President:

DR. K. V. KRISHNAN, M.R.C.P., D.B., D.SC., F.N.I.

MEDICAL EDUCATION

IN his Presidential Address, Dr. Krishnan has laid stress on the great and urgent need for the proper training of the skilled medical men. a fundamental and vital question of the country. In spite of the progress and achievement of the last hundred years, he remarks, there is ample scope for further improvement and expansion in several directions. On the standard of the medical education reached in any country, Dr. Krishnan says, largely depends the soundness of medical men, the efficiency of medical service provided by the Government and its usefulness to the community.

In India we have a dual standard of medical education—lower and higher. The lower standard had to be instituted chiefly for economic reasons and as an interim expediency in the evolution of medical education. But it is now felt in India that the lower standard of education should be abolished and Dr. Krishnan hoped in very near future India would have only medical colleges and no schools.

The number of medical institutions and the number of medical men produced from such institutions have a direct bearing on the needs of medical education of a country. Dealing with this question Dr. Krishnan pointed out that the standard aimed at in Western countries was to have at least one qualified doctor for every 1,000 of the population. India falls much below this standard and while she should have at least 400,000 doctors, ten times the present number, she is having only about 1,700 new doctors every year, produced jointly by the ten medical colleges and 27 medical schools in existence. Dr. Krishnan stresses that unless some practical plan is put forward to hasten production, it will take years before India can hope to solve this question of inadequacy.

Side by side there is the problem of rural needs, which, it must be admitted, are not being satisfied at all at present. India is predominantly a rural country; 95 per cent. of her vast population live in rural areas. The majority of these receive little or no medical aid. Although many attempts have been made to provide in the past, medical aid to rural areas, with the help of men we have been producing in our colleges, no great success has been achieved so far. This is mainly due to the fact that right type of men do not come forward to serve and also appropriate training is lacking. Dr. Krishnan suggests that it is the duty of our medical colleges to select the right type of men and train them suitably.

The importance of women doctors is also emphasised. The total number of women doctors in this country is quite small and utterly inadequate. India, with her medical problems so closely intermingled with her social problem, has a greater need for women doctors than even Russia has (where there is the largest proportion of women doctors, almost 50 per cent.). The medical colleges should throw open their doors freely to women, and offer scholarships in sufficient numbers to attract the right type.

Making suggestions for the improvement of medical education in this country, Dr. Krishnan divides medical training into two parts—under-graduate and post-graduate. Advancement of science can only be achieved through men with a scientific bent of mind. It is the responsibility of the medical colleges to produce such men through inclusion of research programme in education. In India most medical colleges have only limited resources for prosecuting research. Dr. Krishnan suggests that in quantity and quality their research activity need to be much augmented. He also lays emphasis on the importance of providing adequate clinical facilities for teaching purposes. It should be made compulsory for the students and the staff to spend more time at the bedside than in the lecture room or laboratory as at present. Certain reforms should immediately be introduced relating to the instructional staff of the Indian medical colleges in the interest of medical education. Serious damage had been done through allowing private practice to the paid teaching staff of medical colleges. This system should at once be stopped and the constitution of a separate cadre for teaching staff be introduced immediately.

Dealing with the post-graduate courses of study Dr. Krishnan lays stress that there should be training of specialists in one or other differentiated fields of medicine and that there should be refresher courses to the general practitioner and others to keep them abreast of recent advances in their field. For the advanced type of post-graduate training, separate post-graduate institutions are generally established which will serve the purpose of teaching, advice and research. The staff should be composed of men of superior calibre whose main duties should be to give advice on all important scientific matters and to undertake research on problems of national importance.

After discussing the various aspects of medical training, Dr Krishnan points out that almost all the colleges in India are of the ordinary type. The modern tendency is to have wherever possible medical colleges of the University type which, in the words of Abraham Flexner, "would address itself wholeheartedly and unreservedly to the advancement of knowledge, the study of the problems from whatever source they come and the training of men all at the highest level of possible effort". A few colleges in India are struggling towards the university type, and these can be reorganised and remodelled in the near future.

After discussing the various aspects of medical education and giving tentative suggestions for development or improvement in certain directions, Dr. Krishnan remarks that whatever may happen, one thing is certain that the future of medicine in this country will largely depend upon the attitude taken by the Government, the medical profession and the public on the indigenous and other systems of medicine, on the type of medical service and on the basic premical cause of ill-health. We must make up our mind as to what to do with the Ayurvedic and Unani systems of medicine. Dr. Krishnan thinks that these indigenous systems are antiquated and empirical and any sympathy or attachment to them will retard scientific progress. The type of medical service best suited to this country has also to be decided. We must study beforehand the situation in this country thoroughly and find out the type of medical service that will readily and truly take the benefits of modern scientific medicine within the reach of every individual in the country, urban and rural. And lastly, it has to be realised that the medical problem is closely connected with the social and economic problems Unless we stamp out the basic causes of ill-health, namely, ignorance; poverty and lethargy, we will never attain any measure of success with any of the schemes. N. N. D.

