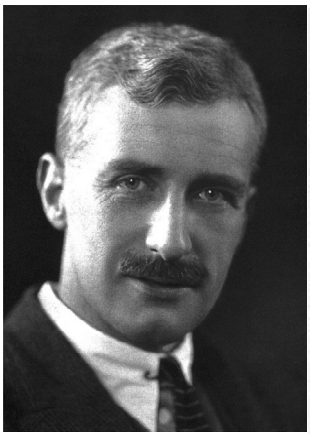
A Report to the Government of India on

Scientific Research in India

by




PROFESSOR A.V. HILL

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Edited by:

Anasua Mukherjee Das

Anup Kumar Das

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Twitter: **@IndiaICSI**

PREFACE

The following 'report' on Scientific Research in India makes no claim to formality or completeness. As ‘Notes and Suggestions’ it was written first, informally and confidentially, for the Government of India, as the basis for discussion before l left last April. To a large extent it was a log book of the travels, Visits, arguments and observations of the previous four months. A strong desire, however, was expressed that something of the kind should be made more generally available, and I promised to put my 'notes and suggestions' into a form rather more suitable for publication.

Various additions have been made and the material has been rearranged; but it still seems rather like a ‘log’, dealing chiefly with what one saw and heard. For incompleteness and possible inaccuracies, shortness of time and lack of previous knowledge of India may be an excuse; for frankness or indiscretion my Indian colleagues must share responsibility through their firm insistence that discretion is not always the better part of valour. For the comments and opinions expressed, I alone am answerable; they may often appear critical, but friendly criticism is a necessary step to progress – at least in science – and I do not underrate the achievements of Indian science and technology in the last 30 years. Indeed, I often had to say, when Indian friends seemed glum about it, that scientific advance in India has been greater in those 30 years than in all previous history. It is coming now to the steeper part of a rising curve.

Various proposals and recommendations are made in the following pages: some of them, it seems, are being adopted already; some of them will need careful working out as part of a long-range plan; others may prove impracticable. I have assumed throughout that the scientific method, rightly and confidently used, will provide the framework within which national development will be planned by Indians for India. In their task they can be sure of the cooperation and goodwill of their scientific colleagues elsewhere. No other method can possibly succeed.

I am deeply grateful to the Government of India for its invitation and for unlimited facilities throughout my visit. To the Department of Education, Health and Lands I would offer special thanks for the care and efficiency of their arrangements; but to many other Departments also my thanks are due for their interest and instant help whenever wanted. To innumerable friends and colleagues all over India I would express profound gratitude for their welcome and encouragement, for their guidance and their boundless hospitality.

I shall recall my visit not only with lasting interest but with warm affection.

A.V. HILL

The Royal Society

London, W.1.

14 August, 1944.

List of Abbreviations

ARC	:	Agricultural Research Council
CSIR	:	Council of Scientific and Industrial Research
DSIR	:	Department of Scientific and Industrial Research
FRS	:	Fellow of the Royal Society
GHQ	:	General Headquarters of the British India Army
GoI	:	Government of India
IRFA	:	Indian Research Funds Association
MIT	:	Massachusetts Institute of Technology
MP	:	Member of Parliament
MRC	:	Medical Research Council
Sc.D.	:	Higher Doctorate in Science
USA	:	United States of America
USSR	:	Union of Soviet Socialist Republics

Contents

A REPORT TO THE GOVERNMENT OF INDIA ON SCIENTIFIC RESEARCH IN INDIA

1. Introduction

It is commonly realized that scientific research and the application of scientific knowledge have played a large and essential part in the war effort of all the nations engaged in the present conflict. Between 1939 and 1941 arrangements were made between the United Kingdom, the Dominions and the United States for close cooperation in scientific research and full communication of scientific and technical Information, in all matters connected with the war. The Dominions and the United States now maintain scientific missions or representatives in London; the United Kingdom has a scientific representative at Ottawa; and a British Central Scientific Office at Washington acts jointly for the United Kingdom and the Dominions for scientific liaison in the United States. In addition many special missions, scientific, medical and technical, are continually at work in all these countries, in connection with weapons, equipment and methods of war, and with problems of food, health, transport, supply, communications, pest-control, etc. The arrangements have worked admirably and have greatly increased the speed and efficiency with which scientific knowledge and research have been applied to the war effort.

It was early realized by scientific men in the United Kingdom that India also ought to be in this picture and in 1941 representations were made through the Secretary of State to the Government of India, to that effect. Unfortunately the need was not recognized then in India and no action was taken.

It is not expected that all this cooperation in scientific matters will end when the war is over; for it is obvious that science, applied with the same whole-hearted collaboration and conviction to the problems of peace, reconstruction and development – for the betterment of the life of the people of the world – could make just as great a contribution as to war. For that reason the Royal Society in October 1941, took the opportunity of the presence in London during the war of scientific representatives of the Dominions to set up a 'British Commonwealth Science Committee' to consider how collaboration in scientific matters between the various countries of the Commonwealth and Empire could be made closer, and how it could aid in tackling common problems of the immediate post-war period and the future. Unfortunately no Indian scientific men were available in London to attend the meetings, but the Secretary of the Education Department at India House attended and Indian aspects of the problem were considered jointly with the others. The report of the Committee was published in March 1943[1],

[1] Reprinted in India in 1943 in 'Scientific Education and Research in Relation to National Welfare', Government of India Press, New Delhi, 1944, pp. 10-17.

and sent to the Governments of the countries concerned. One of results is that it is now proposed that an Imperial scientific Conference shall be called as soon as practicable after the war, to which scientific representatives of the United Kingdom, India, the Dominions and the Colonies will be invited. At this Conference, matters of common scientific interest will be discussed and an attempt will be made to formulate common policy for the interchange of information and research workers, and for cooperation in research and the practical application of results. Once a common policy has been decided on it is hoped to approach the scientific organizations in other countries particularly the United States, with the purpose of obtaining a more general interchange and cooperation for the same ends.

These various activities and the feeling among British scientific men that their Indian colleagues should be taking part in them, became known to the Government of India through two Members of the Viceroy's Executive Council who had been present in London in 1942-43 and in the summer of 1943 the Royal Society was invited by the Secretary of State for India, at the request of the Viceroy to send a representative to India to advise on the organization of scientific research. In a letter to the President of the Royal Society the secretary of State wrote:

> *"… The most important matter to be discussed, I understand, is the organization of scientific and industrial research as part of the Indian post-war reconstruction plan, and its coordination with the corresponding activities here. But advice would also be welcome on current research problems and visits by a distinguished scientist to universities and other research centres would, undoubtedly be much appreciated. I have now been requested by the Viceroy to convey an invitation to the Royal Society to depute a distinguished scientist to visit India, and to enquire whether it will be possible for them to spare Professor A. V. Hill for this purpose. ... Arrangements would be made for him to see as much possible of India's scientific, technical and research work.*
>
> *I myself feel that such visit would be of very great value both generally in regard to relations between this country and India, and specifically as a means of developing contacts with that country in the scientific and academic field."*

The Royal Society agreed to this proposal and to my absence for four months. I arrived in India on 16 November 1943, and left on 5 April 1944.

I took the Secretary of State's Letter as Indicating that my advice was sought rather by informal discussion, visits, contacts, etc., and by arrangements which might arise from them, than by the formal writing of a full report. The subject itself was so wide that a longer time and a regular staff would have been required for the latter purpose. It seemed better 'to get into close personal touch with Indian scientific, industrial, medical and official opinion, and to concern oneself mainly with matters of principle rather than detail. The present report is based on certain notes and suggestions which I left with the Government of India in April 1944, but it

refers also to a few matters which have turned up since: One of its objects is to suggest ways in which Indian scientific men can take more part in the general plan of cooperation referred to above.

I visited a large number of centres[2] where work was going on connected with science, medicine and technology. I was welcomed with the utmost cordially everywhere; and given the freest access to all information. I could have spent much longer at each place and could profitably have accepted invitations to many others had there been time. I might have felt embarrassed by the number of speeches, lectures and talks that people wanted me to give but realized that India has been sorely cut off, in recent years, from intellectual contacts with the rest of the world and that one must do what was physically possible. The great good will manifested everywhere towards my mission seemed to have obviated any misunderstanding of its purpose, or any hostile comment in the Press – which was always benevolent – on speeches which had often to be hastily prepared and frequently contained quite frank and critical remarks.

It seemed to be assumed everywhere that my purpose was friendly and helpful; and since I was, in India not as an individual but as representative of the Royal Society and British science, the hope became a conviction that in the scientific, medical and technical fields there is no difficulty at all in the way of full and friendly cooperation between India and the United Kingdom. In particular, l found everywhere the emphatic opinion expressed – with which I strongly agree – that one of the most important needs today of Indian science, medicine and technology is of better facilities to send the ablest of their young people abroad, particularly to the United Kingdom, for advanced and postgraduate study, for works experience and for training in research. In these subjects, at any rate, there is no tendency whatever in India towards isolationism that swindle has been shown up by world events.

2. The Lack of Scientific Liaison

This complete absence of any spirit of isolationism on the part of Indian scientific, technical and medical people, and their frank recognition of the advantages of cooperation, are in striking contrast with the sorry lack of scientific and technical liaison between Britain and India on problems arising from the emergency of the war. As early as 1940 the Dominion governments appointed scientific liaison officers to their High Commissioners' Offices in London, while in 1941 (9 months before Pearl Harbour) the Office for Scientific Research and Development of the USA set up at the Embassy in London, as office for the exchange of all scientific and technical information, including the most secret. Corresponding to these, the Government of

[2] Aligarh, Bangalore, Bombay, Calcutta, Cawnpore, Delhi, Hyderabad, Jamshedpur, Kirkee, Madras, Mysore, Poona.

the United Kingdom in 1940 established a British Central Scientific Office (now in effect a British Commonwealth Scientific Office) in Washington for the same purpose, and from 1940 onwards has maintained at Ottawa, to collaborate similarly with the National Research Council of Canada, a succession of eminent British scientists. There have been frequent visits also, throughout the Empire and the United States, of key scientific men for special purposes. The advantages which have resulted from such free interchanges have been beyond all measure, both for war purposes and for cooperative relations after it.

It is no fault of British scientific men that there is still very inadequate scientific or technical representation of India in the United Kingdom, or that there have been the most meagre representation in India recently of current and up-to-date British science. Even at GHQ, in India there has been very little expert contact with the mass of scientific work of all kinds connected with the war which has been done in the United Kingdom, the Dominions, and the USA. The consequences have been:

(a) The Indian scientific people have been quite unnecessarily cut off from association with scientific colleagues in Britain, the Dominions and the USA; and from taking part with them – as many of them have wished – in matters connected with the war;
(b) that India has been needlessly isolated from scientific and technical information which would have been freely available to its scientific representatives in London – had there been any;
(c) that the scientific and technical resources of India have not been utilised, or developed, for war purposes to anything like the same degree as those of the other major countries.

It is no good crying over spilt milk, hut there can be no question now of the necessity of starting up as soon as possible the closer scientific connections which should have been flourishing already for several years. The Scientific Adviser to the M.G.O. India has recently been in Britain and America, so his knowledge is now up-to-date, and he has at last the necessary personal contacts with those who are working in the same field. The Government of India has decided to appoint, when a man of a sufficient knowledge and experience can be found, a Scientific Adviser to the Commander-in-Chief. Various scientific missions or parties have recently visited or will shortly be visiting India. A group of Indian scientific men, delayed from May owing to war conditions, will be visiting the United Kingdom in October. I have ascertained that Indian scientific representatives would be very welcome at the British Central Scientific Office in Washington. An offer has been made to the Secretary of State for India, by the President of the Royal Society, that the Society would be glad to nominate a small committee of its Fellows to advise and help the members of an eventual Indian Scientific Office, to be established in London. The Secretaries of the Department of Scientific and Industrial Research and the Medical and Agricultural Research Councils have expressed to me their anxiety to have familiar

contact with research in India in their respective fields. Such arrangements, once established, probably would not end there, but would grow outwards into collaboration in general in the fields of education, learning and research, as well all of technology and industry.

3. Research Training of Young Indians in the United Kingdom

India has been largely cut off intellectually for nearly 5 years from the rest of the world. Many of the most prominent Indians in the fields of science, medicine and technology were trained in other countries, particularly in the United Kingdom; some were undergraduate students abroad, others went as advanced students, either to get a higher degree or qualification, or to work with some master of their subject; or else to get workshop, factory or clinical experience. The universities, medical colleges, research institutions and industrial equipment of India have not yet reached such a level of excellence that this period abroad can be dispensed with for those who are to be the leaders in their subjects; indeed, in scientific matters no country can be self-contained, and the very great scientific, medical and technical progress of the United States in the present century has been largely due to the modest readiness of their people to learn from others, and to the excellent provision made for large numbers of them to pursue advanced studies, or to gain experience, abroad.

One of the most urgent needs, therefore, of Indian science, medicine, technology and industry is for young teachers, research workers and members of technical staffs to be provided once more, as soon as conditions allow, with facilities for advanced study abroad; if possible on an enlarged scale, in order (a) to make up for recent restrictions and (b) to meet the greater needs of the future. The recent training of 'Bevin boys' in mechanical workshops in the United Kingdom has been a successful and popular experiment, and could be widely extended to cover other grades of workers. The sterling balance of India in the United Kingdom, which will be about £1,000 millions by the end of 1944, is now so large that the Government of India could have no difficulty in providing for all the advanced students or trainees it might wish to send for many years.

