

FACTORS IN THE DEVELOPMENT OF SCIENTIFIC RESEARCH IN INDIA BETWEEN 1906 AND 1930

S.N. SEN
Ramakrishna Mission Institute of Culture,
Calcutta

Organized research first appeared in France under Napoleonic reforms in a few specially created institutions such as the *École Polytechnique*, the *École Normale Supérieure*, the *Conservatoire des Arts et Métiers* and others. The idea of developing universities as centres of scientific research first appeared in Germany where Göttingen and Heidelberg provided the first models. To this must be added the opening of Liebig's famous chemical laboratory at Giessen. The United Kingdom woke up to the need of institutionalization of scientific research in the late sixties and early seventies when Grove, Appleton and a few others used the platform of the British Association for the Advancement of Science to direct public attention to the matter and the Owens College at Manchester and a few others started organizing chemical laboratories after the German model.

Unlike Europe, India had no amateur scientists. In the colonial set-up there were a few salaried scientists and technicians in government scientific services. The facilities of these services were not generally available to the people of the country, and there was consequently little or no research effort among them in the nineteenth century. In this background it is significant that the idea of scientific research through a special institution first occurred to an Indian medical graduate, Dr Mahendralal Sircar, as early as 1869, which resulted in the establishment of Indian Association for the Cultivation of Science in Calcutta in 1876.

Organized scientific research became possible in India with university reforms of 1904, recognizing universities as teaching institutions as centres of higher learning. The old Indian Association for the Cultivation of Science and the newly established University College of Science under the initiative of Asutosh Mookerjee, combined with the pioneering research efforts of J.C. Bose, P.C. Ray, and C.V. Raman created a situation favourable for research. Other important factors were (1) large endowments for appointment of whole-time professors and research scholars who should be of Indian origin, (2) endowments for building and equipping modern research laboratories, (3) organization of post-graduate teaching, (4) holding of seminars and conventions, and (5) rise of learned societies facilitating communication of scientific work through bulletins, journals and proceedings. The nature of scientific activity of this initial period is illustrated by some of the early research work of C.V. Raman.

If I have selected the period 1906 to 1930, it is primarily because some of the factors indispensable for the growth of organized research through institutions visibly developed in this period. We have to bear in mind that, despite vicissitudes, India had a long established tradition in scientific work which enabled her to make important contributions in science, albeit spasmodically, in ancient and medieval times. These contributions, as elsewhere, were largely confined to a few individuals. This tradition enabled her intellectuals to recognize the merit of emerging western sciences *vis-à-vis* those pursued in scholastic schools according to time-honoured methods and practices.

Organized scientific research through universities and research institutions is a nineteenth century phenomenon. Scientific advancement was generally made by amateur scientists in a variety of circumstances, specially by those who had means and resources for setting up attic laboratories. Organized research first appeared in France as a sequel to Napoleonic reforms in a few specially created institutions, such as the *École Polytechnique*, the *École Normal Supérieur*, the *Conservatoire des Arts et Métiers* and others. The first lead in developing universities as centres of scientific research was taken by Germany where Göttingen and Heidelberg provided the initial models. To this must be added the opening of Liebig's famous chemical laboratory at Giessen. The United Kingdom woke up to the need of institutionalization of scientific research in the late sixties and early seventies when Grove, Appleton and a few others used the platform of the British Association for the Advancement of Science to direct public attention to the matter. The older Universities of Oxford and Cambridge controlled by the clergy were hostile to teaching and research in sciences, except mathematics.