PHYSIOLOGY

President: Dr. S. N. Mathur

HARMONY AND RHYTHM IN NATURE

SOME of the fundamental factors, such as, CO_2, temperature, oxygen and alternate periods of rest and activity, which are necessary for the harmonious working of the body are dealt with in this address.

The role of CO_2 in normal activities of the organs has been discussed. CO_2 is the natural excitant to vaso-motor centre. It actively increases dilatation of the heart, which indirectly results in an increased cardiac output. A certain tension of CO_2 is essential for the entire activity of the heart. CO_2 is necessary to maintain and regulate the activity of the rhythmic respiratory centre. Besides these, it plays an important part in the regulation of pH of the blood and other fluids and "indirectly ministers for the digestive needs of the body".

The regulation of internal temperature is of greater importance than the maintenance of CO_2 balance. It is found that at higher temperatures the respiratory centre is tuned to work at lower CO_2 tension and at lower temperatures, respiration and circulation become slow and CO_2 tension is raised, a mechanism directed for regulation of temperature rather than maintenance of CO_2 tension.

At low temperatures associated with anoxia, respirations become hurried and heart beats faster, showing thereby that a constant supply of adequate amount of oxygen is even a greater need to the body than maintenance of temperature.

Of primary necessity to life is, however, alternate periods of rest and activity. Next to oxygen comes sleep. Sleep is presided over by the cholenergic part and wakefulness by adrenergic part of the autonomic nervous system. "On this conception the vagus nerve of the heart is considered not an inhibitor but as a nerve which controls and regulates the restful component of the rhythm of the heart and restores the energy lost during contraction."

Besides this diurnal rhythm of sleep and wakefulness, the body as a whole exhibits a less obvious yearly rhythm, consisting of increased activity during spring and summer, and lessened activity during autumn and winter, and thus pulsates with the rest of nature. The yearly rhythm of the body is apparently under the guidance of the two components of the autonomic nervous system. S. H.

ENGINEERING AND METALLURGY

President: MR. J. J. GHANDI

INDUSTRIAL RESEARCH

(With Special Reference to India)

THOUGH the realisation has come that organised research, pure and applied, is an absolute necessity in the present-day economic conditions of life, our research organisation in this country is still in the stage of infancy and the fields of industrial research yet to be covered are vast and boundless How best this organisation can be improved, developed and expanded must be uppermost in many minds. A brief review of the development of Industrial Research Organisation in India starting with the constitution by the Government of India of the Board of Scientific Advice in 1902 to the establishment of the Board of Scientific and Industrial Research in April 1940, shows how slow, inadequate and unco-ordinated are the scientific and industrial research activities in this country. A study of the history of organised research in Germany, Great Britain, United States of America and U.S.S.R. serves to indicate in great contrast our vital weaknesses in the field.

It is often urged that war has filled many gaps in India's industrial structure The statement is misleading. The gaps filled are relatively few and, by no means, of great importance: the major gaps are still unfilled. Even Australia and Canada have been able to accomplish much more in the industrial field than India and are now several paces ahead of us.

There can be no doubt to-day that if India is to survive in the post-war world of progress and competition, in which there will be more of international co-operation and less of national tariff protection, and efficiency will be the main criterion of success, we must draw up a blue-print of what our research organisation should be after the war, and do so now. There is no time to be lost.

To my mind, national research must be planned on national lines in order to prevent clashes of sectional interests, territorial and occupational, and obviate unnecessary overlapping of work and the consequent waste of money and effort. It must be adjusted to the economic structure of the country and not be a blind repetition of some foreign model. The Government, the University and Industry, each must be assigned distinct research functions, though all three must work in close collaboration towards the same end.

To summarise my proposals: The existing Board of Scientific and Industrial Research should be retained, but its membership should include a larger number of scientists than at present, so as to cover all branches of science, and the functions of the constituent bodies of the department should be slightly re-classified to prevent overlapping. The official scientific services should be autonomous in their daily operation, but should co-operate with the above-mentioned department of research. A supreme National Academy of Sciences representing the existing scientific societies should be brought into existence to co-ordinate the work of the various scientific societies and co-operate with the Board of Scientific and Industrial Research in general scientific direction. Provision has also been made for bringing industry into contact with science, and both, into contact with Government, and some indication given of the media of publicity that can be usefully exploited M A. G

PSYCHOLOGY AND EDUCATIONAL SCIENCE

President MR JOHN SARGENT

THE practical aspect of Educational Reconstruction was the subject of the Presidential Address of Mr John Sargent, C.I.E., to the Section of Psychology and Educational Science of the Thirty-first Indian Science Congress held in Delhi

After stating that "anyone who knows anything about the present state of education, to say nothing of other social services in this country will realise that the question is anything but a rhetorical one", and pointing out that in such instruments as education we see the means of raising standards to a level which will at least make government of the people by the people for the people a practical proposition, Mr. Sargent says: "An India, 85 per cent. of whose population are illiterate and liable as we have seen more than once in recent years, to be stampeded by political and religious excitement, however irrational, constitutes a field for mischief-makers, the infinite continuance of which world opinion in search of a more stable future can hardly be expected to tolerate. Is it unreasonable to anticipate that whatever may satisfy government or big business or all the other vested interests, whose vision is either oblique or retrospective, the logic of any post-war settlement will demand a drastic change in the present state of things?"

