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SCIENCE AND INDUSTRY IN INDIA[1]

By the late Lord RUTHERFORD OF NELSON

DURING the past fifty years, the British Association for the Advancement of Science has been invited on many occasions to hold its meetings overseas. Four times it has journeyed to Canada (Montreal, 1884; Toronto, 1897; Winnipeg, 1909; Toronto, 1924), twice to South Africa (1905, 1929), once to Australia (1914). This policy of the association of arranging occasional meetings in our dominions has proved an unqualified success. These overseas visits have had a marked influence on the progress of science throughout our commonwealth and by personal contacts have helped much to promote mutual understanding and cooperation between our peoples.

The visit of a representative group of scientific men to our most distant dominions in 1914, in itself an outstanding event in the history of the association, was rendered even more notable by the dramatic circumstances under which the meetings were held, for the arrival of the party in Australia coincided with the news of the outbreak of the great war. Any one who like myself took part in the meetings in Australia and New Zealand in those troubled but stirring times can ever forget the warmth of our reception. We were privileged to witness that wonderful response of the peoples of these lands to the call of danger—a response which we know grew ever greater with the need.

It has long been the wish of the British Association to hold a meeting in India, and difficulties of time and climate alone have stood in the way of its realization. It has been found most convenient for the overseas

[1] Presidential address before the Indian Science Congress Association, prepared by Lord Rutherford before his death and presented to the congress meeting in Calcutta on January 3. This is the first part of the address which contains two other sections, one on Industrial Research in Great Britain and one on Transmutation of Matter.

visits to take place in the summer months, but such a time is quite unsuitable for India. This difficulty would be in part surmounted if a representative party of scientific men could obtain leave of absence from their duties to visit India during the cold weather.

The celebration of the silver jubilee of the founding of the Indian Science Congress Association offered a suitable occasion for such a visit, and arrangements have been made through the two associations to hold a joint meeting in India. I gladly accepted the invitation of the two bodies to preside over this combined meeting. I feel it not only a great honor but a great privilege and responsibility to be asked to fill this post on such a historic occasion. This visit of the British Association to your shores is a symbol of our desire to extend the hand of greeting and fellowship to our sister society and also individually to our co-workers in science in India.

While science has no politics, I am sure it is of good omen that our visit happens to fall at a time when India is entering upon a new and important era of responsible cooperative government, in the success of which both our countries are deeply concerned.

On behalf of the British Association, I extend to the Indian Association our warmest congratulations on this the twenty-fifth anniversary of its foundation and our sincere wishes for its continued success. We recognize that your association, both in its constitution and its aims so closely resembling the British Association, has proved of great service to the progress of science throughout India. Founded at a time when the universities were becoming centers of original research, it afforded to a widely scattered scientific community a much-needed common meeting ground for the discussion of scientific problems. It helped also to bring to the attention of the interested public the importance of science and of the scientific method in national development. I think it can be safely stated that the success of the meetings of the Indian Association in no small degree influenced the later foundation of specialist societies in India, for example, the Chemical Society and Physics Society.

On such an occasion as this, we must not forget to do honor to those who were largely instrumental in founding your association and in guiding its infant steps. I would refer in particular to Professor Simonsen, Professor McMahon and your first president, Sir Asutosh Mukherjee. The association owed much in its early days to the friendly support and encouragement so freely given by that premier Indian Society, the Royal Asiatic Society of Bengal, of which I am proud to be an honorary member.

In earlier days in India, research was largely confined to the great scientific services, initiated and maintained on a generous scale by the Indian Government, for example, the Survey of India, the Geological Survey, the Botanical Survey, the Departments of Agriculture and Meteorology and many others. Pioneer work of outstanding scientific importance has been done by all these services. In the short time at my disposal, I can only make a passing reference to a few items of work accomplished, and can mention only a few of the array of distinguished names which have been connected with these great scientific services.

The Trigonometrical Survey of India has a long and distinguished history. The splendid series of geodetic measurements along an arc from Cape Comorin to the Himalayas, made by Everest, was of outstanding importance, and his name is forever associated with the highest peak in the world. As a result of this survey, the deflections of a plumb line, due to the gravitational attraction of the Himalayan range, were determined at different points. A careful comparison of the results of observation with calculation, largely due to the work of Archdeacon Pratt of Calcutta and later of Sir Sidney Burrard, disclosed marked discrepancies, the effect of the mountain mass at a distance being much less than was expected. Attempts to explain these and other anomalies ultimately led to the formulation of a new and important theory of mountain formation known as the principle of isostasy. On this hypothesis, the excess pressure due to a mountain mass is compensated for by a deficiency of matter below its base. This conclusion, which is in accord with extensive gravitational as well as geodetic measurements in India, is believed to be of general application to mountain formation throughout the world.