India, unlike Europe, had no amateur scientists. In the colonial set-up, a few salaried scientists and technically qualified persons were engaged in government scientific services for routine research in field sciences. Although important results emerged from these efforts, the facilities were not generally available to the people of the country, and consequently there was little or no research effort among them in the nineteenth century. As early as 1869, the situation was correctly assessed by a graduate of the Calcutta Medical College, Dr Mahendralal Sircar, who was convinced of the importance of scientific research both for the excellence of higher education and learning and for national development. He correctly assessed that, in order to develop a capability for original scientific work, research should be institutionalized, research workers and scholars should be remunerated, laboratory and library facilities should be of the best type possible, high-level lectures and discussions should be instituted, and there should be facilities for communications among research workers through conventions, seminars and publication of bulletins, periodicals and journals. These ideas led to the foundation of the Indian Association for the Cultivation of Science in 1876. Although conceived along right lines, this did not immediately generate research effort due to lack of scientific education in schools and colleges. In the fourth quarter of the 19th century, its energies were mainly spent in organizing scientific education, sometimes at high levels, of which a special example was the series of lectures by Asutosh Mookerjee on mathematics, physical optics and electromagnetic theory of light. Thanks to the foresight of Mahendralal Sircar, Father Lafont and a few others, the Association also developed a good laboratory for work in low temperature physics, discharge tube experiments and other areas, which played no small part in attracting C. V. Raman when the latter decided to spend his spare time over scientific research.

The case for the Presidency College was somewhat different. Successor to the Hindu College of 1817, it had also established a good tradition in scientific education, but its research effort had to await the arrival of teachers like Pedler, P.C. Ray and Jagdish Chandra Bose, all trained in important centres of scientific research in

Europe. The development of the Baker Laboratory towards the end of the 19th and the beginning of the 20th century and the availability of a few trained workers forthwith produced the first signs of original research in physical sciences.

But the movement was yet to gain criticality. Curzon's educational reforms proceeding from the Simla conference of 1901 and culminating in the passage of the University Act of 1904 contributed to this criticality. The original Act of Incorporation of 1857 established the three Universities of Calcutta, Bombay and Madras as mere examining bodies with powers to grant degrees. The actual academic work was left to the colleges. By the turn of the century, it became abundantly clear that the real function of the university was promotion of knowledge and learning through higher teaching and original research. Asutosh Mookerjee observed: "No University is worthy of its reputation which does not enrol among its professors men best fitted to advance the bounds of knowledge. No University can rightly be regarded as fulfilling the purpose of its existence unless it affords to the best of its students adequate encouragement to carry on research, and unless it enables intellectual power, whenever detected to exercise its highest functions"¹. The Act of 1904 empowered the universities 'to appoint university professors and lecturers, to hold and manage educational endowments, to erect, equip and maintain university libraries, laboratories, and museums, to make regulations relating to the residence and conduct of students, and to do all acts, consistent with the Act of Incorporation and this Act, which tend to the promotion of study and research'.

It was one thing to pass an act full of pious intentions and quite another matter to wrest from the unwilling hands of the bureaucracy necessary funds for the appointment of professors and the building of laboratories.

For the Calcutta University, the history of the struggle between the Senate headed by Sir Asutosh Mookerjee as its Vice-Chancellor and the government over the question of funds is well known. Thanks to the provision in the Act for the acceptance and management of educational endowments and the princely endowments of Tarak Nath Pandit and Rashbehary Ghosh, Sir Asutosh was able to execute his plans for the establishment of the University College of Science and Technology. These and other endowments which followed soon enabled the appointment of whole-time professors and research scholars. According to the terms of the endowment, the positions of professors were to be filled by Indians and the principal duties of the incumbents would be to carry on original research with a view to extending the bounds of knowledge, to stimulate and guide research by advanced students, and to arrange for adequate instruction of students preparing for B.Sc. (Honours), M.Sc. and D.Sc. degrees.

Thus was fulfilled the requirement of whole-time research workers, research guides in the form of professors and active research workers in the form of scholars, which Mahendralal Sircar had envisaged in the seventies of the last century. The earlier research efforts of the Association and the Presidency College now proved helpful. By 1913, C.V. Raman working in the Association's laboratories had already

developed into an accomplished physicist with several original papers to his credit, and Asutosh Mookerjee had no difficulty in inviting him to the Palit Chair in Physics to organize researches in physics at the University College. For chemistry, the choice fell to Dr Prafulla Chandra Ray, who had already a distinguished career as a teacher and original investigator at the Presidency College. About the appointment of Raman, Sir Guru Dass Banerjee, the then Vice-President of the Association, observed as follows: "Mr Raman is to be the first Professor of Physical Science in the Calcutta University in connection with Sir Tarak Nath Pandit's endowment.