In order to ensure that facilities are available in the United Kingdom for the adequate reception of such people when the time comes. I strongly suggest that representatives of the Indian universities and other interests concerned should proceed to the United Kingdom as soon as possible in order to make preliminary arrangements with the authorities here. There is plenty of goodwill in British institutions, and (as I have ascertained) in British Industry, towards the idea of receiving able and carefully selected young Indians for research, for advanced study, or for works experience, but the universities, medical schools, technical colleges, and most research laboratories will be overwhelmed, soon after the war, with applications for admission from people whose claims it will be hard to resist. Unless arrangements are made in good time

disappointment will certainly result. Moreover for several years' vacancies In British institutions for Indian postgraduate and research students will be eagerly sought, and it will be necessary to ensure that they are given to the right people, qualified both by intellectual standard and by character to make the best use of them. It is particularly important, in order to gain goodwill for the plan, that the early groups should be most, carefully chosen. There is bound to be a certain reluctance to give vacant positions to young people whose chief assets may be the financial resources of their fathers, or whose main purpose may be merely to get a higher qualification as a step to advancement in a profession. If available facilities, which are certain to be limited for some years, are to be used to the best advantage, and, if the results are to be of the greatest future use to Indian science, medicine, technology and industry, the most careful selection should be made in India of those who are to be given an early opportunity of working abroad.

In the case of medicine and to some extent of engineering it might be best at first to pay special attention to those young men who have served with the Indian Forces. Their wider experience, and the fact that they will have played the same part during the war as most of the young men beside whom they would work in the United Kingdom, would allow them to fit in more quickly and easily; and their selection would be easier because their records would be known. No doubt for most of the rest the Joint Universities' Board and the research organizations of India together could set up a suitable body for the selection of candidates for a period of advanced study or research abroad. In view of the great future importance to India of biology, in connection with agriculture, food, fisheries, post-control, etc., attention should not be concentrated unduly on the physical sciences.

Very many of those who come to work in the United Kingdom would probably have arrangements made for them personally, by their teachers or directors in India, directly with the heads of research establishments, etc. in Great Britain. If, however, an Indian Scientific Office were established in London it would probably be wise for this office to be notified of all scientific workers other than undergraduates arriving in Great Britain and to make contact with them. For those for whom no definite provision had been made, or for whom some changes are required, the Indian Scientific Office in consultation with the Education Department at India House could probably make the necessary arrangements.

4. An Indian Scientific Office in London

If scientific contacts and exchanges are to be extended between India and the United Kingdom, and so with the rest of the empire and other countries, it will be advisable to setup in London an Indian Scientific Office to which would be attached (say) five specialists to deal with scientific matters relating respectively to agriculture, defence, engineering, industry and medicine. This

would follow a recommendation of the British Commonwealth Science Committee of the Royal Society, viz.:

> That a suggestion be made to the Government of the various English-speaking countries that they should consider the possibility of maintaining permanent scientific representation in London and possibly also in other capital cities the English- speaking world.

The President of the Royal Society has suggested to the Secretary of State for India that the Society might set up a special committee of Fellows interested in Indian affairs, for the purpose of advising the Indian Scientific Office, the India Office, or the Office of the High Commissioner for India on any special matters desired. Such advice would have continuity as well as authority, which is more than could be obtained from ad hoc committees, improvised at intervals for special purposes. To take a single example, appointments to various important scientific posts in India will fall to be made from time to time, particularly in the next few years. Some of these will require men of the highest scientific standing. If these are available in India, so much the better; when they are not, and it may be some years in certain subjects before they are, it will be unwise not to offer appointment to the most eminent persons available. Such people do not usually answer advertisements; they have to be sought out and negotiations have to be undertaken with them. An Indian Science Committee of the Royal Society, with expert advice from other Fellows when required, could provide the special knowledge needed in making such nominations to the High Commissioner. A standing sub-committee of this body might afford general scientific assistance to the Indian Scientific Office.

5. Scientific Liaison with the United States

There are many practical problems, to the solution of which scientific methods can contribute, which are common to India and North America. For example, the United States has in recent years had considerable and disastrous experience of the consequences, in dust, erosion and floods, of improvident exploitation of the land, and much thought and research have been devoted with considerable effect to the problems since 1935, when the Soil Conservation Service of the United States Department of Agriculture was established. A similar problem exists in India. Rural health and nursing services have been highly developed in the United States, under conditions, particularly, in the Southern States, which are not so remote from those of India. The control of pests is another common problem. Irrigation and hydro-electric developments are matters of first importance in the West, as they are in India. These are typical examples; there are many others.

In the United Kingdom now scientific men are in extremely close and familiar contact with their colleagues in the United States, and all information relating to the war is shared between us.

Even before the war the mutual knowledge and regard of scientific people in Britain and America were probably higher than of any other group. I have no doubt that the scientific community in the United States would be glad to establish similar relations with their colleagues in India. Considerable advantage would accrue to India from closer contact with the experience of the United States, particularly in in dealing with such problems as the above.

Since 1941 there has been a British Central Scientific Office (BCSO) in Washington through which the mutual sharing of scientific and technical information is conducted. This Office acts now for the Dominions as well as the United Kingdom, and there are representative groups of them all there, Americans have been extremely appreciative of the work of the BCSO and it is hoped that in some way or other its activities may be continued after the war. Scientific visitors or missions to the United States have found its help, its experience and its files of information most valuable. I have discussed with the present Director of the BCSO the possibility of attaching representative Indian scientists to the Office and he assures me that they would be extremely welcome. I strongly recommend that a mission be sent there, representing scientific interests in agriculture, industry, medicine and war equipment; and that India should take part in the future in whatever organization may grow out of the BCSO after the war.

If and when an Indian Scientific Office is established in London there will be further opportunities of scientific liaison with the USA (and the, Dominions) through their scientific representatives here. There can be no doubt of the cordiality with which the Americans would cooperate in closer scientific liaison with India, or of the good which would accrue to India from more familiar contact with American (and Dominion) knowledge and experience.

6. A Research Background in Medical Education

Although the purpose pf my visit to India was not related to any special branch of science, it was natural, as a physiologist, that I should be given special opportunities of seeing hospitals, medical colleges and, departments of medical science. It would be difficult except at very great length, and Improper without much more careful study, to report in general on the state of medicine, public health, medical education, and research in medicine and the medical sciences, and in any case the Health Survey and Development Committee is now examining the whole situation in these respects. Certain impressions and conclusions, however, have been forced on me during my visits and discussions, which I do not think would be altered by a fuller survey.

A. Research in the pre-clinical sciences

Taking these as anatomy (including histology), pharmacology, physiology (including biochemistry and biophysics) and normal psychology, the standard in the medical colleges seems to me on the whole to be unduly low. Routine teaching is done to a moderate standard limited by staff, space and equipment, but there is little significant research. Biochemistry is

probably the best, because of its association with chemistry rather than medicine, because of its relation to agriculture, nutrition and industry, and because it is impossible to employ underpaid medical practitioners to teach it. The pre-clinical sciences are the basis of the scientific study of medicine and of what is now called 'Clinical Science'. If the pre-clinical sciences are weak it will almost inevitably follow – and it has followed in India – that clinical research and the standards of higher medical thought and education will be in a bad way. This is clearly brought out in the Report of the Interdepartmental Committee on Medical Schools (‘Goodenough Committee'), recently published (H.M. Stationary Office, 1944), copies of which ought to be available in every medical college in India. The Report (p. 79) goes on to emphasize the wider importance of these subjects:-

> “It is possible, in view of the increasing national interest in such matters as nutrition, physical education, agricultural and veterinary education and the focusing of more attention on the maintenance of health, that the future may bring anatomy and physiology into wider contact with the life of the community. It may well be that every member of the community should learn some elementary anatomy and physiology from teachers adequately trained in these subjects. Such possibilities indicate the importance of increasing the present recruitment of junior workers.”

and, it is added elsewhere, of improving their salaries, status and conditions. These comments apply equally to India.

There are many medical colleges in India; there are many physiologists anxiously concerned about the prospects of their subject; but India is making, as yet, little significant contribution to it. The reasons are not far to seek:

(a) The departments of physiology are grossly understaffed. Usually there is a professor paid a full-time stipend and often labouring with devotion; but the rest of the staff are apt to be busy medical practitioners who, for a meagre part-time salary, come in and take a turn at teaching the classes. The habit of running departments of physiology (and the same is true of anatomy) 'on the cheap', by employing as teachers people whose minds and interests are bound to be largely elsewhere, has had a disastrous effect on the subject. No real improvement can take place until most members of the staffs of the pre-clinical departments hold full-time appointments, reasonably well-paid, in which researchers well as teaching is regarded as a normal duty.

(b) In Great Britain and the United States many of the most important contributors to physiology have come in from other subjects – physics, chemistry and zoology. In India little encouragement has been given to such people, no doubt partly because, having no qualifications to earn their living by medical practice, they would require full-time salaries.

The result is that in India physiology has not developed as an independent science, but has remained purely an adjunct of medical education.

(c) The physiology departments have, been starved of space, of modern equipment for research and teaching, of technical assistance and of funds available for purposes of research.

(d) Owing to (a), (b) and (c) no great school of physiology has ever developed in India from which teachers and research workers could go out to other schools and raise the standard all sound. That is what happened in other countries. In the United Kingdom, for example, modern physiology started from Sharpey at University College, London; from there his pupils went to Cambridge, Edinburgh and Oxford, and thence their pupils to almost every school in the country. ln those four centres, in particular, physiology has held a proud and independent position as a science in its own right, of the same intellectual standing and importance as any other science. A necessary step in the development of scientific medicine in India will be to start off one first-class department of physiology at which teachers and research workers of a new standard and a new outlook will be reared and thence sent out throughout India. That, however, applies to most other subjects connected with medicine and is referred to again under An All India Medical Centre (section 7 below).

The foregoing remarks refer particularly to physiology; but they apply almost equally to anatomy and pharmacology in the medical colleges; and there is little provision for psychology. Biochemistry is in rather better case because it has developed a certain Independence of medicine, has had a special part to play in relation to nutrition, and has connections with agriculture and industry. It will be a pity, however, if biochemistry is encouraged to develop mainly as a branch of chemistry, in order to, avoid the narrowness and penury of the medical connection. It should be just as closely in touch with physiology, pathology and medicine as with chemistry, agriculture and industry.

B. Research in pathology and bacteriology

In the medical colleges much the same criticism applies to those subjects as to the pre-clinical sciences. The departments are understaffed and ill-equipped and most members of the staff are mainly occupied in earning a living in other ways than by teaching and research. Consequently the scientific standing of the departments is generally low. The scale of staffing required by the Division of Pathology in a University Medical Centre is estimated by the Goodenough Committee (Report p. 291) to be as follows, all full-time:

4 departmental heads (morbid anatomy, bacteriology, chemical pathology and clinical pathology);
4 lecturers;
4 resident assistants;
8 demonstrators.

To this are added about 30 members of technical, assistant, or secretarial staff. It would be quite impossible in India at present, even if funds were available, to staff the Divisions of Pathology of the Medical Colleges on that scale; sufficient people of the right caliber and experience are not available. This makes it the more necessary (a) as soon as possible to send able postgraduate students abroad for higher training, and (b) to establish some centre in India at which pathologists can be trained to a much higher standard than at present.

There are of course a number of other institutes, outside the medical colleges, in which work of the very highest quality has been done in these subjects: e.g. the Haffkine Institute at Bombay, the King Institute at Madras, the School of Tropical Medicine at Calcutta, the Central Research Institute at Kasauli, the Malaria Institute at Delhi, and various others. These are referred to under 'Medical Research' (section 8). India has a very high tradition in connection with tropical medicine; but the work has been done mainly outside the departments of the medical colleges, which remain largely adjuncts of medicine for routine examination and teaching. Research can reproduce, itself only if it is in contact with students and young graduates.

C. Research in Clinical Science

It is scarcely an exaggeration to say that practically no research work of any significance in clinical medicine is yet done in Indian medical colleges. The amount and variety of clinical material are enormous; there is the most urgent need to advance scientific knowledge of the clinical aspects of many diseases; there are plenty of keen able young people who, given the training, the opportunity, and a reasonable salary and status and prospects for their future, would be glad to devote their lives to the advancement of medicine by teaching and research. At Present, however, in India, possibly even more than elsewhere, success in medicine is measured by size of one's Income and the number, wealth and importance of one's patients.

Under the present system there are very few full-time teachers and research workers in the clinical subjects, and there are no, fulltime medical, surgical or gynecological units. Busy and successful practitioners usually control the teaching and stand out as the ideal to be aimed at by the medical student. Their hearts are bound to be mainly in their private practices. It seems to me imperative that full-time clinical units should be started in all Indian medical colleges, in medicine, surgery and gynecology, as soon as teachers and research workers of a high enough standard are available and that the full-time professorial heads of these units should control the use of the hospitals and laboratories for all purposes of education and research.

The scale of staffing of the Divisions of Medicine, Surgery, and Obstetrics and Gynecology in a University Medical Centre, is estimated by the Goodenough Committee (Report p. 292), for example in the Division of Medicine:-

1 professor, full-time;
2 readers, full-time;

8 physicians or assistant physicians, part-time;
10 assistants or registrars, full-time;
10 pre-registration house-physicians, full-time.

I realize that nothing on this scale could be done in India at present, except at one or two centres; there are not enough people of sufficiently high standard available, and probably a good deal of opposition to the full-time principle would be met, as in the United Kingdom and America, from existing interests. Moreover, its universal, adoption is bound to be very expensive, and medical education in India is under the Provinces and States, not-under the Central Government. If, however, it started gradually in various centres, as opportunity occurred and staff became available, its obvious advantages would be seen and the principle would tend to spread. A start might be made by the Medical Research Board (proposed in Section 19 below) setting up complete full-time Clinical Research Units in one or two centres.

7. An All India Medical Centre

In all the subjects of a medical course, in laboratory as well as hospital, the crying need in India is for full-Lime workers, capable and well-trained, able to devote their lives to the advancement of the science and practice of medicine by education and research. It has become almost a cliché to say so, but in no other subject than medicine it is so necessary that education should be given in a research atmosphere. Each patient presents a problem, each diagnosis is a theory, each treatment is an experiment, often an expensive and painful one; and it must seem to anyone of scientific upbringing almost a crime that the results of nearly all those costly experiments go unrecorded. In the right research atmosphere this would not be so, but in that of an ordinary general hospital, with a very part-time staff and no provision, e.g., by an almoner's department, for ‘follow up’, it literally is. How can medical education produce a scientific attitude of mind in such circumstances? In fact it very seldom does.

