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THE HUMAN FACTOR IN SCIENTIFIC RESEARCH

NO one could claim that the Conference on Scientific Research and Industrial Planning held by the Division for the Social and International Relations of Science of the British Association (see p. 8) in London on December 7 and 8 broke fresh ground or threw up any new ideas. One of its most interesting features was rather the evidence it afforded of the way in which ideas once regarded as impractical or revolutionary are permeating the whole field of science and industry, and indeed of Government itself. Already it is clear that principles advocated in the Barlow Report on scientific staff, in the Nuffield College Statement on Problems of Scientific and Industrial Research and in reports from the Parliamentary and Scientific Committee, the Association of Scientific Workers and the Federation of British Industries, to mention only a few, have found widespread acceptance. Speaker after speaker, whether from the industrial, the academic or the Government side, referred to the importance of such factors as the interchange and mobility of staff, freedom in the publication of results, the importance of status and the like in attracting the right type of mind and in encouraging creative and original thinking. The lessons of team-work demonstrated so convincingly during the War are being taken to heart, and it is realized that such co-operation and team-work must above all be based on conditions of employment which both attract the right type of man in sufficient numbers and stimulate him to give of his best.

It might well be argued that the title of the Conference was something of a misnomer, and should have been "The Human Factor in Scientific Research"; for the human factor, not the subject of research, except in so far as that itself embraced the human factor, was the main theme of the Conference. One session was indeed devoted essentially to the human factor as a field of research; but although two of the papers at the opening session were concerned with research on specific technical subjects, in essence they were concerned to make the point that, without sufficient freedom in academic research, neither the fundamental knowledge nor the qualified investigators would have been available for dealing with the urgent problems that arose in certain fields during the War. Taken as a whole, the Conference displayed a remarkable agreement on tactics; though equally it left no room for doubt as to the need for applying such tactics much more widely and vigorously throughout Government departments, industry and in the universities in order that the supply of trained research workers may be adequate for the country's needs both in quality and in numbers, and that the most effective use may be made of their abilities.

The application of tactics can scarcely be dissociated from some measure of planning, in science any more than in other fields; but one of the most striking features of the Conference was the *rapprochement* between the more vigorous protagonists of planning and the defenders of the freedom of science

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MACMILLAN & CO., LTD.,

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Telegrams: Phisus Lesquare London

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Prof. Polanyi's fine address at the opening session struck a note which was generally welcomed, and the fundamental importance of freedom of investigation and of communication was emphasized from all quarters; so much so that the staccato enumeration by Prof. J. W. Baker, at the end of the second session, of discoveries which could not have been planned struck a jarring note. From the point of view that whatever planning in fundamental research might be necessary as a matter of priorities should be in the hands of scientific men themselves there was no dissent; and the opening sessions of the Conference once more stressed that in regard to fundamental research the right policy is to see that it is adequately endowed and allowed to develop along the lines which the search for new knowledge alone directs, leaving the investigator the widest possible freedom in selecting his subject.

Although the importance of freedom of investigation and communication was fully recognized, and also the desirability of allowing fundamental research to develop along its own lines, it was equally recognized that some measure of direction is necessary to secure the full use of Great Britain's resources of man-power and materials. Even when conditions are such as to attract into a scientific career a sufficient proportion of the ablest minds, we have to remember that our scientific man-power is not unlimited. At the moment, the bottleneck in the way of expansion, as Mr. J. A. Lauwers pointed out, is in teaching, and as has been suggested by Sir John Anderson (see *Nature*, Dec. 22, p. 733) industry may have to forgo its demands while university departments are equipping themselves to train the increased number of research workers and other scientific workers required by industry, government departments and the universities themselves. Equally, however, it would be undesirable at another period for an excessive proportion of the ablest men to enter industry or government departments, leaving the universities starved of the best brains for teaching or research, and as has already been said, some measure of wise planning is indispensable to secure the application of the correct tactics at the right time.