Though no part of that princely endowment has benefited the Science Association directly, it has indirectly benefited us by giving an occasion for the deep satisfaction that the first professor of physics in our University had his training ground in original research in the laboratory of the Science Association''².

The interaction between the University College of Science and the Science Association did not end with the appointment of Raman to the University Chair. The University had the endowed chair but no physical laboratory at that time, while the opposite was the case with the Association. The two acted as complementary to each other. Furthermore, the scholars appointed from endowed funds and interested to work under the guidance of Raman found a readymade laboratory at the Association. These favourable circumstances – whole-time research guide, research scholars, well-equipped laboratories and libraries stocked with latest publications of learned societies – soon produced visible results in physics, chemistry and other branches of science.

In Physics and Applied Mathematics, Sudhansu Kumar Banerjee, Rashbehary Ghosh Scholar, started working at the Association from 1915 on the problem of generation of sound waves by the impact of two spheres and proved to be a research worker of great distinction and promise. The following year, Nalini Mohan Basu and J.C. Kameshwara Ray, both University scholars, followed the example of Banerjee, and the process continued for several years during which the Association continued to act as the training ground for scholars as well as for the young members of the staff of the Science College. Thus, Phanindra Nath Ghosh, Sisir Kumar Mitra and Bidhu Bhusan Ray, all of whom became University Professors, had their initial training at the Association. The success of the experiment spread far and wide, and enterprising students intending to make a career in scientific research flocked to Calcutta to work either at the Science Association or the University College of Science.

Chandi Prasad of Queen's College, Banaras, R.S. Deoras from Nagpur College of Science, A. Venkatasubbaraman and K. Seshagiri Rao of Madras University, N.C. Krishna Aiyar of Rangoon College, Nihal Kanan Sethi and C.M. Sogani of Banaras Hindu University, K.R. Ramanathan and S. Ramakrishna Iyer of Maharajah's College in Trivandrum and several others worked in these institutions from 1917 throughout the twenties. Commenting on the research activities of the time,

Prof. C.V. Raman described the phenomenon as 'a real school of physics, the like of which certainly does not exist in any other Indian University, and which, even now, will not compare very unfavourably with those existing in European and American Universities'³.

In his review of the progress of mathematics and mathematical physics, Prof. Ganesh Prasad, first occupant of the Ghosh Chair in Applied Mathematics, compared the performance of the B.Sc. (Hons.) and M.Sc. students of Calcutta University with those of Cambridge Tripos and found no considerable difference between these two groups. In his view, the holders of first class M.A. and M.Sc. degree in Mathematics of the Calcutta University were as good as the best wranglers as far as their mathematical knowledge and capability for research were concerned⁴. Dr Prasad attributed this resurgence of interest in higher studies and research to the organization of Honours Course at the graduate level and post-graduate teaching and research at Calcutta University. P.C. Ray also found the scholarship system important for the development of research talent in chemistry. "The foundation of research scholarships by the government of Bengal", he observed, "also helped the movement to a certain extent. A student who passed the M.Sc. with credit and who showed aptitude for a branch of science could now on the recommendation of his Professor secure a scholarship of Rs 100 per month tenable for three years. From 1900 on one scholar was always attached to my department, who, in the early probationary stage, cooperated with me in my line of research but later on was allowed to develop in his own way and strike out a line of his own. In this manner some of the scholars were enabled not only to secure Doctorates on presentation of theses, but also won the blue ribbon of the Calcutta University, the Premchand Roychand Scholarship"⁵.

Ray's first research scholar was Jatindra Nath Sen who won the Premchand Roychand Scholarship and later on joined the Agricultural Institute at Pusa. From 1905, Panchanan Neogi who made a name for his historical studies such as *Iron in Ancient India* and *Copper in Ancient India*, Atul Chandra Ganguly and several others joined Ray as research scholars. This group went on increasing and attained a comfortable size with the organization of the chemical laboratories at the University College of Science. Several of them went abroad to work for their doctorate degrees at reputed centres of chemical research such as London and Berlin. Brojendra Nath Ghosh, H.K. Sen and B.B. De obtained their degrees in England. Nilratan Dhar and P.C. Mitter were awarded their degrees by London and Berlin University respectively. Early doctorates in chemistry from the Calcutta University included Rasik Lal Dutta and Panchanan Neogy. The total contributions of these scholars to the chemical literature of the time attained such a respectable size that Ray frequently used to refer to it as 'Calcutta School of Chemistry'.

