The Bose Research Institute, Calcutta.

IN view of the lively interest that has been aroused by the lectures that have been delivered recently by Sir J. C. Bose in London and elsewhere, on the methods and results of his investigations on the physiology of plants, it will no doubt be agreeable to many readers of NATURE to have some general information concerning him and his work, and about the Research Institute which he has founded in Calcutta.

Already a B.A. of the University of Calcutta, possessing a fair knowledge of physics and chemistry, Sir Jagadis Bose came to England in 1880 for the purpose of studying medicine, and entered University College, London, where he made his first acquaintance with biology in the course of instruction given by Sir E. Ray Lankester. However, he soon found that his health, then somewhat precarious, could not stand the strains peculiar to medical study, and decided to go to Cambridge in order to devote himself to natural science. Accordingly he presented himself as a candidate for an open scholarship at Christ's College, to which he was duly elected, and went into residence there in January 1881. At Cambridge he pursued the general course of work for the Natural Sciences Tripos: he studied chemistry, and especially spectroscopy, under Liveing; physics under Lord Rayleigh in the then newly erected Cavendish Laboratory; physiology under Michael Foster; embryology under Francis Balfour; botany under Vines, who was also his college tutor. He took his B.A. degree in 1883: in the meantime he had taken his B.Sc. at the University of London, and ten years later the D.Sc. degree was conferred upon him. He thus acquired a good all-round scientific education, with a special knowledge of physics.

On returning to India in 1884, Sir Jagadis was appointed officiating professor of physics in the Presidency College, Calcutta, on the recommendation of Lord Ripon, the then Viceroy. As the value of his work came to be appreciated, he was soon raised to full professorial rank. This office he continued to hold until 1915, when he retired with the distinction of emeritus professor.

Whilst adequately discharging the onerous duties of his office, Sir Jagadis carried on research as actively as circumstances permitted. He produced a series of papers on electrical subjects which were communicated to the Royal Society by the late Lord Rayleigh, his former teacher, and made his first appearance as a lecturer in England with a discourse on "Electric Waves" at the Royal Institution in 1896, which he soon afterwards repeated in Paris and in Berlin.

At this point came the widening of Sir Jagadis' horizon to include living as well as non-living matter. He incidentally observed, in the course of his researches, that the metallic receivers of the electric waves showed 'fatigue' after prolonged service, and regained their activity after a period of rest; and conversely, that they became inert after too long a rest, but could be revived by an electric shock. He was so struck by the close resemblance of these phenomena to those presented by living muscle and nerve under similar conditions, that he proceeded to make a series of comparative experiments, the results of which were embodied in his book, "Response in the Living and Non-Living" (1902). It is there established beyond doubt that metals (but apparently no other form of non-living matter) possess to a certain degree the 'irritability' which had hitherto been regarded as peculiar to living protoplasm. When a nerve is stimulated, whether electrically, mechanically, or thermally, it gives an electrical response of negative variation. The amplitude of the response can be made to vary by changes in the conditions; it is increased, within limits, by a stronger stimulus, by a rise of temperature, or by treatment with stimulant substances; it is decreased by weakening the stimulus, by lowering the temperature, or by treatment with depressant substances; it can be altogether arrested, either temporarily or permanently, by excessive heat or cold, or by treatment with poisons. All these reactions Sir J. C. Bose obtained with strips of metal. This leads to the remarkable conclusions that 'irritability' is not exclusively the property of living matter; that the 'negative variation' response to stimulation is not a sign of 'life.' Irritability would appear to indicate a certain unstable molecular constitution common to metals and to protoplasm: the negative electric variation, to be the expression of molecular disturbance due to stimulation.

In the book to which reference has been made, the first evidence was given that not only the 'sensitive' plants, as was already known, give this electric response, but also that all plants, and all parts of plants, do so. It was made clear that all plants are sensitive, though only the so-called 'sensitives' are conspicuously motile. The novelty of the idea led Sir Jagadis to devote himself more to the biological than to the physical side in his further investigations; and rather to plants than to animals, because the physiology of animals had advanced much further than that of plants. Progress in the study of the physiology of plants had been hindered by the too mechanical conception of it that had prevailed: it seemed to have been forgotten that both animals and plants consist essentially of protoplasm, and that they must therefore present essentially the same reactions, though modified by special adaptations.