Far the most effective way of producing a change in all this would be to set out deliberately to create teachers and research workers of a new kind, people who would devote their lives to the single object of advancing in India the art, science and practice of medicine. For this purpose a great All-India Medical Centre[3] should be established, an ‘Indian Johns Hopkins’, staffed in all departments by the ablest people available anywhere, employed full-time and adequately paid. The students of the All-India Medical Centre should be highly-selected ones, preferably with good degrees in arts or science as a start; and since a large proportion of the most desirable students cannot meet the financial cost of a long training, in medicine, all who require help should be given it in the form scholarships or bursaries (see the Goodenough Committee's Report, pp. 100-104, particularly paragraph 26).

[3] Presently known as *All India Institute of Medical Sciences* (AIIMS), established in 1956 at New Delhi.

This last point is a very important one and can be put in this way. There is little doubt that the medical profession does not tap much of the best ability of any country, partly because medicine, as usually practiced, does not appear to offer the same Intellectual interest, or challenge, as science does, but largely because of the cost of a medical education and of maintenance during it. Many medical students in all countries are in fact of rather inferior intellectual quality. The importance, however, to any country of a really high type of doctor is great; and the importance of a high type of medical teacher and research worker is very great indeed. The intention of the All-India Medical Centre would he to produce the future leaders, of Indian medicine and public health, the teachers and research workers. Now in industry it is recognized that the cost of any product depends upon design, manufacture and raw material. The cost of raw material is often so small a part of the total expense that it is folly to use anything but the best if a high-class product is required. The total cost per student in the All-India Medical Centre is bound to be high; if by liberal scholarships amounting to (say) 10% of the total annual cost the final product could be made on the average 50% better, then obviously the scholarships are money very well spent. That I believe is exactly the situation. The best possible students should be brought into the Centre, regardless of all other considerations – financial, racial, religious, political, provincial and so on. If any reason whatever was accepted for admission other than ability and character the project would lose at once a large part of its value.

The All-India Medical Centre should be genuinely an All-India affair. It might be thought best to establish it in some great industrial city; but the need to avoid communal, political, inter-provincial and inter-state difficulties and rivalries is so great, the need to avoid jealousies and conflict with existing interests so evident, that I have been convinced that the Centre should be established in the capital city of India. Delhi University is growing in stature and importance; there are many scientific institutions in and around Delhi. Delhi is the meeting ground of many scientific and medical interests. Delhi will probably become headquarters of u future national academy of sciences and of other specialist national scientific bodies; and air transport in the future will make communication with other parts of India vastly quicker than at present. If the All-India Medical Centre is to play the national part, it should in advancing medicine and public health, and to gain the international repute which will put Indian medicine ‘on the map’ and attract first-class teachers and research workers from any part of the world, then I think it must, be given the national recognition and status which is possible only by its establishment at the capital of India.

The project of an All-India Medical Centre is bound to be very expensive. Well-designed air-conditioned buildings and the best modern equipment and libraries, though important, will represent only a small part of the whole cost. The chief expense will be that of the full-time staff required. Supposing recurrent expenditure to be met from interest on invested funds, an

approximate estimate of the total capital required, allowing for interest at 3⅓%, is about Rs 7 to 10 crores. It should be possible to obtain a considerable part of this from Indian and other benefactors and from international foundations. If it proved possible to build, equip and endow the Centre entirely from voluntary gifts, the freedom and independence so given to it would greatly strengthen its hand against eventual political or other pressure, to compromise with which would inevitably lead to a lowering of standards. *An All-India Medical Centre might be a very fitting national memorial to the Indian Forces after the war, a sign of the national determination that nationhood and national pride shall mean the welfare of the people as a whole.* For better health is the first need of India.

> *As regards the running cost of the proposed All-India Medical Centre, a substantial contribution could be obtained by providing special accommodation for private paying patients, as in many American university hospitals. Since first-class medical and surgical treatment would be available, many wealthier patients would probably prefer the Medical Centre to a private nursing home. Their fees would go entirely to the Medical Centre, not to the individual physician, surgeon, bacteriologist, pathologist, etc.*
>
> *It would be an advantage, not a disadvantage, to the Medical Centre, to have patients of all, not merely of the poorer classes, and the fees could be adjusted as at the Mayo Clinic, Rochester, Minn., to the income of the patients. Moreover, the goodwill and interest, of international patients who had benefited by treatment at the Medical Centre, would be of value in forwarding the principles and ideals for which the Centre was founded. The tendency in America to use the university hospitals for private patients in this way has been strong in recent years, and the same tendency is evident In the United Kingdom. It is one to be encouraged in India.*

A Malaria Hospital. As part of the All-India Medical Centre there should be a special hospital for the clinical study of malaria. Malaria in India is public enemy number 1. The discovery of modern chemical repellents like DDT has given hope of for more effective attack on the Malaria mosquito. Even so, there are many hundreds of millions of people throughout the world who already have the malaria parasite in their systems, and it seems unlikely that the disease will be abolished altogether except by learning how to cure it in human patients to eliminate the malaria parasite from their bodies so that the mosquito cannot carry it to others. The possibility of an effective cure is not yet apparent, but the developments of chemotherapy in recent years have been so rapid and astonishing that it would be folly not to reckon with the probability that some chemical agent not yet known, or yet properly tried out clinically, may be found to be effective.

If this line of attack is to be successful it will require the most careful clinical and laboratory studies on malaria patients subjected to various treatments and therapeutic agents, and an elaborate follow-up system to find out whether apparent cures are permanent. The clinical staff

of the Malaria Hospital would need to be in close and continual touch with chemists engaged in the organic synthesis If new agents, with pathologists, biochemists and immunologists. A hospital of about 200 beds would be required, with special laboratories.

The most suitable patients might be soldiers of the Indian Army, who, on leaving hospital, would return to their duties under conditions in which 'follow-up' would be easy, re-infection could be avoided and conditions of health and nutrition controlled.

Nowhere in the world, to the best of my knowledge, is there a hospital specially devoted to the clinical study of malaria. India has played a large part in the study of tropical disease, particularly of malaria, and it would be appropriate that she should continue her contribution to world medicine in this way.

8. Medical Research

Medical research ln India, by a long tradition, has been done in the main at special institutes, usually quite unconnected with the medical colleges and universities. The research department of the Indian Medical Service, in adjustment, with provincial and state authorities, has been mainly responsible for these; and the Indian Research Funds Association (IRFA) has provided research grants and salaries. Very distinguished work has been done in them, particularly in tropical medicine. Among them are:

- The Central Research Institute, Kasuali
- School of Tropical Medicine, Calcutta
- The Haffkine Institute, Bombay
- The King Institute, Madras
- The Malaria Institute of India, Delhi
- The Drug Research Laboratory, Jammu, Kashmir
- The All-India Institute of Hygiene and Public Health, Calcutta
- The Nutrition Research Laboratory of the IRFA, Coonoor.

There is an obvious advantage in placing talented research workers in a situation where they need not be unduly burdened by teaching and routine; conversely, however, there is disadvantage in isolating medical education and the clinical work of teaching hospitals from all contact with research. Moreover, it is a serious loss to many research workers to remove them from the stimulus of young inquiring minds and from the general scientific contacts of a university.

The process, therefore, of setting up separate institutes in India for medical research has probably gone far enough; and some advantage would now result from bringing existing research institutes, where practicable, into closer contact with the medical colleges and higher

medical education. The National Institute for Medical Research and the Lister Institute in London are treated for purposes of postgraduate study as Schools of the University of London. Similar arrangements could be made in India. In setting up new institutes for medical research in India, or in promoting new schemes for research units, the advantage should be borne in mind of associating them with appropriate existing medical colleges and hospitals.

In the United Kingdom the Medical Research Council (MRC), founded in 1914 and working under the Lord President of the Council, has had very great influence in promoting new knowledge of medicine and allied sciences. It has acted mainly by organising, encouraging and financing research work in existing university laboratories and medical schools. The National Institute for Medical Research belongs to the MRC but its activities represent only its fraction of the work done under the Council's auspices. The MRC has an extremely free hand in the use of the funds allocated to it, and its plans have never been seriously held up for lack of them. It is not directly associated with the Ministry of Health, and there is no suggestion today that it would be better placed under that Ministry. It is able to undertake the most fundamental work of long-range character, but it is equally able to tackle emergency problems when they turn up. The governing council consists mainly of eminent research workers and experts in medicine and public health.

The Indian Research Funds Association (IRFA) plays a rather similar role in India. Its funds, however, are very scanty, though it is not hampered in the application of them such all they are. The IRFA is an independent registered body deriving its funds from, not from extra-departmental minister with a special care for research, but from a ‘user’ department (Education, Health and Lands). Because of its poverty it cannot take the same broad view of its functions as the MRC does; for example, to maintain even a single clinical research unit in one of the medical colleges would be financially out of the question until ampler funds are available.

9. Vital Statistics and Population

It is greatly to be regretted that the Census of India of 1941 was not completed or its results fully worked out. The population of India is increasing now very rapidly, and is likely for some time to increase even faster as public health and nutrition improve and the present appallingly high mortality diminishes. All future planning of the nation's resources, and of the scale and direction of national development, depends on the size and age distribution of population at the dates considered. Since the trend of population can be foreseen by analysis some time before it is apparent in gross figures, it is very desirable that the data for analysis should be available, and that prediction should be carried out on various probable assumptions as to the effects of improvements in public health and nutrition on the mortalities at different ages. With any reasonable assumptions all to such effects, the size and urgency of the task of national

development will be apparent, particularly in regard to food and agriculture; and it will be realized that every improvement in health and nutrition ought to be accompanied by some corresponding effort to educate the people, particularly the women, to some sense of responsibility in reproduction.

It is commonly argued that a rise in the standard of living will lower the birth rate[4]; so in India all that needs to be done is to raise the standard of living and all will be well! So far as this pious belief does not rest on the use of all ambiguous and misleading term, the crude birth rate (which depends much on longevity as on fertility!), it is probably quite untrue that the net reproduction rate falls as the standard of living rises – until at least the standard of life has risen so high that education has led to sophistication, and all kinds of aspirations, emulations and desires have displaced the urge to reproduction. At any rate a quantitative comparison of different groups, and in different regions, of similar people at different levels of prosperity and nutrition could determine whether the first effect of a rising standard is likely to be useful, or a rise of the rate of reproduction. The fact that the birth rate and the net rate of increase in the Punjab are significantly higher than in India as a whole suggests that the first effect of higher standard may in fact be a rise.

A similar statement frequently repeated is that 'industrialization' will lead to a fall of 'birth-rate'. In England and Wales throughout the nineteenth century, the age of industrialization, the net rate of increase – in spite of heavy emigration – lay between 12 and 18% per 10 years, averaging 14%. Whether the present downward trend in, the United Kingdom is due to 'industrialization', or to a variety of other causes, can be argued about , but at any rate it did not begin for a whole century. It would be possible by collection of data and analysis to find out, roughly at least, what effect industrialization is likely to have in India on rate of increase of population; though it must be remembered that the population of India is bound to remain predominantly agricultural for a very long time.

The crude death rate is well known to be an entirely misleading criterion for the comparison of mortality in populations with different age distributions. For example, the crude death rate in India is about twice that in Britain, but the mortality at any specified age up to 55 in India is 4 to 8 times that in Britain. The population of India, owing to the higher mortality, is much younger than that of Britain and the mortality of a younger population (other things being equal) is less. To compare the crude death rates is not a comparison of like with like. The decision of where

[4] Recorded birth rates in India appear to be too low by about 2-3 per thousand. In the absence of significant emigration or immigration, successive census figures should be calculable from one another by means of differences in intervening years between birth and death rates. In order to get the correct figures, higher differences must be used. Presumably about 7% of births are not recorded.

the available effort for national development should be directed depends largely upon a public understanding of the actual facts and probable trends of morbidity, mortality, reproduction and population. It is greatly to be hoped therefore that the Government of India will ensure that all the necessary information is obtained, analysed and published; and that a careful, objective and intelligible statement is made available for the public, to assist them in drawing conclusions as to where the most urgent needs to India lie for national betterment. I understand that an expert Committee has been set up by the Government of India to explore the subject of population; presumably it could undertake the wider task suggested above, and – remaining in being – could bring it up to date from time to time.

10. Agricultural Research

Agriculture is by far the most important industry and interest in India and a great expansion of it is necessary; *first*, to provide more adequate nutrition for the present population of rather more than 400 millions; *secondly*, to anticipate the food requirements of an increase of population which at present is about 15 per thousand per annum, and is likely to become appreciably higher as public health measures and nutrition improve; and *thirdly*, to provide for expansion of crops required for industry and export. Unfortunately limitations of time, together with my own lack of expert knowledge of agriculture, made it impossible for me to gain a first-hand acquaintance with the very considerable effort which is being made in India in agricultural research – a greater effort than is yet being applied in any other scientific direction. Some reference, however, is necessary here to so important a subject.

Agricultural research in India is carried on:

A. In institutions maintained and controlled by the Central Government;
B. In agricultural and veterinary departments of Provincial Governments and leading Indian States;
C. By All-India Committees for Cotton, Jute and Lac, and the Imperial Council of Agricultural Research.

Under A come:

1. The excellent *Imperial Agricultural Research Institute* at New Pusa outside Delhi, with separate sections of Botany, Mycology, Entomology, Soil Science and Agronomy. Originally it was established in 1905 at Pusa in Bihar, but was transferred to Delhi in 1936. The Institute has four substations, at Pusa in Bihar, at Karnal in the Punjab, and at Coimbatore (for sugarcane breeding) and Guntur in Madras. The annual grant, at present, is about Rs 8.5 lakhs.

2. The *Imperial Veterinary Research Institute* at Mukteswar in the UP, with some sections at Izatnagar; the annual grant is about Rs 10.75 lakhs.

3. The *Imperial Dairy Research Institute* at Bangalore, with an annual grant of about Rs 3 lakhs.

4. The *Imperial Institute of Sugar Technology*, with an annual grant of about Rs 3.25 lakhs. I understand that the Government of India is considering a proposal to constitute an Indian Central Sugar Committee on the lines of the Indian Central Cotton Committee (see below). The Committee would receive a grant from the Central Government from the cess levied on white sugar produced in British India. If this Committee is formed the administration of the Imperial Institute of Sugar Technology would be handed over to it.