Mr. Sargent then states the minimum programme of development and essential requirements, which will place India on an approximate educational level with other countries. The scheme provides for a national system of education to provide all children in India with eight years of basic education and enable promising children to pass on to high schools, universities, technical and commercial schools and art institutions. The following are the essential requirements in brief:—

(1) Universal compulsory and free education for all boys and girls from the age of five or six until fourteen, in order to ensure literacy and the minimum preparation for citizenship.

(2) A reasonable provision of education before the compulsory age for school attendance in the form of nursery schools and classes. This is particularly important in the interest of health in areas in which housing conditions are unsatisfactory.

(3) Secondary or high school education for those children, who show the capacity for benefiting by it. Variety, both in types of school and in the curricula of individual schools, to suit the varying tastes and aptitudes of the individual pupils, is essential. In addition, so that no boy or girl of outstanding ability may be debarred by poverty from further education, liberal financial assistance in the form of free places, scholarships and stipends must be forthcoming.

(4) University education, including post-graduate and research facilities for picked students.

(5) Technical, commercial and art education.

(6) Adult education, both vocational and non-vocational, of all kinds and standards to meet the needs of those who were denied adequate opportunities in their earlier years.

(7) Arrangements for training the vast army of teachers, which a system of this kind will require.

(8) An efficient school medical service, which will see the children are made healthy and keep healthy.

(9) Special schools for children suffering from mental or physical handicaps.

(10) Recreational facilities of all kinds.

(11) Employment Bureaux, to guide school and college leavers into profitable employment.

(12) An administrative system which will place initiative and authority in the hands of those who understand and care about education.

These requirements, states Mr. Sargent, can hardly be described as extravagant. They were all covered by the British system of Education as it existed before the war, while in many parts of the United States of America and in some European countries a still more liberal system of public instruction was available.

Then Mr Sargent examines how far the Indian system, as it exists to-day, falls short of these desiderata and whether it is practicable to build upon it a national system on the lines which have been already outlined. Speaking of compulsion, he says that it exists only in a very limited number of areas, usually towns, and covers only the primary stage, and in the majority of cases, compulsion is admittedly a failure. Further, an examination of figures of enrolment by classes shows that less than one out of every four children stayed long enough at school to reach the earliest stage, *viz.*, Class IV, at which permanent literacy is likely to be attained. The result is that the money spent on the others (nearly 80 per cent.) may be regarded as almost entirely wasted.

He then speaks of teaching service in India and states that the average pay of a primary teacher in Government schools in India is about Rs. 27 per mensem and in private schools is below Rs. 10 per mensem; and such a service can hardly attract the sort of people who ought to be in charge of the nation's most valuable asset, *viz.*, its children during its most malleable stage. In Great Britain the scales of salaries of ordinary assistant teachers in primary schools range from £150 to £408 per *annum*.

As regards adult education, Mr. Sargent says that at least 85 per cent. of the population of India is illiterate, and if the problem of illiteracy is to be dealt with as effectively and quickly as appears to have been the case in Russia, it will have to be attacked at both ends, *i.e.*, by the establishment of universal, compulsory and free primary education, and by the provision at the same time of abundant facilities for those whose education was neglected in their earlier years.

Mr Sargent points out that if a national system of education is to be introduced within a reasonable period it will have to be not merely subsidised but also stimulated and co-ordinated from the Centre. This means a strong education department in the Central Government. He then concludes that the present Indian system of education when considered either on its merits or in comparison with systems in other countries, is deficient in almost every branch and that if any real progress is to be made a large part of what exists to-day will have to be scrapped.

Then the expenditure on education to bring it to the same level as existed in other countries before the war is considered in detail, and Mr Sargent concludes that for British India the scheme would cost by the time it is fully established, *i.e.*, at the end of forty to fifty years, Rs. 313 crores annually, of which Rs. 277 crores will probably have to come out of public funds.

As regards the actual working of the scheme it is suggested that the work might be spread over eight five-year programmes, the first being devoted to working out plans in detail, regarding the administrative system and setting up the training schools and colleges necessary to provide the teachers required. During each of the succeeding seven periods an area roughly equivalent to one-seventh of the area of each province would be taken in hand.

Concluding, Mr. Sargent says, "If my premises are accepted, there can be no half-way house between what is and what ought to be. It is all or nothing. All means expenditure on a scale which frighten those who have defended inertia on the ground that India is too poor to have what other countries enjoy. Anything less than all means—and there is no evading this conclusion—that India accepts a position of permanent inferiority in the society of civilised nations."

B. V.-S.

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