I may recall that a former distinguished superintendent of this survey, Sir Gerald Lenox Conyngham, is head of the department of geodesy in Cambridge.

The Geological Survey, one of the oldest scientific services in India, has a fine record of work accomplished, and its survey of the mineral resources of India has proved of great value to Indian industry. Among many distinguished names, I may specially mention that of Sir Thomas Holland, a former director, who has done such good work for your country in peace and war. I believe that it was largely due to his energy and scientific insight that the great Tata Iron and Steel Works were begun.

The Department of Meteorology has done much pioneering research and was one of the first to realize the importance of studying the conditions of the upper air by means of small balloons—a subject of ever-increasing importance with the advent of the aeroplane. I have always felt a certain connection with this department, as many of its members are known to me personally. Amongst them is Sir Gilbert Walker, a former director and once president of this association, who did much to improve the Meteorological Service

in India and himself made important original contributions to our knowledge of the southwest monsoon. I may recall that the present distinguished head of the Meteorological Office of Great Britain, Sir George Simpson, was for many years a member of this Indian department.

The study of the botanical riches of India owes much to the work of Roxburgh, Wallich and Prain, and also the explorer and naturalist Hooker, whose work on the flora of British India is known to you all.

In forestry, India has at Dehra Dun probably the finest research laboratory of its kind in the world. We in England owe a debt of gratitude to India in providing us with our distinguished professor of forestry at Oxford, Professor R. S. Troup, and the first two directors of our Forest Products Laboratory, namely, Sir Ralph Pearson and W. A. Robertson.

While in this brief survey I can only mention a few departments out of many, yet I must not omit to refer to the great advances in knowledge due to the Indian Medical Service, so well represented by the pioneer work of Ross on malaria and by Leonard Rogers on cholera and leprosy, researches which gave new hope to the people of India.

In the early days of the Indian universities, attention was mainly directed to teaching and examining the large number of students who presented themselves, and comparatively little attention was paid to research. There were always a few, however, who recognized that the universities had a wider part to play in Indian education and should become centers of research as well as of teaching. Amongst those pioneers who distinguished themselves by original investigations and by the stimulation of others, I should particularly mention Sir Alexander Pedler, Sir Alfred Bourne, Sir Jagadis Bose and Sir Prafulla Ray, and it is of interest to recall that the last three have all been presidents of your association.

As a result of the Curzon Commission on Education in 1904, many of the universities introduced honors courses, and by new appointments and improvements in laboratories stimulated research in science. Excellent well-equipped schools of research have arisen in many Indian universities, where good opportunities are available for the training of potential investigators in the methods of research. The Indian student has shown his capacity as an original investigator in many fields of science, and in consequence India is now taking an honorable part and an ever-increasing share in the advance of knowledge in pure science.

Amongst many workers of distinction, I may specially mention Sir Venkata Raman, Professor Saha and Professor Sahni, each of whom has made outstanding contributions. That premier scientific society of Great Britain, the Royal Society, has recognized the value of their work by election to its fellowship.

We in Great Britain watch with pride this growth of the scientific spirit in India and are pleased to help in any way we can. As an example of our interest, I may recall that Trinity College, Cambridge—my own college—assisted that mathematical genius Ramanugan to continue his studies in Cambridge. He was soon elected a fellow of that college and a fellow of the Royal Society. But for his premature death, it may be said of him, as Newton said of Cotes, that we had known something.

The researches in astrophysics of Chandrasaka in Cambridge were at once recognized by the award to him of an Isaac Newton studentship and later by his election to a fellowship in Trinity College.

As a member of the Royal Commission for the Exhibition of 1851, I would like to refer to some events this year of special interest to India. This commission awards each year a number of overseas scholarships to our dominions as well as senior research studentships open to competition in England by all members of our commonwealth. The opportunity offered by these scholarships to promising investigators from overseas to continue their work in England or abroad has proved of great value to the progress of science. I am proud to remember that I myself was awarded an 1851 scholarship on the recommendation of the University of New Zealand.