Inspired by this principle, Sir Jagadis proceeded to investigate the irritability and movements of plants by applying the methods that had yielded such fruitful results when applied to animals, and devised apparatus of special sensitiveness for the detection and automatic record of their less vigorous response. His results and conclusions have been published in a series of books, in a number of papers in the *Proceedings*, and in the *Transactions of the Royal Society*, of which he was elected a fellow in 1920; and in the *Transactions of the Bose Research Institute*, of which four volumes have appeared (1918–21).

Without going into too much detail, a few of Sir Jagadis' most striking researches and discoveries may be mentioned. For example, his book "The Physiology of Photosynthesis" (1924) gives the most satisfactory extant account of a process which is of cosmic importance. In his "Physiology of the Ascent of Sap" (1923), he brings forward convincing experimental

evidence that the sap is raised in the tree-trunk by the active contraction of special propulsive cells, the position of which he was able to localise by the electric probe, which he originally devised for the detection of the geo-perceptive layer of cells in stems and roots, a conclusion which is still strongly contested by the adherents of the traditional physical explanation of the process. His most recent book, "The Nervous Mechanism of Plants" (1926), brings together all the evidence scattered throughout previous works that the conduction or transmission of excitatory impulse in plants is a physiological process and is limited to a particular tissue, certain elongated tubular cells of the bast in the vascular bundle, which may justly be termed 'nerve,' in opposition to the current view that the process is purely mechanical and that the tissue concerned is the wood. The conducting tissue in the stem and leaf was located by the electric probe, which again did good service, and the physiological nature of conduction is established by the observation that, in the plant as in the animal nerve, conduction is affected by changes of temperature, by blocking and by stimulating agents, which could not have any such effect upon it were it merely mechanical. A special account is given of the nervous arrangements in the motile leaf of the sensitive *Mimosa pudica*, in which reflex action is demonstrated.

Taking together this book and that on the ascent of sap, it may be generally stated that Sir J. C. Bose's researches have established the existence in the vascular plants, at least, of a circulatory and of a nervous system, using the terms in a loose general way. The 'circulatory system' includes neither heart nor veins, consisting entirely of strands of propulsive cells distributed throughout the plant, representing a contractile arterial system: similarly, in the 'nervous system' there are no central organs, such as brain, spinal cord, or even ganglia, only nerves, of which some have been shown to be sensory, others to be motor. No doubt there remains much yet to be discovered along these various lines of research.

The Research Institute at Calcutta (Fig. 1) was founded and built by Sir J. C. Bose as a place where he and his students and their successors might continue to carry on the researches of which some account has been given above. It was publicly inaugurated on November 30, 1917, and has been in active operation ever since. It is a beautiful and commodious building, standing in its own spacious grounds, with all the details of its construction and arrangements carefully thought out to ensure its perfect adaptation to its purposes. There is a large auditorium capable of accommodating 1500 persons, a library, and rooms and laboratories for work of various kinds. No elementary teaching is undertaken: the only object in view is post-graduate research. The carefully selected scholars, of whom there are at present about sixteen, are admitted on the condition that they devote themselves wholly to the prosecution of research, not as a means of livelihood or for the satisfaction of personal ambition, but, in the words of the founder, "in order to realise an inner call to devote one's whole life to the infinite struggle to win knowledge for its own sake and to see Truth face to face." They receive a modest allowance for their maintenance so that they may be free from distracting cares. The line of research pursued is essentially physiological in its direction, and includes both animal and plant in its scope, though so far the plant has received more

FIG. 1.—The Bose Research Institute, Calcutta.

attention than the animal. But it is physiological in the widest sense, encroaching, as occasion arises, on physics, on bio-chemistry, on botany and zoology, and on histology. At the present time there are no workers at the Institute other than the staff and the scholars, but it is the hope and desire of the founder that it may be frequented by students from all parts of the world, who are assured beforehand of a hearty welcome and of a hospitable reception.