The grand total under this heading A is about Rs 26 lakhs annually (£200,000).

Under B the facilities for research in the Provinces are more highly developed for crops than for animals and a large variation exists between different provinces in the effort made in research. In the Punjab an elaborate organization has been created; in Orissa and Sind financial considerations are said to prevent any substantial contribution. The same variation is true of the State of Hyderabad, Mysore and Baroda have fairly well developed institutions but the smaller States have very little; though 25 of the smaller States of Central India have set up a joint concern called the "Indian Institute of Plant Industry" financed by pro rata contributions from the constituent States and subsidised by the Indian Central Cotton Committee, for research on breeding problems of cotton in that tract.

Under C come:

1. The *Indian Central Cotton Committee*, constituted by statute and deriving its income from a cess on raw cotton, normally about Ra 7 Iakhs annually. The Committee maintains a Cotton Technology Laboratory at Matunga, Bombay, and sub-station at Indore with the Indian Institute of Plant Industry referred to above. The Committee deals with all problems relating to the production of raw cotton, its processing and supply.

2. The *Indian Central Jute Committee*, deriving its annual grant (about Rs 4 lakhs) from the Central Government and maintaining a Technological laboratory at Calcutta, and a farm at Dacca.

3. The *Indian Lac Cess Committee*, deriving its income, normally about Rs 3 lakhs, from a cess on the export of lac and maintaining a technological institute at Ranchi.

4. The *Imperial Council of Agricultural Research*, (established in 1929) which is responsible for all research on crops and animals which has not been handed over by the Central Government to special committees. Its income is derived from a cess levied on the export of certain agricultural commodities, being normally about Rs 14 lakhs but at present – owing to the war – considerably below that figure. The secretariat is maintained by the Government of India. The ICAR has representatives of Provinces, States and a variety of interests; it appoints scientific and commodity committees. It does not, in practice, undertake any research work directly, but finances special projects at appropriate institutes throughout India.

The grand total under this heading C is normally about Rs 27 lakhs (£200,000).

Excellent work is being done in India in agricultural research; and it could obviously be greatly extended, particularity by undertaking largo scale trials, if funds and scientific staff were available. The total expenditure in India for research in agriculture, in all regions and subjects together, must be of the order of £500,000 (say Rs 70 lakhs annually). This is about two-thirds as much as was spent in Great Britain before the war on agricultural research, in a country of one-eighth the population and one-twentieth the area; and in Great Britain it is being urged (*A Scientific Policy for British Agriculture*: Parliamentary and Scientific Committee, 1944) that expenditure on agricultural research should be raised to at least £3 millions per annum. Great and effective as the effort in India has been in agricultural research, the amount-spent on it is still only about one quarter of an anna per inhabitant per annum, one-tenth of an anna per acre of the total area. India is not so poor that a considerably greater effort could not be devoted to research in its greatest industry and its most important interest. Recent announcements, in fact, of a plan for increasing agricultural production by 50% in 10 years, by 100% in 16 years, suggest that steps are already being taken to that end.

11. Surveys and Natural Resources

The material resources of India are very great but most inadequately known. The Geological Survey of India was founded in 1851, the Botanical Survey in 1889, the Zoological Survey in 1916. The Geological Survey is active and has done distinguished work under distinguished directors, but is quite inadequately staffed for the enormous task it has to accomplish. The Directorship of the Botanical Survey has been in abeyance for 7 years, and very little financial aid has been available for 14 years for botanical field work. The Zoological Survey for many years has done practically no field work and, its activity has been restricted to maintaining a museum; this followed a report of a 'Retrenchment' Committee in 1931.

Fishery research has been done in various small provincial stations it; it also has a place under the Zoological Survey. The effort devoted to it, however, has been quite inadequate when its importance is considered. The fish supplies of India, from fresh water and sea, are potentially very great, and could make a substantial contribution to national nutrition. If, however, the fisheries were exploited without careful scientific survey and control, their present yield would be less than it need be, and their future productivity might be gravely prejudiced. I gather that a plan exists for two national Fishery Research Institutes, one for sea-fisheries at Bombay, the other for fresh-water fisheries near Calcutta. I would most strongly recommend that this plan be proceeded with, that Directors be appointed as soon as possible and that staff be collected and trained in preparation for the time when buildings, ships and equipment can be provided. The possible contribution of fishery research to national welfare is very important; the magnitude of this contribution, and the speed with which it becomes available, will depend at

least as much on first-class staff and Ideas as on buildings and equipment, and there is no need of delay in collecting and training staff and making plans.

> The cess for biological research stations for fisheries has been well stated by Dr H. Srinivasa Rao in a Presidential Address to the Zoological Section of the Indian Science Congress in 1942.

In deciding on the future of the Botanical Survey, that of the Royal Botanic Gardens at Sibpur, Calcutta, with the great Herbarium there (which is really the national herbarium of India), should be considered too. Both of these latter have been maintained hitherto by the Government of Bengal. It would be natural to associate them, by arrangement between the Government of Bengal and the Central Government, with the Botanical Survey. The Botanical Survey, restored and re-invigorated, should be able to play an essential part in long-range plans for agricultural development.

As regards the Zoological Survey, the enormous wealth of the Indian fauna demands something more than a museum. Apart altogether from the duty of any great country to promote the scientific knowledge of its own resources, such knowledge could not fail to have an important practical bearing on Indian agriculture and industry.

As regards the Geological Survey, I gather that there is a serious shortage of competent and experienced Indian geologists and of university departments to train up younger ones. Geology nowadays requires also men trained in modern geophysical methods and there is a strong move in the United Kingdom now to provide more funds and facilities for training and research in geophysics. Some of the excellent young physicists now available in India could be diverted with profit to this field. The knowledge of Indian mineral resources is still sketchy; which is a hindrance now in the war-effort of the country and will be a continuing handicap in post-war development. Moreover, geology impinges on such important subjects as water supplies and irrigation, soil erosion and land maintenance. It is clear that considerably increased effort should be devoted to geological work of all kinds in India, and that the training of the personnel required should proceed as early as possible.

Modern statistical methods have a considerable application to the survey of national resources of all kinds, as they have also to ‘quality control' of industrial production. Fortunately there are distinguished statisticians in India, and a number of workers experienced in sampling methods; and the Indian Statistical Institute is a focus of important activity. For the rapid post-war development of the country a full detailed knowledge of natural resources, agricultural production, etc. will not always be quickly available and statistical methods of the requisite degree of significance will have to be employed. Emphasis, therefore, must be laid in the coming years on the need to increase the number of trained statistical workers, particularly by facilities for advanced study abroad; and on giving them opportunities for the fuller use of their methods in studying national resources and needs.

In the discussion of national resources as whole other important subjects need obviously to be considered, such as water-power, water supply, forests, soil, population, etc. It is suggested below under a Central Organization for Scientific Research (section 19) that a special Research Board should be set up on 'Surveys and Natural Resources'. This would provide the most effective means of obtaining, maintaining, and making generally available the accurate quantitative assessment of natural resources which is essential to national planning.

12. Industrial Research under the Government

The foundation in 1940 of the Board of Scientific and Industrial Research represented a very notable step forward in the organization of Government Science in India; its full influence has not yet had time to be felt, though already it has produced important results. The example of the Department of Scientific and Industrial Research in United Kingdom, which founded in 1916, has attained a very important position and will have an increasing influence as time goes on, indicates the directions in which Industrial Research should develop in India. Financial provision was made in the recent Budget for some of these developments, for Fuel Research and Glass Research, and for National Laboratories for Physics, Chemistry and Metallurgy. Many other projects remain still to be considered, for example for research in food processing and food-pests, in ship design, in aeronautics, in radio, in building, in engineering, in road construction, and in many other subjects; though probably some of these would be taken over by other Research Boards (section 19 below). Moreover, the question of starting cooperative Industrial Research Associations (of which in the United Kingdom there are already 24), as joint concerns with Industry, remains to be thought out. Some of these cooperative Research Associations in the United Kingdom are already strong and effective agencies; though it is clear that they cannot replace the very important research activities of individual firms.

Further reference to Industrial Research is made in sections 13, 16, 19 and 21 below.

It will be very important for the Board of Scientific and Industrial Research in India to be in close and familiar contact with the DSIR in the United Kingdom and with corresponding bodies in the Dominions. Such contact will be warmly welcomed. The forthcoming visit to the United Kingdom of the Director of Scientific and Industrial Research for India with some of his colleagues will give him the opportunity of studying the working of the DSIR and its establishments, and of planning the machinery of closer collaboration and exchange. The projected Imperial Scientific Conference would allow these contacts to be extended.

One criticism I would make; the headquarters staff, technical and administrative, assisting the Director of Scientific and Industrial Research for India is far too small. With the additional commitments he will now be taking on, his burden, without more help, would become intolerable. He will see in the DSIR in the United Kingdom something of the magnitude of the

task likely to confront him later in India and of the provision made for assisting his opposite number here; and he will be able to claim more adequate assistance and support, when he returns.

> Early this year at Oxford, Nuffield College organized two conferences on 'Problems of Scientific and Industrial Research', as a result of which a Statement has recently been published by the Oxford University Press. This Statement represents the common ground of a wide range of expert opinion in the United Kingdom; many of its conclusions might find possible application in India.

13. Scientific Research by Industry

The Bell Telephone Laboratories in New York of the American Telegraph and Telephone Company employ about 4,000 scientific workers and technicians. At the end of the spectrum, research work of the purest academic type and of the highest quality is carried out; at the other end, the technical development of processes and equipment through the various stages preceding – and up to – large scale manufacture; and the spectrum is continuous. The General Electric Company at Schenectady, NY, Eastman Kodak at Rochester, NY, and many other firms have similar laboratories and facilities.

In Britain research work by industry is not on so magnificent a scale, but a very great effort in fact is made. The research departments of the GEC at Wembley, of BTH at Rugby, of Metropolitan Vickers at Trafford Park, Manchester, of ICI, of Burroughs Welcome, or Brown, Firth and Co, of Lever Bros., of various engine and aircraft firms, and so on, have made essential contributions to British industry, and lately to the British war effort. In addition to these many private enterprises of individual firms, there are the Industrial Research Associations, 24 in number at present, maintained jointly by Industry and the Department of Scientific and Industrial Research.

In India the Metallurgical Laboratory of the Tata Steel Works at Jamshedpur is probably the nearest approach to the American and British model. There are several industrial laboratories on a smaller scale, supported by individual firms, but mostly for purposes really of testing rather than research. There are no cooperative Industrial Research Associations on the British pattern.

India is still on the whole a poor-country; but some of its industries have recently been prospering exceedingly. The way to make prosperity secure is to keep well ahead with scientific research and development. The amount which could possibly be spent on research in India at present is not large, for the number of men capable of doing it effectively in any field is still very limited. Admitting that India as a whole is poor, I feel nevertheless that Indian industry is not yet making nearly the research effort it perfectly well could on its own behalf.

There are things that a Government should do, but there are thing that industry should do for itself; and all experience in America and Britain shows that research, pure as well as applied, by firms taking the longer view, earns a very handsome dividend. Where would Eastman Kodak be now had not its whole policy been based for many years on research? And what might have happened but for research and development applied by Rolls-Royce to aero-engines? It is no good leaving these things to the Government, or to anyone else. Success goes to the industry that takes farsighted initiative itself. Taking the lowest view of the matter, research pays – real research; but Indian industry as a whole has not yet appreciated the degree to which it pays.

14. Technology

There are various good colleges, institutes and departments of engineering and technology in India, but not sufficient of them as yet and none of the same excellence as many In other advanced countries particularly the USA. (One gathers also that in the USSR, now there are enormous numbers of students of technology in large and well-equipped institutions). The subject of technical education in India is dealt with in the Report by the Central Advisory Board of Education (January 1944); my few remarks, therefore, need be devoted only to the higher education which is associated with research or advanced training.

Among scientific and technical people in the United Kingdom the opinion is widely held that Britain has lagged behind in the provision of facilities for higher education and research in technical subjects. The new Education Act will improve the position in respect of technical education at the lower levels; at the higher levels, however, there is no institution as yet in the United Kingdom comparable in magnitude, in the quality of equipment and in excellence of teaching and research work, with the Massachusetts Institute of Technology at Cambridge, Mass., or indeed with several similar institutions in the USA. The view is held by responsible people that two or three such institutes should be set up, or that existing institutions should be expanded for the purpose, at such centres as Glasgow, Manchester, Birmingham and London.

This being the view hold in the United Kingdom, where conditions after all are not so bad, how much more can we recognize the importance of one or two such institutes or colleges of very high standard in India? The future of Indian industrial and agricultural development must depend upon the supply of first-class technical brains, trained in an atmosphere both of original research and of practical experience. This requires not only that there should be facilities for technical training at all important centres in India, but that one or two technical institutes of the highest possible standing should be founded, or developed from existing ones (e.g., at Bangalore, whore the Indian Institute of Science comes most closely of existing institutions to what is wanted). In these, research work of high quality would be done and practical training given, and the ablest students could be brought up in an atmosphere both of research and of

practical realism. The principle is the same as that underlying the proposal of an All India Medical Centre (section 7).

The cost will be considerable, but if Indian Industry and agriculture are to be developed to the highest level by Indians, and if Indians of the required quality are to staff the new National Laboratories to be built under the Board of Scientific and Industrial Research after the war, then Indians must be trained to the highest level themselves. Nationalist fervour cannot replace first-class scientific ability and technical training.

I have bracketed industry and agriculture together in these remarks. The future of agriculture in India depends very largely on mechanization, land utilization and maintenance, fertilizers, irrigation, transport, roads, food-processing and a great variety of other scientific and technical factors. Agriculture is the greatest industry in India, and likely to remain so; the welfare of the vast majority of the people of India depends on it and it is essential to increase its productivity greatly, in order to raise the level of nutrition and to meet the needs of a rapidly increasing population. To bring it into close touch, at a high level of education and research, with science, engineering and technology, would help to ensure that it gains all that is possible from such contacts.