It has for some time been the wish of the 1851 Commission to be able to offer one or more of its overseas scholarships for award to students in India. Owing to difficulties of finance, it was only this year that this project was realized. A preliminary committee of selection was set up in India, and the commissioners with whom lay the final choice have appointed Mr. N. S. Nagendra Nath, of the Indian Institute of Science, Bangalore, as the first 1851 Exhibition scholar from India. He has gone to Cambridge to carry out investigations in theoretical physics. For the first time also, an Indian student in Cambridge, Dr. H. J. Bhabha, has been awarded in open competition one of our valuable senior 1851 studentships in recognition of the importance of his researches in theoretical physics. The commission would like to be in a position to allot a second science scholarship to India, but funds are insufficient. The machinery, however, is there and I know that the commissioners would be only too happy to administer a second award if any one in India who is interested in her scientific progress were generous enough to provide the necessary endowment.

While, as we have seen, the universities of India have in later years made substantial progress both in teaching and research in science, yet it must be borne in

mind that still greater responsibilities are likely to fall on them in the near future. This is in a sense a scientific age, where there is an ever-increasing recognition throughout the world of the importance of science to national development. A number of great nations are now expending large sums in financing scientific and industrial research with a view to using their natural resources to the best advantage. Much attention is also paid to the improvement of industrial processes and also to conducting researches in pure science which it is hoped may ultimately lead to the rise of new industries.

It is natural to look to the universities and technical institutions for the selection and training of the scientific men required for this development. In India, as in many other countries, there is likely to be a greater demand in the near future for well-trained scientific men. With the growth of responsible government in India, it is to be anticipated that the staff required for the scientific services in India and for industrial research will more and more be drawn from students trained in the Indian universities. It is thus imperative that the universities should be in a position not only to give a sound theoretical and practical instruction in the various branches of science, but, what is more difficult, to select from the main body of scientific students those who are to be trained in the methods of research. It is from this relatively small group that we may expect to obtain the future leaders of research both for the universities and for general research organizations. This is a case where quality is more important than quantity, for experience has shown that the progress of science depends in no small degree on the emergence of men of outstanding originality of mind who are endowed with a natural capacity for scientific investigation and for stimulating and directing the work of others along fruitful lines. Leaders of this type are rare but are essential for the success of any research organization. With inefficient leadership, it is as fatally easy to waste money in research as in other branches of human activity.

The selection of such potential investigators and leaders is not an easy task, for success in examinations in science is no certain criterion that the student is fitted for a research career. A preliminary training in research methods for a year or two is required to select those who possess the requisite qualities of originality and aptitude for investigation. A system of grants in aid or scholarships to approved students may be required for such postgraduate training. In Great Britain the financial help given by the universities and other educational institutions for training in research is in many cases supplemented by maintenance grants to promising students, awarded by the Department of Scientific and Industrial Research. This system has proved of much value both in developing the research activities of the universities and in providing a supply of competent men both for research in pure science and in industry.

I have so far mentioned some aspects of the scientific work carried out by the universities and government services of India. I am well aware that much attention has also been directed to the need of scientific research in agriculture and in certain industries. A cotton research association has been set up which has given admirable service, while the Indian Lac Institute arranges for investigations in that unique Indian product, some of which are carried out in Great Britain. I am interested to know that an agricultural research council has recently been formed, largely as a result of the findings of a commission of which His Excellency the viceroy was chairman.

While I can not lay claim to have any first-hand knowledge of Indian industries and conditions, yet I may be allowed to make some general observations on the importance in the national interest of a planned scheme of research in applied science. If India is determined to do all she can to raise the standards of life and health of her peoples and to hold her own in the markets of the world, more and more use must be made of the help that science can give. Science can help her to make the best use of her material resources of all kinds and to ensure that her industries are run on the most efficient lines. *National research requires national planning. If research is to be directed in the most useful direction, it is just as important for a nation as for a private firm to decide what it wishes to make and sell. It is clear also that any system of organized research must have regard to the economic structure of the country.* One essential fact at once stands out. India is mainly an agricultural country, for more than three quarters of her people gain their living from the land, while not more than three per cent. are supported by any single industry. A glance at the official review of the trade of India shows that the annual production of wheat has risen since 1914 from about 8.3 to 9.5 million tons, while exports in the same period have fallen from 1.2 million tons to 10,000 tons. In the case of another important food, rice, the Indian production, exclusively of Burmah, has remained fairly steady, varying between 22 and 25 million tons annually, but here also exports have fallen from about half a million tons before the war to about 200,000 tons.