The foundation of the Research Institute in Calcutta, as well as of the branch, Mayapuri, situated at Darjiling at 7000 ft. elevation, in an altogether different climate, was due, in the first instance, to the munificence of Sir J. C. Bose; since then, considerable sums have been contributed by Indian princes and others for extensions and for endowment. The Imperial Government of India has recognised the value of the services rendered by the Institute to the advancement of science by making an annual grant out of public funds for its upkeep. The Institute has continued from the beginning to expand both materially and intellectually. It has shown what important results can be obtained by the combination of the logic and the scientific methods of the West with the imagination and the idealism of the East. Even now it is still only at the beginning of its career, a career, let us hope, of ever-increasing usefulness and brilliance, which ought to be assured by the principles of self-abnegation upon which its constitution is based, more than fulfilling the most sanguine expectations of its founder and reviving the ancient reputation of India as a home of learning.

The Lewis Evans Collection at Oxford.

RECENT ADDITIONS.

WHEN the oldest of British museums was re opened for the scientific treasures presented to the University of Oxford by Dr. Lewis Evans, it was foreseen that that fine collection must act as a lodestone and attract cognate objects to itself. This expectation has been realised in a remarkable measure by gifts and loans of apparatus, and by the discovery and reconstruction of long-forgotten instruments. The first fruits of the reversion of a part of the Old Ashmolean building to its original use as a Science Museum are now on exhibition.

Several colleges have contributed apparatus that is second to none for illustrating the early history of many scientific inventions. Both Merton and Oriel Colleges have proved themselves faithful custodians of the quadrants and astrolabes of their astronomer-fellows of the fourteenth century. No other educational institution can boast continuous possession of scientific appliances for so many centuries. Contemporary manuscripts written about these very instruments, describing their use, collected when the instruments to which they refer were three centuries old, were given by Ashmole to be "preserved in the presses" of his Science Museum, that his good name might endure "for all time." There they remained for yet another two hundred years, while the instruments, to the use of which they supplied the key, languished in college chests and cupboards. To-day the instruments are on exhibition in Ashmole's building, while Ashmole's own books about them have been put away out of sight in hidden recesses in buildings other than those named in his will. If both books and instruments were once again placed side by side, we should have visible proof of the scientific pre-eminence of the Merton School in the fourteenth century.

To a distinguished fellow of Merton we owe the beginning of our technical scientific literature. Richard, the son of a blacksmith at Wallingford, received a practical education that enabled him in 1326 to compose in terms as clear as those of a proposition of Euclid, a model treatise, the first of its kind known to have been written by an Englishman, upon "How to Make" a scientific instrument. He prescribed the exact dimensions of the metal parts, both in the rough and in the finished state; and he illustrated the shaping and fitting by working diagrams, so that it is possible to interpret his meaning after six hundred years. His distinction as a man of science led to ecclesiastical preferment. Richard, the maker of our first recorded astronomical clock, became abbot of St. Albans. His 'rectangulus,' figured in NATURE for January 12, 1924, has been partly reconstructed this very year in honour of the sixth centenary of his original invention.

Two centuries later the needs of Elizabethan navigators and gunners advanced the skill of the instrument maker to higher levels, both of execution and of invention. By the generosity of the University Court of St. Andrews, there is on view the finest astrolabe known to have been made by an English craftsman. It is 2 feet in diameter, and 33 pounds in weight. It is inscribed with the name of its maker, Humphrey Cole of London, and is dated with the day of the month, May 21, 1575, the very year when he was getting ready the instrumental outfit for Martin Frobisher's first expedition in search of the North-west Passage to Cathay, an enterprise in which Elizabeth herself was financially interested to the extent of 1900*l*. By the finding of Cole's great astrolabe we have proof for the first time that there were in London craftsmen capable of executing work equal in quality to that of the instrumental equipment of the best-endowed observatory in the world, the astronomical observatory of Tycho Brahe at Uraniborg. Nor was this Cole's only claim to a place in our memory. He was the first Englishman to engrave a copperplate map for the illustration of a book, the Bishops' Bible of 1572. The advent of the Lewis Evans collection has also led to the discovery of one of Cole's early theodolites in the Library of St. John's College. This discovery proves him to have been the maker and improver, if not the original designer, of our premier surveying instrument, an invention usually associated with the name of Leonard Digges of University College.

A century later and we come to the epoch of the great experimenters, too soon to be followed by the epoch of the great destroyers. The Royal Society, finely equipped in the days of Daniel Colwall and Grew