As laboratories were organized, the number of research workers increased, and research papers started to be produced, need for scientific meetings and conventions for exchange of views naturally developed. From Mahendra Lal's time, the Science Association had developed a good tradition in scientific lectures.

Originally, the purpose was popularization of science. Mahendra Lal himself set a brilliant example of this. Raman carried this to further perfection with his equal mastery of the English language, great wit and unrivalled experimental skill. Some of his early scientific lectures concerned his own investigations on physical optics, experimental investigations on the maintenance of vibrations and the tactics of a violin spring. As researches gathered momentum, the Association developed the practice of the reading of papers by distinguished scientific workers at the Annual General Meeting immediately after the transaction of administrative business. Such reading of papers started at the Annual General Meeting of 27 November 1913 at which Dr D.N. Mallik presented a brief historical survey of the optical theories and Raman discussed some remarkable properties of synchronous motor⁶. The Annual General Meeting of 25 November 1914 records the reading of four papers: (1) Manindra Nath Banerjee – ‘Atomic Impact’, (2) Asutosh De – ‘The Resistance Board Potentiometer’, (3) D. N. Mallik – ‘A Brief Outline of Optical Theories’, and (4) C. V. Raman – ‘Further Investigation on Elastic Impact’⁷.

During 1915, the Association received 15 research papers – 9 in Chemistry, 2 in Physics, 2 in Geology, and 2 in Biology. It became clear that papers in such numbers could not be presented, let alone be discussed in one meeting, particularly at the fag end of the Annual General Meeting. At the initiative of Prof. P. C. Ray and Prof. Hemchandra Das Gupta, a decision was taken to hold quarterly meetings for proper presentation and adequate discussion of papers. Moreover, the meetings were to be organized under three sections, viz, Physico-chemical, Chemical, and Natural History, for each of which a President was to be appointed. At the first quarterly meeting inaugurated during 1915, the three sectional presidents were Dr Ganesh Prasad, Dr Prafulla Chandra Ray and Dr Banwari Lal Chaudhury. These quarterly meetings met with so large a success and generated such enthusiasm among the small band of scientific workers in Calcutta as to elicit the following comments from Dr Chunilal Bose, “Those who have watched the career of the Association and noted its progress as described in the annual reports for the last two years, cannot fail to be convinced of the fact that we are going to realize, to some extent at best, the high ideal of the Founder-Secretary of this Association”⁸.

In the meantime, the Indian Science Congress Association, modelled after the British Association for the Advancement of Science, was established in 1914. The Congress held its first sessions in the rooms of the Asiatic Society of Bengal on 15, 16 and 17 January that year. The Congress, presided over by Sir Asutosh Mookerjee as its General President, was divided into six sections: Chemistry, Physics, Zoology, Geology, Botany and Ethnography. The number of papers was small – 8 in Chemistry, 7 in Physics, 9 in Zoology, and so on, contributed by European as well as Indian research workers, but the contributions from the latter had already attained significant proportions.

From 1917, the quarterly scientific meetings of the Association were replaced by an Annual Science Convention, to be held in the month of November. The first