This does not mean of course that agricultural education and research should be limited to such places; it means simply that agriculture requires the resources of science, engineering and technology for its full development and should be regarded as providing one of the most important fields of application of these.

One chief purpose of the proposed new Institutes of Technology[5] would be to provide teachers and research workers of high quality for other places. This function also would be, similar to that of the, proposed All-India Medical Centre (section 7).

15. Meteorological Research

Meteorology is a subject of great importance, both for its scientific interest and for its practical applications. Its connection with the requirements of the Fighting Services, particularly of the Air Force, and its application to civil flying, have ensured that a considerable effort has been devoted to it recently; and indeed, in India, Meteorology appears to me, within the limits of staff, facilities and equipment available, to have been very well done. It has in fact many other applications than those to flying and the defence services, e.g., to radio and, in India particularly, to agriculture and to emergency warning of floods.

In the United Kingdom now arrangements have been made for research to be intensified not only on applied meteorology but on its more fundamental aspects. Flying, and modern physical

[5] Presently, Indian Institutes of Technology of IITs.

methods particularly those of radio und radar, have opened up new possibilities of research in meteorology, for which India should make a particularly fruitful location. Proposals have been made to the Board of Scientific and Industrial Research for the further development of fundamental research in meteorology in India. These proposals have been accepted and it is hoped that a start may be made soon.

The Meteorological Services of India are administered by the Department of Posts and Air, with, of course, strong attachments at present to the Fighting Services. If a Central Organization for Scientific Research (section 19) is set up in India it would be natural to attach *research* in meteorology in some way to this, possibly under a Joint Committee of the Boards for War Research, Scientific and Industrial Research, Agricultural Research, and Surveys and Natural Resources. It would have much more chance of broad development as a scientific subject under a central scientific organization than in a department concerned only with certain practical aspects of it.

16. Scientific Instruments and Equipment

Scientific instruments and apparatus are the basis of all scientific and technical work and of the technical control of many industrial processes. There is very little manufacture of such things in India, at any rate of higher-class products. Instrument manufacture can never in itself, financially speaking, be a large Industry, but it is a key one and urgently requires encouragement. Given training and experience Indian workmen have all the natural aptitudes required for the manufacture of scientific instruments and apparatus. A very high standard should be adopted from the start, for second-rate equipment is a thorough nuisance and every wise head of a laboratory or workshop will rightly prefer to pay more for a better imported article if one is available.

The manufacture also of good surgical instruments and equipment is all urgent necessity; a lead has been given in the Ordnance Laboratories at Cawnpore.

Special consideration might be given by the Board of Scientific and Industrial Research to the encouragement of these trades.

17. The Post-War Disposal of Government Stock

After the war a considerable amount of scientific and medical equipment and machine tools will be available for disposal, much of which would be of the greatest value to scientific, technical and medical laboratories which have been starved of such, things for many years. If all this is sold to big interests for resale, those may indeed make large profits but factories and workmen will be put out of employment and essential trades may be lost. It would be far better if a free distribution could be made to university and other institutions of equipment they require. Their available funds then would not be used up, and since the appetite for scientific and workshop equipment grows by what it feeds on, the essential trades in these things would be tided over a difficult time and maintained in being.

I suggest that the Government of India should set up a committee to consider the disposal, when the time comes, of scientific and technical stores of all kinds. One of the most obvious criticisms of the majority university laboratories in India refers to the poverty of their scientific equipment and the frequent absence of any proper workshop facilities and tools. Considerable help could be given them by free disposal of the stores referral to, at small cost to the Government and without damage to skilled and highly desirable trades.

18. Research for the Fighting Services

The present conditions are entirely abnormal, but it is obvious that the existing research organization of the Defence Services in India was not designed for the contingency of India being the base for major naval, military and air operations. Anything which can be done now to improve the arrangements for research in connection with the Services should be planned, not only for the purposes of the present war but in view of the future necessity, under a new constitution, of an Indian Government taking responsibility for the military, naval and air defences of India, for the design and manufacture of her own war-material and for devising the technical methods of her defence. That should be a major consideration, for without security from aggression self-government sooner or later would prove an illusion. Science has played a very large part in the present war, from fundamental research at the one end to the planning of operations at the other. It will probably play a still greater part in future conflicts possibly in ways at present not commonly realized. The scientific knowledge and experience required for modern war cannot be improvised quickly, nor can it be purchased from others. A proper scientific organization must be built up within the War Department itself.

As regards the needs of the present war, an obvious weakness has been the very imperfect knowledge in India of what is being done, or has been done, in war-research in the United Kingdom, the Dominions and the USA. The situation in this respect has been bettered recently

by a visit to the United Kingdom and the USA by the Scientific Adviser to the Master General of Ordnance, and by several visits of scientific men for special purposes to India. It will be further improved by various scientific missions which the Services are sending to India, and by the visit of Indian scientific men to the United Kingdom this autumn.

There is a corresponding lack of knowledge in the United Kingdom of the scientific resources of India, in men, equipment and facilities, and of the scientific aspects of war requirements for operations for which India is or will be the base.

This mutual lack of Information has been due mainly to the almost complete absence of current personal contact of scientific people in India with their colleagues in the United Kingdom; it has been aggravated by the absence of any sufficient organization in the United Kingdom for keeping India supplied with papers and reports referring to the scientific work which is being done in Britain for war purposes, or of the organizations which have been created for such work. The scientific resources of India in men, laboratories, workshops and equipment are not inconsiderable, but nothing near full use of them for the war effort has been made; as operations of war develop from India there will be increasing need of a proper scientific organization on the spot to deal with new problems as they emerge. To refer them all to the United Kingdom is bound to be inefficient, time-consuming and unsatisfactory; to tackle them in India without proper knowledge of what has been done elsewhere will often mean fruitless work and loss of time and opportunity.

The chief scientific and technical organization in India for the Fighting Services is that of the Master General of Ordnance. It is mainly devoted to Inspection, which has increased greatly owing to the enormous increase of the war-production of India. Under the general cover, however, of Inspection, a certain amount of research is in fact one. Moreover the admirable Ordnance Laboratories at Cawnpore, only opened in 1943, are capable of a good deal of research. Important extra-mural research on war problems is done also in a variety of institutions outside the organizations under the Commander-in-Chief, e.g., in the laboratories of the Director of Scientific and Industrial Research, the Metallurgical Laboratories of the Tata Steel Works at Jamshedpur, the Indian Institute of Science at Bangalore, etc.

There are testing facilities under the Engineer-in-Chief, India, but only for routine matters; there are no facilities at present for engineering research. I was informed that a project is being considered of setting up a Research Unit for work on soil-stabilization, runways, roads, bridges, structures, etc. The work of such a Unit might be of great importance to SEA Command, but it would probably better remain under GHQ, India, and be tied in with the research organization referred to below.

The RAF in India at present is mainly under SEA Command, and it has organized for itself under the Chief Maintenance Officer the special research and development facilities required. It uses also when suitable the facilities available under GHQ, India.

The Royal Navy of the Eastern Fleet until recently had no research organization in India, but I gather that a party has now been sent. Other scientific parties are proceeding shortly to India from the Admiralty for the examination of problems affecting weapons, equipment and personnel. The Royal Indian Navy will no doubt take the opportunity of the presence of these scientific parties from the United Kingdom to set up the nucleus of a scientific organization of its own.

The operational research groups in India are under SEA Command, one for the Army; one for the RAF. The Royal Navy had no operational research party in India at the time I left. It would be wise for GHQ, India, to ensure that the experience of these operational research groups is not lost to the future War Department of India after the war is over.

There is no doubt that the research organization under GHQ, India, needs tightening up, strengthening and coordinating at a higher level. For this purpose last February the late MGO proposed, and I very warmly agreed, that a new post of Scientific Adviser to the C-in-C should be established, with the full authority of the C-in-C to watch over and coordinate all the scientific activities under GHQ, India including 'extra-mural' work of various kinds. For this post a man of the highest qualifications would be needed, with recent knowledge and experience of the scientific and technical work which has been done in the last few years in the United Kingdom and elsewhere. He would require a scientific and technical staff of his own and he would probably wish to bring with him assistants with similar recent experience. He would need the fullest authority to order the necessary equipment and supplies. He would occupy the position of a Joint Secretary in the Defence Department. This proposal was agreed to by the Government of India. Details presumably will be worked after an appointment has been made.

The proposed Scientific Adviser to the C-in-C, India, would be responsible, with the authority of the C-in-C, for watching over and coordinating scientific and technical work now going on under or on behalf of GHQ, India, for initiating and planning new work and any new organizations required for it, and for providing scientific and technical assistance to the Operational Research Organization under South East Asia Command in tackling problems for which that Organization has insufficient technical facilities. As an important item in his permanent set-up should be a Board consisting of scientists and engineers, official and unofficial, in various fields (including biology), together with Service representatives. This Board would meet only at fairly long intervals; its work would be done chiefly by committees (not too large), under the chairmanship of the appropriate members of the Board, and consisting of scientists, engineers and Service representatives. There would probably be a fairly large number of such committees, and their chairmen would be encouraged to take-considerable initiative in enquiring into matters of

importance, in visiting Service and experimental, stations, in making themselves acquainted with Service needs and problems, and in starting research as required. The whole of this organization would be very similar to, though on a smaller scale than, that of the Advisory Council for Scientific Research and Technical Development in the Ministry of Supply in the United Kingdom together with its associated committees; these have done most valuable work in the last four years. It would constitute the War Research Board of the Central Organization referred to below in Section 19.

The Scientific Adviser to the C-in-C would doubtless insist on having proper arrangements made for efficient and quick liaison with all allied research organizations in the United Kingdom and elsewhere.

Such an organization as that sketched above, under a Scientific Adviser to the C-in-C, would be of permanent value to India under the new constitution which will probably come into being in the next few years. Presumably India will then have a War Minister under whom will come the Indian Army, the Royal Indian Navy, and the Indian Air Force, each with its own staff. The War Council would contain the Chiefs of Staffs and officers connected with Training, Supply etc.; the Scientific Adviser to the War Minister would be a member of the War Council, on the same level us the others. His direct access to the War Minister, and his equality with the Service members of the War Council, ought to ensure that India in the future does not make the disastrous mistake of underrating the importance of scientific research and technical development in modern war, as has happened too often elsewhere.

If, as suggested under a Central Organization for Scientific Research (section 19), scientific research for India is to be concentrated under a single Minister, it would probably be wise to transfer the system of Board and committees proposed above to the new organization; the Board would become the War Research Board. Thus the Scientific Adviser to the War Minister would also be Secretary and Executive Officer of the War Research Board and a member of the Scientific Consultative Committee of the Honorable Member for Planning and Development. This would not affect at all the working of the organization under the Scientific Adviser, though he would probably require an Executive Assistant to look after it; but it would ensure that its work was kept in touch with that of the civil Research Boards, and that the help available through them was fully available for defence purposes.

One special aspect of War Research h8.8 been largely neglected until comparatively recently, viz., that connected with the human problems of health, fitness and adaptation in fighting personnel-in relation to the conditions of their service and the equipment they employ. Flying, diving, jungle-warfare, armoured vehicles, tropical conditions, and the skilled and efficient use of modern scientific and technical equipment, on land, in the air, and on and under the sea, all provide special problems affecting the bodily and mental condition of fighting men. During the present war, in the United Kingdom and the USA, considerable attention has been paid to all

those matters and more will be paid in the future; the results, moreover, may often be of considerable value in civil life and industry. It is strongly suggested that a *Services Medical and Personnel Research Committee* should be set up in India. Its ultimate position under the proposed new arrangement might be that of a Joint Committee of the War Research and the Medical Research Boards.

19. A Central Organization for Scientific Research

The *Medical Research Council*[6] (MRC) in the United Kingdom was founded in 1914 and placed under the Lord President of the Council, not under the Ministry of Health. Its executive head is its Secretary who is nominated. by the Council itself; both of those who have held this office, Sir Walter Fletcher, FRS, and now Sir Edward Mellanby, FRS, have been eminent scientific men. Its governing body is its Council which is composed for the main part of distinguished workers in medicine and the allied sciences.

It has free control of funds once allocated to it, and has never in fact been held up, for any important project, by lack of money. To it is attached the Industrial Health Research Board. The National Institute for Medical Research is maintained by the MRC. Most, however, of its activities are carried on throughout the country in existing university, medical and other institutions, by individuals, by special research units, or by grants.

It is in close touch with many Departments of the Government and is available to help and advise any of them.

It is assisted by a large number of special committees, and most of the distinguished workers in medicine and the medical sciences in the United Kingdom are, or have been, to some way associated with its activities.

It has made very great contributions, in its 30 years of existence, to medical progress; and during both the wars has tackled very effectively a number of emergency problems which have turned up.

Its Secretary reports directly to the Lord President of the Council.

The *Department of Scientific and Industrial Research* (DSIR) was founded in 1916. It is similarly placed under the Lord President of the Council; not under the Board of Trade. Its executive head is its Secretary, who ranks with the Chief Permanent Secretaries of the main Departments of the Government. The last three Secretaries have been eminent scientific men, Sir Henry Tizard, FRS, Sir Frank Smith, FRS, and now Sir Edward Appleton, FRS. It has an Advisory Council composed for the most part of distinguished scientists and engineers, with a certain number of

[6] Presently, Indian Council of Medical Research (ICMR)

eminent industrialists with scientific lo interests. The last two chairmen of the Advisory Council have been Lord Rutherford, FRS, the great physicist, and Lord Riverdale (formerly Mr. Arthur Balfour) a great industrialist.

The DSIR has a very large number of activities of which only a few need be referred to, it is responsible for the National Physical Laboratory in which there are divisions of engineering, physics, electricity, aerodynamics, optics, radio, ship design, metallurgy and metrology. It maintains laboratories or establishments for:

Chemical Research;
Fuel Research;
Road Research;
Building Research;
Food Research (including the Low Temperature Station at Cambridge);
Food Pests Research, etc.

It is concerned also with a large number (24) of cooperative Industrial Research Associations which are joint interests of the DSIR, and the various industries; about 40% of the expenditure of these Associations comes from the Government through the DSIR.