Apart from this, the Conference also emphasized that not only has the management of research to pay attention to the recruitment, training and handling of the research worker, so as to secure the right quality and the fullest use of the comparatively limited numbers available, but also that the human factor, and indeed the whole social and economic aspects of production, offer a field in which the application of scientific methods is required on a much larger scale, especially in Britain. The two aspects are in fact closely linked, for as was pointed out in a reference to the success of team-work in our war effort in enlisting individuality and originality of thought in the attack on definite objectives, a large part of research management lies not merely in the selection of objectives and programmes of work but also in securing a proper balance between the different elements in the team, and in so handling the personalities and aspirations of its members as to provide an environment favourable for creative effort. The operational research to which passing reference was

made at the Conference is clearly a field worthy of close study, both by scientific workers in general and the industrial psychologist in particular, and a careful examination of the reasons for its outstanding success may yield invaluable lessons to be applied in facing the post-war problems.

Prominent among the problems which, in addition to those enumerated by Mr. Alec Rodger, require the attention of the industrial psychologist is that of incentives. The importance of the social motive as a stimulus to research had been stressed at the earlier conference on "The Place of Science in Industry" held under the auspices of the British Association a year ago, and Mr. Herbert Morrison referred to the importance of social purpose as an incentive to match the inspiration derived from the nation's needs in war. Sir Edward Appleton referred significantly to the way in which such an incentive influences young scientific workers who consult him regarding the choice of a career. Mr. Rodger incidentally expressed the view that industrial psychology will only be able to make its full contribution to social and economic life when a full employment policy has been implemented and we have a planned wage structure for the whole of industry, so that the workers are no longer anxious as to whether improvements would result in fewer jobs for fewer people.

Although nowhere consciously expressed, the Conference was pervaded by the sense that these themes—the freedom of science, its value as a cultural activity, the wide application of the scientific outlook and method to problems of economics and management, the study of the human factor and the question of incentives and the structure of society—are not unrelated, but represent threads which must be woven into a coherent pattern if scientific research is to make its full contribution to human welfare at the material, the administrative or the cultural level. The fundamental need is for a closer and fuller integration of academic and industrial research, of industry and Government, with the needs and purposes of the society they exist to serve. To achieve this end, we require what Dr. J. T. MacCurdy suggested in "The Structure of Morale"—an intelligence or liaison system corresponding in efficiency and intricacy with that of the individual human brain.

The evolution of any such system is ultimately a problem in thinking. Much that was said at the Conference supported this comment of Dr. MacCurdy's on the problem of organisation, whether we look, internally, at the problems of the management and organisation of research or, externally, at those questions of public relations which so powerfully influence the application of the results of scientific and industrial research or the extension of its technique into the economic and social field. No one present at the Conference could fail to be aware of the difficulties in this task: the uneasiness and concern with which the new problems of the use and control of atomic energy are regarded was apparent at most sessions. The Conference represents a great challenge to thought, particularly on the part of the scientific worker himself. Colonel Urwick, who emphasized that challenge most clearly, saw too the

real reason for optimism, and the note of optimism with which he closed the session on "Economic Aspects of Research" is one on which the whole Conference might fittingly have closed. The obstacles are essentially human obstacles, and by right thinking they can be overcome.

THE COMPLETE CORRESPONDENCE OF LEEUWENHOEK

Alle de brieven van Antoni van Leeuwenhoek
(The Collected Letters of Antoni van Leeuwenhoek).
Uitgegeven, geïllustreerd en van aantekeningen
voorzien door een Commissie van Nederlandsche
geleerden (Edited, illustrated and annotated by a
Committee of Dutch scientists). Deel (Volume) 2.
Pp. 506+29 plates. (Amsterdam: N. V. Swets and
Zeitlinger, 1941.)

THE first volume of this great undertaking was published in 1939 and was reviewed in *Nature* of that year¹. The edition is lavishly produced, the format being an 'off'-size octavo 11½ in. × 8½ in., beautifully printed on a good heavy paper, and suitably bound. The spacing of the text is unnecessarily generous, and clearly suggests a time when economy in paper and labour could be disregarded. Although the present volume was printed before the War, it was not published until 1941, and so far only two copies have reached Britain. Assuming that the enterprise is not compelled to sacrifice the completeness of the first two volumes, the letters will require another ten volumes of five hundred pages each, and a final volume of biography, critical essays and bibliography will bring the total to thirteen. The Commission, however, has estimated for twenty volumes, which, if correct, will dangerously postpone the completion of the work, and interest in a long-drawn-out publication is apt to waver and expire before the end of the task has been reached.