Convention held on 23 and 24 November 1917 was inaugurated by Sir Asutosh Mookerjee. Time was propitious for such a Convention. The Calcutta University Commission under the Chairmanship of Sir Michael Sadler was then examining the question of post-graduate studies and researches in the University. The Convention gave an opportunity to the members of the Commission to listen to young research workers of the Association, the Science College, the Presidency College and form an idea of the quality of their work. In his inaugural address, Asutosh Mookerjee observed: "I desire, however, to point out that this Convention stands, in one respect at least, on a different footing from all the Conventions which have preceded it... We had on no previous occasion.... among our audience such distinguished scholars as Dr Sadler, Vice-Chancellor of the University of Leeds, Dr Gregory, Professor of Geology in the University of Glasgow, and Mr Hartog, Academic Registrar of the University of London.... I may also dwell on the significant fact that on the present occasion so many devoted students of Science have combined together with a determination to make our Convention a decided success..... I feel convinced, however, that we must concentrate all our resources in order to make scientific researches successful in this country, and I can very well imagine how the scene we are witnessing this evening would have deeply gratified our illustrious founder, the late Dr Mahendra Lal Sircar, the pioneer of scientific studies in this country. He is the spiritual father of everyone of us however eminent whose aspiration lies in that direction"⁹.

Another important factor already mentioned is the communication of the results of scientific investigations through bulletins, proceedings, journals and similar serial publications. Raman's first few papers on physical optics andoustics were published in foreign journals, e.g. *Nature*, *Philosophical Magazine* and *Physical Review*. Witnessing the growing interest in his work, the Association first decided to reprint these papers in the form of Bulletins. By 1912, 5 Bulletins were issued, and also circulated to some of the leading societies and learned bodies in Europe and America. These Bulletins not only elicited appreciative comments, but occasioned a fruitful exchange relationship with some of the societies like the kgl. Preuseische Academic der Wissenschaften, Berlin, the Physikalisch Technischen Reichsanstalt Charlottenburg, Kaiserlichen Akademik der Wissenschaften, the Royal Swedish Academy of Sciences, Stockholm, the Royal Academy of Sciences in Amsterdam, and the Cambridge Philosophical Society, all of which reciprocated the action by sending their own transactions and proceedings. Very soon, the Bulletins became by their own right important vehicle of original research papers and even attracted papers from abroad. Most of Raman's early experimental investigations on the maintenance of vibrations, dynamical theory of the motion of bowed strings and of musical instruments of the violin family appeared in these Bulletins. Here we also find D.N. Mallick's papers on Fermat's law, historical survey of optical theories and the theory of dispersion. At the First Annual Science Convention, Raman spoke of these Bulletins as follows: "The success which has attended these efforts is indicated by the fact that during these ten years the Association has issued, as its own publications, fourteen special Bulletins, and three volumes of proceedings, besides regularly publishing its Annual Reports.

These publications have been warmly received abroad, and the Association is now in exchange relations with about fifty learned societies and institutions in various parts of the world. Its publications have been reviewed at length in current scientific literature and quoted by foreign scientific workers in original papers and standard text books¹⁰.

The Bulletins dealt with occasional papers and reviews. The papers presented at the Annual Convention led to the publication of another type of serials, the *Proceedings*. At first these *Proceedings* did not have separate entities, but were published along with the Annual Reports with a separate title page to distinguish between the two. With the increase in the number of papers, Prof. Raman assumed charge of editing and publishing the *Proceedings* as separate serials independent of the Annual Reports. From 1926, the Association started the *Indian Journal of Physics* in which the *Proceedings* were incorporated.

The realization of the importance of scientific publications along with laboratory research has been *characteristic* of Raman. He steadfastly maintained that the results of work carried out in India and considered important should be published in India – a point of view which has only recently received serious consideration as an important aspect of national science policy. At the Association's Annual General Meeting on 20 September 1918, Prof. Raman remarked: "In my view, the time has come when work of a really important character can be carried out and published exclusively in the *Proceedings* of the Association and receive adequate recognition from specialists abroad. There are and ought to be no international barriers in the realm of scientific knowledge, and I can quote several instances within my personal knowledge of work published in India which has been referred to in standard treatises published in Europe and elsewhere. It is our best work that ought to be offered to our own journals and publications and thus enable them to win adequate recognition"¹¹.

Thus, the major factors for the growth of organized scientific research – well equipped laboratories and libraries, whole-time paid research guides and workers, facilities for communication among scientists through meetings, conventions and congresses and through serial scientific publications, and adequate financial support for all these activities – developed within a short space of time and resulted in the emergence of viable schools of physics, mathematics and chemistry.

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