It is associated with the activities of many Departmental of the Government, but is outside all of them. This greatly strengthens its positions as a national agency for research. During the present war the greater part of its effort has been turned over to problems connected with the war.

It distributes maintenance grants for 'students in training for research', particularly in such subjects as are related to industry, and it supports research under experienced investigators in any laboratory or institution in the country.

The *Agricultural Research Council*[7] (ARC) was established in 1931. It also is under the Lord President, not under the Ministry of Agriculture and Fisheries. Recently a separate Agricultural Improvement Council was established in that Ministry for applying the results of research directly to the practical problems of agriculture; the Agricultural Research Council and the Agricultural Improvement Council are independent of one another but their work is closely linked by common membership, etc. The four Secretaries hitherto of the ARC have been eminent scientific men, in order, Sir William Dampier, FRS, Sir Edwin Butler, FRS, Professor WWC Topley, FRS, and now Mr JCF Fryer. The Secretary of the ARC reports directly to the Lord President of the Council.

The ARC has a Field Station of its own. It also maintains or assists work going on in universities and research institutions.

[7] Presently, Indian Council of Agricultural Research (ICAR)

It is possible that another *Research Council* may be established, also under the Lord President, to deal with all those branches of research which cannot be classified as Medical, Industrial or Agricultural (for example in ecology, marine and fresh-water fisheries, oceanography, meteorology, cytology and genetics, psychology, general physiology, biophysics). At present many of these are lacking any Government support and they do not make to the private benefactor either the sentimental appeal of medicine or the practical appeal of industry or agriculture. If the fourth Council wore formed the picture of direct Government intervention in science would be complete.

The *War Cabinet Scientific Advisory Committee* will set up in 1940 under the Lord President of the Council. Originally Lord Hankey, FRS, was Chairman and later Mr RA Butler; both were Cabinet Ministers. The arrangement now is that the Lord President of the Council is la President of the Committee, while the Committee of the Royal Society is Chairman in his absence. The membership of the Committee is (i) the three Secretaries of the DSIR, MRC, and ARC respectively, and (ii) the three principal officers of the Royal Society. This ensures a balance of 'official' and 'unofficial' science in the membership.

The chief function of the War Cabinet Scientific Advisory Committee is to discuss the more general questions of scientific policy, or any special and important matters referred to it by the Cabinet. It took an active part, for example, in plans for closer scientific liaison between Britain and the USA; it has advised on a number of special scientific appointments; it took an important part in the discussions which led to the appointment of the three Scientific Advisers to the Minister of Production; it initiated the critical consideration of the Armaments Organization of the Royal Arsenal which finally resulted in important changes in the Armaments Research Department and the Armaments Design Department; it has reported twice on service research organizations, and made proposals for future arrangements; it has produced a Cabinet paper on the use and dedication of patents; it started discussions, which have resulted in a confidential report by a Treasury Committee, on the pay and status of scientific men in the Government service: it has made plans for the preparation of a scientific history of the present war; and it has advised on a number of matters at present confidential. This list of typical examples shows that the War Cabinet Scientific Advisory Committee has found an important part to play in the 'high-level' discussion of scientific policy, etc.

Although named the War Cabinet Scientific Advisory Committee at its foundation in 1940 it seems pretty likely that under another title and perhaps with a different constitution it will continue after the war is over. Its membership, partly official and partly unofficial, has proved satisfactory for its main purpose. Frequently, of course, it invites scientific men from outside, or representatives of the services, to be present for the dissuasion of special subjects, or to give evidence and on several occasions it has had valuable meetings with scientific men and others from the Dominions or the USA.

A member of the Cabinet Secretariat acts as Secretary to the Committee.

This short account describes the Central Organization for Scientific Research in Great Britain. Of course a vast amount of research is done entirely outside the Government system, (i) in universities, medical schools and other privately endowed institutions, and (ii) in industry. Moreover a considerable part of the research done under or for the Government is not centralized under the Lord President; the most notable part of that is for the Defence Services and Home Security, put, in addition, there is research under the Colonial Office in and for the Colonies, research under the Post Office, and the work of the Government Laboratory (chiefly chemistry, in connection with Customs and Excise) not attached to any Department; and there are various odds-and-ends of research (e.g., for fisheries) done under the auspices of a peculiar and anomalous body, the Development Commissioners. These odds-and-ends could be tidied up if a fourth Research Council were formed in the Lord President's organization (see above); the Colonial Office work is well tied-in, by common membership, with that of the three Research Councils and the War Cabinet Scientific Advisory Committee; the work of the Post Office And the Government Laboratory is mainly ad hoc; and the work for the Defence Services obviously needs special treatment, though in peace-time it could with advantage be more closely associated with that of the Central Organization.

In India under the Central Government a variety of separate Departments and other bodies are responsible for research. *Meteorology* (section 15) is under Posts and Air; the *Geological Survey* (section 11) is under the Labour Department; the *Survey of India* is under Education, Health and Lands; so are the *Zoological* and the *Botanical Surveys* (section 11), *Medical Research* (section 8) comes under two authorities:

> (i) The Indian Research Funds Association which is an independent registered body deriving its funds from, but not controlled by, the Department of Education, Health and Lands; it has free use of its funds, and its method of working is father similar to that of the Medical Research Council but on a much smaller scale;
>
> (ii) The Department of Education, Health and Lands which,-with contributions from the Provinces and States, is responsible (in some cases jointly with Provinces and States) for the Research Institutions referred to in section 7 above; there are about 30 officers in the medical research section of the IMS, which is under the Department of Education, Health and Lands.

Agricultural Research (section 10) also comes under two authorities:

> (i) the Imperial Council of Agricultural Research which, like the Indian Research Funds Association, is an independent registered body; it derives its funds from a cess on exported agricultural products and by adjusted contributions from the Central Government, the Provinces and the States;

(ii) the Department of Education, Health and Lands which is responsible, by adjustment with Provinces and States, for It number of Research Institutes, including the Imperial Agricultural Research Institute.

Scientific and Industrial Research (section 12) as it started under the Government of India in 1940 was directly under the Department of Commerce. In 1942 a change in its constitution was brought about and it was placed under a governing body called the Council of Scientific and Industrial Research (CSIR), which is an independent registered body of which the Chairman is the Honourable Member for Industries and Civil Supplies. Recently it was decided to have the Secretary of that Department as Vice-Chairman for two years, in order to relieve the Chairman. It was further recommended that certain powers, particularly in regard to administration and finance, should be handed over to the Director of Scientific and Industrial Research. There is a Scientific Advisory body, the Board of Scientific and Industrial Research, of which also the Honourable Member is Chairman.

Research for the Fighting Services (section 18), so far as it yet exists, is under the organization of GHQ.

In the Provinces and States research is widely dispersed under many separate authorities, sometimes in adjustment and consultation with authorities of the Central Government.

The Universities are maintained by the Provinces and States. There is as yet no central University Grants Committee as there is in the United Kingdom, nor is there any central fund for assisting and promoting research in them.

If scientific research in India is to make a concerted and coordinated contribution, as it ought, to national development in all its phases, it should be brought together under some more systematic plan. There is a special reason for this in India in the fact that so many of the institutions and laboratories at which research is being or might be done, and so many of the agencies by which the results of research are being applied to the practical problems of improving public health, prosperity and welfare, are under the Governments of the Provinces and States. A common policy in research can only be arrived at by understanding and appreciating the needs, the resources, the weaknesses and the susceptibilities of all of them. So long as the research organization of the Central Government remains I dispersed under a number of separate Departments or bodies, most of them having many other serious duties and preoccupations, there cannot be the same hope of arriving at the best common plan. If anything at all should be common to India as a whole, surely scientific research can be among the first to claim that common interest. Can that be fostered, however, by a number of different Departments of the Central Government and other bodies acting independently?

There are six main categories of scientific work affecting the welfare of the country, in addition to the 'pure' or academic research lying at the back of each of them. These relate respectively to:

(1) Medicine and Public Health;
(2) Agriculture and Animal Husbandry;
(3) Industry;
(4) Surveys and Natural Resources;
(5) Engineering (particularly, but not exclusively, civil engineering, dealing with roads, aerodromes, irrigation, bridges, soil stabilization, dams, etc.);
(6) The Defence Services.

Many subjects overlap several of these main categories. Nutrition for example lies in the fields of (1), (2), (3) and (4); meteorology of (2), (3), (4) and (6); metallurgy of (3), (4), (5) and (6); fisheries of (2) and (4);: electrification, and geology and geophysics, of (2), (3), (4) and (5). Such overlap must be accepted as inevitable, indeed desirable; but its inevitability further strengthens the case for bringing all six categories of research under a single central organization.

In the United Kingdom the Lord President of the Council is a Minister of a very special kind. He has no ordinary department. From 1940 to 1943 Sir John Anderson, who held the post, took over for the Prime Minister a number of duties to which the latter's preoccupation with the war did not allow him .time to attend. Lord Woolton now as Minister of Reconstruction is presumably in a somewhat similar position in relation to future planning. Recently in India an analogous appointment has been made, to the Governor General's Executive Council, of a Member for Planning and Development. This presents the possibility of placing under a single Minister without ordinary departmental duties, on the analogy of the Lord President in the United Kingdom, a *Central Organization for Scientific Research*. The actual practical steps of Development would still need to be taken by Departments of the Central Government, or of the Provinces and States; but the research would be brought together.

The *Central Organization for Scientific Research* working under the Honourable Member for Planning and Development would have the following constitution.

A. *Six Research Boards* would be set up, the Medical Research Board, the Agricultural Research Board, the Industrial Research Board[8], the Board of Surveys and Natural Resources, the Engineering Research Board, the War Research Board.

B. Each Board would have as Chairman an eminent person, either a scientist or a professional man in the field concerned - man of the type of Lord Rutherford, Lord Riverdale or Lord Hankey. The Chairmen would not be concerned with the detailed administration of the work

[8] The words 'scientific and' should be omitted; the other Boards would be equally ‘scientific’.

of their Boards. The Member for Planning and Development would not be chairman of any of the Boards; the chairmen would report to him.

C. The *Members of the Boards* would be eminent and experienced scientific men, together with a certain number of professional men in the respective fields; the Boards should be primarily Scientific and the professional men should not outnumber the scientists, the purpose being research. In the appointment by the Lord President of members of the three Research Councils in the United Kingdom the concurrence of the President of the Royal Society has to be obtained in each case. Some safeguard of this kind would give confidence to Indian scientific men. Perhaps the National Institute of Sciences of India might be allowed to nominate some of the members of the Boards. There would be a certain number of ex-officio members representing Development interests (see below).

D. The work of the several Boards should be coordinated by providing for a sufficient degree of *common membership*.

E. In each subject there should be a *Director of Research*. He should be a scientific man of high standing. He would be Secretary and principal administrative officer of his own Board and a member ex-officio of each of the other Boards. He would be given adequate scientific and administrative assistance. He would be answerable to the Member for Planning and Development, and would have the status of a Joint or Additional Secretary of an ordinary Department.

F. The Director of Medical Research,
The Director of Agricultural Research,
The Director of Industrial Research,
The Director of Surveys and Natural Research,
The Director of Engineering Research, and
The Director of Scientific Research in the War Department would be responsible, with the advice of their Boards and under the Member for Planning and Development, for directing, organizing, initialing and coordinating research, on a nation-wide scale so far as constitutional considerations allowed, in their respective fields.

G. Each Board would appoint *Committees* dealing with the various aspects of its work; the chairmen of these Committees would be selected from among members of the Board and would be encouraged to take considerable initiative.

H. *Joint Committees* would be set up between two or more Boards for dealing with special subjects.

I. Each Board would have the power to allocate *grants* for specific researches in its own field, to be carried out by agreement in any institutions in India.

J. A *Research Grants Committee* would be set up jointly between the different Boards, to award grants to university and other laboratories throughout India, for the encouragement of

fundamental scientific research in general. If a *University Grants Committee* were set up, these general research grants would be given in consultation with it. (See also section 23).

K. A *Research Studentships Committee* would be set up jointly between the different Boards, to consider applications for *Research Studentships* by young workers of proved ability desiring to gain further research experience, particularly in good laboratories abroad (see section 3).

L. All chairmen and members of Boards and Committees, apart to from, official and *ex-officio* members, would retire after a period of service to be determined. After a suitable interval they would be eligible for reappointment on similar terms.

M. Each Director of Research would prepare *estimates* for the work of his Board, which after dissuasion and approval by the Board would be submitted to the Member for Planning and Development. A *Joint Estimates Committee* under the chairmanship of the Member or his Secretary would compare and coordinate the different estimates before submission to the Finance Department.

N. After the estimates had been approved, each Board would be able freely to spend the funds at its disposal without further application or argument.

A *Scientific Consultative Committee* would be appointed to advise the member for Planning and Development on general policy in relation to research, and on any special matters submitted to it. It would consist of the six Directors of Research together with six other distinguished scientists, one in each field; the latter should not be officials of the Central Scientific Organization, though they could be members of any of its Boards, or research workers in its institutions. The six unofficial members would retire after u. Period of service to be determined, but would be eligible for reappointment after a suitable interval. One of the six unofficial members would be elected as Chairman of the Committee. The Chairman would report the findings of the Committee to the Honourable Member.

The establishment of a National Research Council has been much discussed and strongly advocated recently by Indian scientific men, and the National Institute of Sciences of India passed, formal resolutions on the subject at the beginning of this year. The opinions have been justly held: (i) that Indian science has not yet been given the opportunity of making the contribution it could make, both to the war effort and to public welfare; (ii) that the unofficial scientists of India have had little influence or means of making their views known; (iii) that scientific research under the Government of India is dispersed between different Departments and bodies and uncoordinated at the top; and (iv) that much more effort should be devoted to and money spent on research. The resolutions of the National Institute of Sciences were designed to overcome these difficulties, and to give Indian science and Indian scientific men a greater and more appropriate part in national affairs.

The present proposals are designed to meet the same needs and difficulties as the proposals of the National Institute of Sciences; they are somewhat different in form, being based on

considerable experience in the United Kingdom. I believe they would be acceptable to the National Institute of Sciences.