In our first review, occasion was taken strongly to criticize the hybrid character of the English translation of the letters. This might have seemed ungracious to many, especially as the knowledge of English of our Dutch colleagues puts to shame our own ignorance of Dutch. Nevertheless, good linguists as they are, the English version of Leeuwenhoek's letters reads strangely to a modern Englishman, and it is hence essential that the translation should be revised by an English biologist. This would not be a heavy task, since the Dutch translators may be trusted to render correctly the sense of the originals, and all that is necessary is to check transgressions against English idiom and literary form. We are glad to learn from Prof. G. van Rijnberk's preface that the Commission admits the justice of our criticism, and that future volumes will be free from the blemishes to which we were constrained to direct attention. Unfortunately, volume 2 was in type before the change could be introduced, and hence it perpetrates the same defects as volume 1, to which it would now be superfluous to direct attention. We may also expect further improvements from the fact that Dr. A. Schierbeek, of The Hague, has taken over the editorship of the work, and in the hands of this active biologist and Leeuwenhoek enthusiast the many problems of interpretation which Leeuwenhoek's unmethodical writings have bequeathed to his successors will be explored so far as is

humanly possible. Holland itself can supply the learned advisers whom he will need. We may take this opportunity to express our deep sympathy with Dr. Schierbeek, whose house and valuable library were bombed and destroyed during the War. But his soul goes marching on.

The present volume includes letters 22-42 (new enumeration), but the manuscripts of letters 24, 29 and 36 have not been recovered, and hence only eighteen letters are dealt with in a volume of more than five hundred pages. The list, however, includes the long letter 18 (old enumeration) on the Protozoa, and letter 22 on the discovery of the spermatozoa—two of the most important of Leeuwenhoek's communications to the Royal Society. The former was first published in full by Dobell in 1932. In it Leeuwenhoek records his discovery of bacteria, and many of his most striking observations on the Protozoa—a "truly amazing document" as Dobell describes it. All the letters are printed exactly as written, the Dutch and English versions with their appropriate footnotes and bibliographies facing each other verso and recto, so that translation and original can be compared without turning over pages. Letter 42 is followed by a list of those authorities who have assisted in clearing up difficult passages, and whose results are recorded in footnotes, and the volume is completed by a list of the weights and measures used by Leeuwenhoek, a bio-bibliography of authors cited, and author-subject indexes. The plates include photographic reproductions of such of the original drawings as have survived; but other modern figures necessary to illustrate the text and footnotes are added. As in the first volume the photographs of Leeuwenhoek's microscopes are not good, and that of the eel microscope could easily have been bettered.

When this work was projected by the Leeuwenhoek Commission it was recognized that the genius of this great Hollander could be justly honoured only if two conditions were satisfied: first, the publication *in extenso* of all recoverable manuscripts, accompanied by English translations; and, second, an exhaustive analysis of the texts to determine exactly what Leeuwenhoek had seen and discovered and to assess the historical value of such discoveries. It is perhaps too much to hope that the project can be completed in the opulent typographical style of the initial volumes, but we can at least be sure that the Commission will not go back on the main purpose of its adventure. That every effort has been put forth to secure perfection is evident in this stately volume. The editor himself would not claim that it is the last word, but he is to be congratulated on having laid an enduring foundation on which all future commentaries must rest.

One of the most difficult tasks in the interpretation of Leeuwenhoek's writings is the identification of the species on which he laboured. In some cases there can be no doubt, but in others the commentator must either admit that he does not know, or attempt a long shot, which may be wide of the mark, and in any event achieves only the dubiousness of intuition. The Dutch editors have adopted the latter alternative, and in doing so have thrown timidity to the winds. On p. 69 they identify a ciliate as *Holosticha* which it is true is probably a hypotrichid, but the species named by them on p. 71 as the "flagellate" (sic) *Prorodon*, and by Dobell as a "small ciliate", belongs obviously to the unidentifiable category. The *Oikomonas* attribution on p. 73 is also more than doubtful—in fact it is only probable that the organ-