In view of these facts, it would seem clear that, in any national scheme of research, research on foodstuffs has a primary claim on India's attention. Quite apart from improvements in the systems of agriculture used in India, there is a vast field for the application of

scientific knowledge to the improvement of crops, for example, by seeking for improved strains suitable for local conditions, by research on fertilizers and in many other directions. The fact that surplus wheat for export has decreased suggests that the present production is required for home consumption in India. When the permanent schemes of irrigation now in hand bring much more land under full cultivation, India may again wish to take her place in the export market. To do this in the face of international competition, well-planned agricultural research will be essential.

While the character of India's exports has seen many changes in the last hundred years, to-day exports of cotton, jute and tea amount to about 60 per cent. of the total exports of India. Next in importance come oil and seeds, 6 per cent., hides, 5 per cent., and lac 1 per cent. There is no doubt that more scientific knowledge would increase the production of all these things. There is of course the need to make sure that there is a market for such surplus. Of India's staple exports, cotton represents about 20 per cent. of the total value. It is characteristic of Indian cotton that the staple is short and, until the cultivation of better varieties is more general, no competition will be possible with cottons of the American type, and trade must mainly be confined to the Indian market and the far eastern countries. Here there appears to be a wide field for applied research. Good work has been done by the Indian Cotton Committee, which has taken steps to improve the staple and prevent adulteration and intermixture of various varieties. The problem can be approached, however, not only in the seeking of better varieties but in finding uses and methods of treatment for the short staple variety. The importance of research on the cotton itself is well brought home by the results achieved in the United Kingdom. The Cotton Research Association there has found that many of the defects which appear in the finished article can be traced back to defects in the raw material.

Finally, a word might be said concerning the need for research on radio-communication, so important a matter to a large country like India. I do not refer to technical research in transmitting and receiving apparatus but rather to the type of fundamental investigation pursued under the Radio Research Board in Great Britain. These investigations, begun in the early days after the war, have shown that the propagation of radio-waves over large distances is very dependent on the electrical state of the upper atmosphere. It is now established that a number of electrified layers exist in the higher atmosphere which under certain conditions are able to reflect electric waves. The details of this electrical distribution vary considerably with the hour of the day and with the season of the year, as well as with geographical location. Such information, which is of practical importance in the selection of the most suitable wave-lengths for radio-communication, must obviously be secured by research conducted in the country itself. Moreover, it does not seem impossible that such a survey may prove of value in long-range weather forecasting.

There is here then much scope for research in a wide field, which I hope will be pursued vigorously in India. It is pleasant to note that a more promising stage in tackling fundamental radio problems of this character has already been made here by Professor M. N. Saha and S. K. Mitra and their students. The importance of survey work of this kind has already been recognized in other parts of the Empire, where it has received official support and encouragement. I refer in particular to the admirable work in this field by the Radio Research Board of Australia.

SCIENTIFIC EVENTS

THE NEW YORK BOTANICAL GARDEN

THE Board of Managers of the New York Botanical Garden on January 10 received the report of Dr. H. A. Gleason, head curator, officially closing his term as acting director. Since the appointment of Dr. William J. Robbins as director, Dr. Gleason has been serving as assistant director. He stated that the herbarium is exceeded in the number of flowering plant specimens only by the National Herbarium in Washington. In its collections of fungi for study it is exceeded only by the Department of Agriculture and the Farlow Herbarium at Harvard, while in mosses it is probably the largest in the world.

Thirty-one botanists from other cities and countries have engaged in research in the herbarium during 1937. Its contents have been made available to others by the loan of more than 16,000 specimens.

Studies of heredity received special attention during the year. As useful by-products of this research, beautiful new forms of day lilies and many hardy seedless grapes have been developed. Work on the grapes, which have been especially created for culture in New York and other northern and eastern states, has been undertaken in conjunction with the New York State Agricultural Experiment Station at Geneva. About 175 new kinds have been developed, a number of which are deemed suitable for commercial culture.

Other work included studies of diseases of ornamental plants and the preparation of monographs on