In India unfortunately there is commonly assumed to be a fundamental antagonism between the official and the unofficial, between the individual and the Government. This idea, not unnaturally, tends to colour the views of the scientific community, and independent scientific opinion in India would probably prefer to introduce stronger safeguards than I have suggested for the claims and influence of unofficial science. It is quite true that the unofficial science of country is the backbone of all its scientific work. Having played on both sides, however, in this game I do not believe in safeguards which are a permanent sign that one side is nervous that the other side will not play fair. If a proper organization is created, the good sense of both sides will prevail and official and unofficial will cooperate in fulfilling it properly.

It is realized that the setting up of the Central Organization for Scientific Research proposed above would moon considerable changes in the attachments of various existing scientific organizations and establishments to Departments of the Government; but it would not imply any substantial alterations to those organizations and establishments themselves, except in so far all such alterations were decided on later for the expansion of their work or for the more efficient conduct and coordination of their activities. In the main, existing organizations and establishments for research could be transferred as they are to the new set-up, though in existing circumstances the transfer might very well have to be carried out gradually.

If may be objected that the effect of removing Research from the direct control of the various Departments under which it now is would be damaging to the other work of those Departments. That might seem indeed to be the immediate effect, and obviously a temporary disturbance would be caused. The final result, however, would be that more and better research would be done, that the various branches of research would be brought into better coordination with One another, that gaps and weaknesses now apparent would be made good, and that a more uniform and consistent effort would be devoted to the whole business.

It is a mistake in general to tie up research too directly to the solution of immediate practical problems; and those who were responsible in the Departments for tackling the practical problems would be able, by ex-officio membership of the various Boards and Committees, or by contact with the various Directors of Research, to obtain all the scientific information they required and to give sufficient bias to the directions in which research was undertaken.

Nobody in the United Kingdom would now suggest putting the National Institute for Medical Research under the Ministry of Health; the National Physical Laboratory or the Industrial Research Associations under the Board of Trade; the Industrial Health Research Board under the Ministry of Labour; the Geological Survey under the Ministry of Labour or the Ministry of Fuel and Power; the Food Investigation Board and its laboratories under the Ministry of Food;

the Radio Research Board and its establishments under the Post Office; the Building Research station under the Ministry of Work; while any suggestion of putting the Agricultural Research Council and its Field Station under the Ministry of Agriculture and Fisheries was obviated, and a much better solution arrived at, by setting up an Agricultural Improvement Council in that Ministry. It is difficult to see why the same general principle of bringing Research into a single organization, and of leaving the Departments to make their own arrangements for applying the results of research to the practical problems they have to face, should not apply to India also.

One great objection to the organization of research under a number of separate authorities, quite apart from the lack of coordination and a common plan resulting from it, is that financial and other absorb for research is often patchy and inadequate. The present sorry position of the Zoological and the Botanical Surveys of India, and of Fishery Research, is a good example of how important scientific activities can be starved under a Department in which, at some moment, there was a failure of interest in them. The decision not to complete the 1941 Census of India could never have been taken if its consequences had been properly thought out. Even from a Department in which there is plenty of interest, financial support may be quite inadequate; the Indian Research Funds Association, for example, does excellent work on the same lines as the Medical Research Council in the United Kingdom, but it could spend with advantage many times the present amount, e.g., in establishing Clinical Research Units in medical colleges. Under a central organization for research the different subjects could hope to be treated with some degree of uniform encouragement, according to their needs. There is possible danger, for example, in India of Industrial Research, under capitalist pressure, being regarded as the main or only interest, to the partial exclusion of others. Such a possibility could be obviated by bringing nil forms of research into a single system, in which all interests would be considered together and a uniform healthy development planned.

If these proposals for a central scientific organization were adopted it would be well to set up, in the 'user' Departments, *Development or Improvement Councils* (similar to the Agricultural Improvement Council in the Ministry of Agriculture) to apply the results of research directly to the various practical problems affected by it. Joint ex-officio membership either way of an Improvement Council and its corresponding Research Board (or Boards) would ensure on the one hand that the results of research were fully known to those who had to apply it, and on the other that those who had to do the research were kept aware of the practical needs.

It may seem to some that the distinction between Research on the one side and Development (or Improvement) on the other is arbitrary and unnecessary; but in fact it is better to be quite clear about the sequence of processes by which pure research at the one end is translated into large scale production or application at the other. In engineering we hear about research, technical development and large scale industrial production. It is true that the exact boundary between these is sometimes blurred, but so is that between many processes which in principle

are distinct; to suppose that they are all fundamentally the same, that they can best be carried out by the same people in the same laboratories, workshops or factories, may very well result in difficulties being glossed over or essential stages omitted. The same fundamental distinctions exist in other activities than engineering, e.g., in medicine and public health, or in agriculture. First, there is the original scientific inquiry; followed by early laboratory attempts to if the outcome of the inquiry is likely to yield practical results of importance. Second, there is the development process, the pilot plant stage, by which the practical results are produced or tested experimentally on a small scale, in the workshop or the field. Third, there is the final stage, carried out on the large scale required for industrial production or national application.

If then a Central Organization for Scientific Research of the kind here proposed were set up, the various Departments of the Government would still be left to deal with the second and third stages, corresponding respectively to Development and Production. I do not believe that in the long run any damage would be done, but rather, the reverse, to the work of Departments by embodying in the organization a fundamental distinction which does in fact exist, even though it may be obscured in the by-no-means perfect system at present existing.

In order to ensure that Development as well as Research is well looked after and coordinated at a high level it would probably be wise to set up under the Member for National Planning and Development, as an opposite number to the Scientific Consultative Committee, a *Development Consultative Counci*l. This also would have a few appointed independent members from industry or the professions concerned; other members ex officio would be the Secretaries of the interested Departments, together with the executive and technical officers responsible for the relevant Development Sections or Improvement Councils. This would imply no interference with the executive responsibility of Departments to deal with their separate projects of Development; it would only ensure that attention was kept focused on those various projects, that the Member for Planning and Development was kept properly informed of them, and that they were welded together into a consistent and well balanced national plan.

20. A Central Register of Scientific and Technical Personnel

At the end of 1938 in the United Kingdom the Central Register of the Ministry of Labour was established. Its purpose was, in case of war, to provide a national register of all people with higher scientific, technical or professional qualifications who would be available for posts in government work or in essential industrial or other service.

The Scientific Section of the Central Register was constructed by the Royal Society in collaboration with various national scientific societies or institutes. The Technical Sections were compiled by the Engineering and other Institutions. A Medical Register was constructed separately by the British Medical Association. The Central Register has been worked by the

Ministry of Labour and National Service, under an experienced Director and expert scientific assistants, with the advice; when required, of expert panels in the various subjects. It is as nearly complete as any such register can be. For some years it has been the main channel by which scientific and technical personnel have been selected and made available for work connected with the national war effort.

In certain categories, e.g., of physicists and engineers, a shortage began to appear quite early in the war. Under the direction of Lord Hankey the Central Register undertook the selection and training of suitable young people. Very large numbers have been made available in this way.

In the United States in 1940 a similar, National Roster was set up. It has functioned in much the same way as the Central Register.

The Central Register has been an essential part of the scientific and technical effort made in the United Kingdom. It is regarded now as an institution of permanent value to the country, to be kept in being and up-to-date after the war. Exactly how it will be organized in peace-time has not been decided.

In India partial registers have been constructed for special purposes, but none which is general and authoritative, or dealing with people in all subjects of science and technology. It is not a simple matter to construct or use a really effective register; it cannot be left to clerks, but requires expert and critical handling. The value to India of a Central Register of Scientific and Technical Personnel, critically constructed and handled by experts, would probably be great, not only in meeting the scientific and technical needs of the war as these continue to emerge, but also in the great process, or, National Development, involving science and technology in almost all branches, to be foreseen after the war. In a survey of national resources, a critical assessment of the scientific knowledge, skill and experience available must be reckoned one of the more important items.

The construction of an Indian Central Register for Scientific and Technical Personnel would not be expensive, but it would require a good deal of expert guidance and help. I did in fact suggest to the Officers of the National Institute of Sciences of India that the National Institute itself should undertake its construction, and I understand that a beginning has been made. Its administration and use would have to be taken over finally by some central scientific agency of the Government of India, e.g., by the Central Organization for Scientific Research referred to in section 19. The experience of the Central Register in the United Kingdom would be made available to India.

21. The Pay and Status of Scientific Workers in the Government Service

Some concern has been expressed in the United Kingdom in recent years about the position of scientific men in the Government service. As regards pay, the administrator has, been paid 50% more than the scientific or technical man of the same standing, experience, training and ability; and the scientist, however able and productive, has been unable to attain more than a very limited position and salary without, taking on administrative work, often to the exclusion of most else.

Moreover, in many scientific jobs under the Government the conditions and amenities of working, facilities for publication and discussion, possibilities of attendance at scientific meetings and conferences and recognition by colleagues of one's scientific work, are all less attractive than they need be. The consequence has been that teachers have tended to deflect their ablest pupils from scientific service under the Government.

Substantial improvements are likely to result from recent discussions in the Treasury, and from a realization that it is false economy not to offer at least as attractive conditions in the Government scientific service as exist outside it. I realize that the position is not the same in India as in the United Kingdom, and other factors are involved; for example, conditions of service in the universities and in industry are not nearly so attractive in India as in Britain. Undoubtedly, however, scientific service under the Government is not in general comparable in pay and status with the civil service or such as to secure the appointment of the ablest men, or to give them the best opportunities for developing and utilizing their talents. In the next few years there will need to be a great increase in the number of a scientific men employed in the service of the Government of India; it will be very desirable to make the conditions of their employment such as to attract and hold a substantial number of the best men, and to give all of them as good opportunities as possible for their work and its recognition by their colleagues outside.

In view of this it might be wise to set up in India soon a small Committee to consider the whole subject. The Indian scientific men who are coming to London in October could ascertain what improvements are likely to be effected here; this knowledge might be of value to them as a general guide in the discussions which would take place later in India.

22. Scientific Societies in India

The development of science in every country depends very much on the familiar association of scientific men in the activities of scientific societies. These are the common meeting grounds at which ideas are ventilated and criticized, new facts discussed, common policy decided and people get to know each other. The progress of science in the United Kingdom has been

intimately bound up with the development of its many learned societies, starting with the Royal Society in 1662.

We are fortunate in Great Britain in having in the colleges of the older universities, in some of the senior common rooms of the newer ones, in various clubs and in many other such associations, a means of bringing scientific men and scholars into close and familiar contact with one another. There are fewer opportunities for such contacts in India. It is all the more important, therefore, that scientific societies should be fostered and encouraged.

Scientific societies are of two kinds, general and special, with memberships drawn respectively from the whole of science or from a single branch of it. Both kinds have an important part to play in the publication of scientific papers and results, and – through their libraries and collections – in providing repositories of scientific information. Scarcely less important is their influence in making living communities out of a number of people always critical and often highly individualistic. In India where so many causes tend at present to separate individuals, groups and communities from one another, a strong common interest in science as a whole, or in some branch of it, could have as a by-product an important influence in keeping people working sensibly together.

The oldest learned society in India is the Royal Asiatic Society of Bengal, originally, the Asiatick Society, which was founded by Sir William Jones in Calcutta in 1784. From its activities has sprung by far the larger part of subsequent scientific activity in India, not to mention all its own work for literature, history, archaeology and philology. It may be regarded as the mother, of the Indian Science Congress Association which held its first meeting in 1914, and the grandmother of the National Institute of Sciences of India established in 1935. The Indian Science Congress Association has taken already a great place in Indian scientific activity; it is the opposite number of the British Association for the Advancement of Science. Besides the National Institute of Sciences, which is the nearest equivalent in India of the Royal Society, there are two other general scientific Academies claiming national scope:

(a) the United Provinces Academy of Sciences founded in 1930 at Allahabad, which was intended primarily to cater for all branches of science in Northern India; it was renamed the National Academy of Science, India, in 1936; and

(b) the Indian Academy of Science founded at Bangalore in 1934.

Of these three, the body best suited by constitution and membership to assume the role of a national academy of science, such as,

The Royal Society (London);
The National Academy of Sciences (Washington);
The Royal Swedish Academy of Science (Stockholm);
The Royal Danish Academy of Science (Copenhagen);

The Academy of Sciences of the USSR (Moscow), etc.

is the National Institute of Sciences of India. It is oddly named for such a body, but that was due to a compromise which was necessary at the time it was founded. Its present headquarters are in the rooms of the Royal Asiatic Society of Bengal in Calcutta, but it has decided, when possible, to transfer its headquarters to Delhi. It hopes, as time goes on, to take over in India more and more of the functions which are discharged by national academies of science in other countries.

The National Institute of Sciences was invited last winter by the Royal Society to send representatives to London for the discussion or such matters and to concert joint plans for the cooperation of the scientific societies of India and of the United Kingdom. Among plans to be discussed will be those for the Imperial Scientific Conference to be held soon after the war is over, possibly in the summer of 1945. The time is coming when India will be an independent unit of the British Commonwealth with science as important as it will be in the world of tomorrow; it will be essential for Indian science as a whole to have some strong independent national scientific body to represent it both to the Government of India and in relation to the science of the rest of the world. It is hoped, therefore, by the National Institute of Sciences that some formal recognition may be given to its position by the Government for example by a Royal Charter such as the Royal Society and the British Academy have. Few things could do more to stabilise the position of science in India, or its relations with science in the rest of the Commonwealth, than to have a strong and effective national academy of science, independent of the Government but recognised by the Government.

There are now specialist national societies in India in most scientific subjects, e.g., in Geology (1906), Mathematics (1907), Botany (1921), Chemistry (1924), Physics (1934), Soil Science (1934) and Physiology (1934). Some of these are of nation-wide membership and scope, others have as yet only a small membership and influence. Most of them were started by the initiative of scientists in Calcutta, and some have not yet been properly supported in other parts of India. It is not yet sufficiently appreciated that the status of a scientific subject depends to a considerable degree on the strength of its corresponding society; if, for example, physiologists throughout India complain of the little regard paid to their subject, they should join and support, and take joint action through, the Indian Physiological Society.

All these scientific societies are a product of the independent activities and keenness of scientists themselves. They cannot be a direct concern of the Government. The Government, however, could assist, and encourage them in various ways which would not diminish their independence. For example:

(a) they could be invited to appoint representatives on government advisory committees or boards;

(b) they could be invited to institute special inquiries, to collect information, or to advise, on matters of national importance;

(c) grants could be made to assist their scientific publications; these could be allotted by the National Institute of Sciences as corresponding grants in the United Kingdom are by the Royal Society;

(d) a Government Grant-in-aid for Scientific Investigation, and another for International Scientific Conferences, could be put at the disposal of the National Institute of Sciences for distribution, as is done by H.M. Government in the United Kingdom to the Royal Society;

(e) universities and other employers could be advised that attendance within reasonable limits, at meetings of scientific societies may be regarded as among the normal duties of scientific men:

(f) financial assistance could be given to their libraries and museums, and towards the expenses of delegates to meetings in India or abroad. In this connection, a proposal has been made by Sir Henry Tizard that, in lieu of government subsidies to airlines, the Government might purchase a certain mileage of air travel and allot it for distribution to such bodies as scientific societies. This would certainly help to 'mix scientists up'.

The expenditure involved in such grants or assistance would be small, but would produce an effect altogether out of proportion, to its extent. It would be natural for the National Institute of Sciences to take up such matters with the Government, on behalf of its sister societies.

23. Scientific Research in Indian Universities

This subject would require long and careful study and much fuller consideration than I have had time to give it. It might be wise at a later stage to appoint a small Commission, under an able and experienced scientific man as Chairman, to go into the whole subject. All I can do now is to make a few general comments.

A. Scientific research in the universities, both for its own sake and as background for scientific education, is the *fundamental basis* of all scientific progress.

B. Research in the *pre-clinical sciences* and in *clinical medicine* has been referred to in sections 6, 7 and 8. So far as it exists, it is mainly conducted in medical colleges which, although formally attached to universities, are largely independent of them. In the United Kingdom the tendency now is to bring medical education and research more and more under the influence of the universities (see the Goodenough Committees report); of the wisdom of this in Great Britain I have no doubt whatever. It may be that in India there are special difficulties which make this undesirable; if so, that is a very unfavourable comment on the universities

themselves and points to conditions which ought to be put right. It could equally well be argued that the present unsatisfactory state of research in the medical colleges is due to the absence of academic influence or a university atmosphere. The subject deserves full and careful consideration. The present state of affairs ought not to be allowed to continue without full examination.

C. The most notable contributions of Indian scientists have been in *physics, mathematics and chemistry*. It cannot be expected that strong departments in all scientific subjects should exist at all centres, but there are in fact a good many strong departments in physics and chemistry in Indian universities. No doubt the situation in these subjects could be greatly improved still, but the tendency to do so already exists and must be encouraged.

D. In the *biological sciences*, the university departments are nearly always small, ill-equipped and under-staffed. The modern physiological or functional approach to zoology, which has been the chief feature of the subject in the United Kingdom and the United States for a good many years now, is almost completely absent. There is very little original work of any kind going on in cytology or genetics, in spite of the great practical interest of the latter in an agricultural country. Biophysics is almost completely absent, except at the Bose Institute in Calcutta, which is not a department of the University. Biochemistry is quite strong in some centres, but tends to be associated with chemistry rather than physiology, zoology or botany. Except in one or two centres physiology has no place outside the Medical Colleges, in spite of its importance for general education.

There is a growing conviction in Great Britain, the United States and (I believe) the USSR that many of the future great applications of science will be in the biological field; or perhaps rather in the field intermediate between the biological sciences on the one side and physical (including chemical) sciences on the other. For these applications, which are already becoming apparent in various directions, India will be ill prepared unless the biological departments in the universities are greatly strengthened.

E. In *geology*, so far as I have been able to gather, the universities are weak. If geological work is to be pushed on in India, as national development demands, a certain number of good university departments of geology will be required.

F. I have seen too few *engineering colleges* to be able to make any very useful comments. The Engineering College at Madras (founded in 1784) seemed to me an excellent institution, well supported by the Madras Government; its Principal had no complaint except of the urgent need, as he felt it to send the younger members of his staff for further technical experience and training in research to the United Kingdom (see section 3). There are some good engineering laboratories at the Bangalore Institute.

In section 14 above I have suggested that there ought to be founded in India a few Colleges of Technology on a really great scale, like the MIT at Cambridge, Mass. That, however, would not obviate the need for the various universities to maintain departments in engineering and technology of a sufficient standard to meet the ordinary needs of industry and public works for men well trained and accustomed to the idea of research. I have no evidence as to whether the majority of the existing engineering colleges and departments are of that standard; but knowing the very high requirements of modern engineering laboratories, and the heavy cost of their equipment, I should doubt it.

G. It is at suggested above, section 19, I, J and K, that grants for special researches, for research work in general and for research studentships, should be distributed on a national scale by the proposed Research Boards and Joint Committees of them. If the funds put at the disposal of the Board for the purpose were large enough this would have a most beneficial effect on research in the universities. If a University Grants Committee were established the Joint Research Grants Committee should work in close consultation with it.

In allocating, general research grants from central funds to a university, or university department, it might usually be made a condition that some proportionate grant should be made by the local authority concerned. This is a common practice with the Rockefeller Foundation and other benefactors, and it has a good effect in exciting a local interest and pride in the object of the benefaction. If an interest in scientific research is to be raised and maintained in India as a whole, the establishment of a central grant-giving body with Substantial funds and a carefully thought out national policy would probably be best way to set about It.

The Royal Society last winter set up a number of special committees to investigate the post-war needs of fundamental research in the United Kingdom in various fields. These committees have now reported and representations will be made by the Society to the appropriate authorities. Nearly all the recommendations affect the conditions of research in the universities. Other reports affecting scientific research in the universities have been published in the United Kingdom during the last year, e.g., by the Association of Scientific Workers, the Association of University Teachers, Nuffield College, the Parliamentary and Scientific Committee, etc. Similar investigations under independent auspices, conducted for example by the National Institute of Sciences, or the Indian Science Congress Association, would be valuable in India.

24. Private Benefactions to Science

Substantial benefactions have been made to science, medicine and technology in India from private sources, particularly by the Tatas. Most, however, of the scientific work done in India derives its financial support from the Government. Government support usually means more or less of Government control, and although that need not be the bogey it is often represented to be, there is no doubt that a reasonable measure of independence is desirable in any organization for research; indeed of fundamental scientific work done in the past in other countries the vast majority has been carried out in independent institutions. Scientific research in Government establishments may be very good indeed, but It can rapidly become dull or sterile, particularly in normal times, unless it 'is continuously fertilised by contact with imaginative thought from outside, or prodded by independent criticism. Until human nature changes it will continue to be a great safeguard that scientific research should not be solely dependent on Government support, but should have independent resources and an independent existence.

Although India on the average is a poor country there are rich men in it who, if they were so minded, could without feeling any significant difference themselves, contribute enough to the promotion of scientific research in India to produce a very substantial improvement. One of the greatest needs in India is of scholarships, studentships and fellowships for research. Nearly every outstanding British scientist has at some time or other benefited from these; their number is great. Indian scientists could benefit at least as much were they available in India. That is an obvious direction in which private benefactions could be applied without any danger – which does in fact exist - that a private gift may merely cause a reduction in a Government grant. In Great Britain we have Beit Fellowships, Leverhulme Studentships together with the scholarships, studentships, fellowships, etc., of the universities, the Royal Society, the 1851 Exhibition, and many others of the same kind for scientific or medical research. As a recent industrial example, Imperial Chemical Industries announced this summer their intention to provide 80 senior fellowships in certain British universities, averaging £600 a year in value, for research in physics, chemistry, biochemistry and some allied fields. In America, there are similar benefactions associated with such names as Rockefeller, Guggenheim, Harkness, Carnegie, GF Baker, and very many more. What a notable contribution might be made to Indian Science if wealthy Indians could be induced to perpetuate their names by the foundation of scholarships, studentships, fellowships and research professorships for the improvement of scientific and medical knowledge.

There are very few completely non-official scientific institutions in India. The existence of independent endowed research institutions of sufficient status can provide a very valuable stimulus and addition to science, as is shown by the contributions of the Rockefeller Institute in

New York, the Royal Institution and the Lister Institute in London, and many other similar foundations throughout the British Commonwealth and the USA. In India there are a few such institutions, e.g., the Indian Association for the Cultivation of Science, and the Bose Institute in Calcutta, and the Tata Memorial (Cancer) Hospital in Bombay. Hero again is a great opportunity for Indian benefactors.

A.V. Hill, MP, ScD, FRS

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By

Anasua Mukherjee Das

Anup Kumar Das

[with a *Bibliography of Publications Citing the Hill's Report*]

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A.V. HILL's Report and Shaping of Modern Science in India

Anasua Mukherjee Das[1]

Anup Kumar Das[2]

Nobel laureate Professor Archibald Vivian Hill (b. 26 September 1886, d. 3 June 1977), also known as A. V. Hill, was a British physiologist and biophysicist. He was one of the founders of the diverse disciplines of biophysics and operations research. He was the recipient of the 1922 Nobel Prize in Physiology or Medicine (jointly with Otto Fritz Meyerhof) for his elucidation of the production of heat and mechanical work in muscles. He was elected as a Fellow of the Royal Society, the United Kingdom, in 1918. He later served the Royal Society in different capacities. As an active member of the Royal Society and then the Biological Secretary, Hill was invited by the Government of India (GoI) in 1943 to visit the country and to advice on the organization of scientific and industrial research as a part of India's post-war reconstruction plan. After visiting the lengths and breadths of the country for more than three months beginning on 16th November 1943 till 5th April 1944, Hill submitted a detailed report titled "A Report to the Government of India on Scientific Research in India." This report later became a valuable sourcebook for the history of science and technology in modern India. UNESCO in its 1972 document "National Science Policy and Organization of Scientific Research in India" recognized contributions of the Hill Report in shaping S&T roadmap, infrastructure and institutional frameworks in India as well as in South Asia.

> ***The Hill Report:*** *Professor A.V. Hill, then Secretary of the Royal Society of London, was invited by the Government of India to visit the country, in 1943, and discuss the organization of scientific and industrial research as a part of India's post-war reconstruction plan. After a careful study, he submitted a valuable report embodying a forceful plea for the expansion and better co-ordination of research in India backed by liberal financial support from the Government. Two of the most important recommendations called for the establishment of liaison between India and other countries, and the creation of a central organization for scientific research. It was noted that so long as research organizations of the Central Government remained dispersed*

[1] Independent researcher based in New Delhi, India.
[2] Centre for Studies in Science Policy, School of Social Sciences, Jawaharlal Nehru University, New Delhi – 110067, India Email: anup_csp[at]mail.jnu.ac.in

under a number of separate departments or bodies, most of them having many other duties and preoccupations, it was not possible to evolve a common plan to guide them all in the best interest of the country. It was therefore, proposed that all the scientific work affecting the welfare of the country, namely, in medicine and public health, agriculture and animal husbandry, industry, surveys and industrial resources, engineering and various services, should be brought under a single central organization, which would function under the Member (Minister) for Planning and Development. The Report also proposed the appointment of a Consultative Committee to advise the Member for Planning and Development on general policy in relation to research and on any special matters submitted to it. On the basis of these recommendations, the Government of India set up a Scientific Consultative Committee for Planning and Coordination of Research administered by the various departments. [National Science Policy and Organization of Scientific Research in India, UNESCO, 1972, p. 12-13].

Hill's Report was discussed or analyzed in details by many historians of Indian science and technology in the past four decades since the publication of UNESCO (1972) document. Eminent S&T historians in India, such as Deepak Kumar and Pratik Chakraborty, have discussed journeys towards producing the Hill Report that started commissioning of the one man committee by GoI, gathering of information by visiting existing S&T institutions, reporting on S&T infrastructure available, and finally suggesting appropriate measures to be taken by the new government during the post-War reconstruction period. Some of the important texts, written by S&T historians discussing the Hill Report, are produced below:

[Kumar, 2001, p. 388, 389]: *In 1942 a Council of Scientific and Industrial Research was established under S.S. Bhatnagar (1894-1955). Two years later A.V. Hill (then Biological Secretary, Royal Society) was invited to report on the state of scientific research in India. He talked of a quadrilateral dilemma, that is, population, health, food and natural resources. To him the fundamental problems of India were 'not really physical, chemical or technological, but a complex of biological one referring to population, health, nutrition and agriculture all acting and reacting with another'…. Hill himself argued for centralisation (which he would not prescribe for Britain). Centralisation and concentration of power were to become hallmarks of the scientific establishment in post-independent India.*

[Chakrabarti, 2004, p. 290]: *When the War came to an end, the question that bothered Indian scientists and policymakers were those of organizing and financing post-independence Indian industrial research. The tilt towards the British model became further prominent when A.V. Hill of the Royal Society was approached to advice on the organization of scientific and industrial research as a part of post-war reconstruction plan. Hill's visit resulted in the famous A.V. Hill's Report in 1944. Hill's plan was generally in favour of a centralized research*

organization. Research agencies and national laboratories were to be constructed within the overall control of the government machinery, namely under the Member, Planning and Development. The Hill Report suggested creation of six Research Boards…

[Kumar, 2008, p. 225]: *In 1942, Council of Scientific and Industrial Research was established. The end of colonial era was pretty near. With the A.V. Hill's Report in 1944 on Scientific Research in India, the curtain dropped.*

In the CABI online database of scientific literature, maintained by the Centre for Agriculture and Bioscience International (CABI), the Hill Report has a special mention. CABI states: *This valuable report on the organization and application of scientific research in India includes references to biology and agriculture, and will be of considerable interest to all those interested in the progress of plant breeding in India.*

This Hill Report is a highly cited document as reflected in the Google Scholar database. No doubt, the Hill Report will be steadily getting new citations in the near future, as it captured the essence of S&T progress in India during the much happening time for Indian and the world history. An indicative bibliography of citing literature is given at the next section for facilitating the future researchers in identifying the works of literature that cited Hall's this particular piece of work.

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