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ANGLO-AMERICAN TECHNICAL CO-OPERATION

THE broadsheet, "America and Britain", which has recently been issued by Political and Economic Planning (P E P) directs attention to some of those technical aspects of co-operation between Great Britain and the United States, which are as important for the implementing of common policy and the achievement of common purposes as the great traditions and ideals on which Anglo-American co-operation is ultimately based.

Although the vivid realization of common danger and the need for joint measures against it has provided a stimulus to Anglo-American co-operation, it is not the only one. Already the question of dealing with food surpluses and their relation to European needs after the War has been responsible for joint planning and co-operation. The United States is vitally interested in the work of both the Leith-Ross Committee and the Willingdon Commission, and the agreements with the Governments of Australia and New Zealand on the disposal of their surplus food production recently announced by Mr. Arthur Greenwood are part of a great scheme of international reconstruction, the success of which depends on common action with the United States and with the Latin American republics.

Developments in this sphere providing the means by which the United States can, in accordance with President Roosevelt's pledge of March 15, play its great part in the period of world reconstruction for the good of humanity, cannot but have a profound bearing on the problem of the formal organization of Anglo-American co-operation which is the theme of Mr. Streit's "Union with Britain Now". Indeed they may well provide the experience upon which any federation proposals can be most securely based, and seen from one angle represent experiments in keeping with the traditions of both democracies from which new methods can be most surely developed.

There are other fields also in which this experience is being gained. A notable article by Prof. A. V. Hill in *The Times* has described the way in which organization is being developed for an effective Anglo-American partnership in research. Already last summer, as a result of an approach by Lord Lothian, President Roosevelt invited the British Government to send a mission to the United States to consider ways and means of sharing scientific and technical information between the United States Services and the National Defense Research Committee on one side and the British Services and scientific organizations on the other.

The very satisfactory arrangements ultimately made as the outcome of Sir Henry Tizard's mission have played an important part in creating good will and enlisting the co-operation of American men of science, and the liaison now established will become increasingly important as the Lease-Lend Act operates.

The possibilities of co-operation in this way are as yet barely realized by the majority of scientific workers, and whether in research or the supply of skilled personnel, collaboration between British and American men of science offers immense advantages to both countries, in peace as well as in time of war. The advantage to the United States of British experience in war research and in operations against the enemy should be as obvious as is that of the vast scientific and technical resources of the United States to Great Britain. What is less apparent is that the increasing dependence on American supplies to which the Lease-Lend Act commits us implies in the long run the acceptance of United States patterns, often adapted from Allied types, or in the light of Allied experience, as the basis of the army and air force equipment of all the forces using American supplies.

An understanding between the United States and the British Commonwealth on the standardization of equipment is accordingly essential, with agreement as to the best form of mechanisms and devices of warfare. This, with the establishment of rapid transport both ways for essential information, experimental equipment and key personnel is one of the most important immediate objectives on the scientific and technical side. Following this might come some agreement as to the location of research on different types of problem, the more immediate problems being tackled in Great Britain, the longer-range problems in the United States, for example.

The many able men and women attracted to Washington by the New Deal provide the United States with an invaluable source of staff for the war-time organizations, and the strengthening of the United States Civil Service in the last ten years has also been a major factor in enabling the administration to deal with its new tasks. As is increasingly recognized in Great Britain, even more important than the new powers and new machinery of government is the way in which they are used. This is primarily a question of personnel, and there is little doubt that both countries could profit by use of the other's experience in such fields as labour policy, the handling of man-power, and all questions of priority, both in respect of man-power and materials. Co-operation indeed in this field offers the only prospect of obtaining the full efficiency involved in maintaining the proper balance between the British armed forces and the overseas workers. The former can only be maintained at its level of nearly four millions because the United States and the Dominions provide its supplies. The establishment in London and Washington of a common research organization to consider the economics of the British Empire and the United States in this way might be a useful practical recognition of such unity and powerfully assist the elimination of bottle-necks.

Even in a country as wealthy as the United States, some shortages are bound to occur—probably with non-ferrous metals such as manganese and chromium and the special steels—and some rationing of raw materials on the British model may be required, with a thorough discard of the idea that monetary means can secure smooth and rapid production for war. Already it is recognized that some restriction of consumption so as to divert output from the non-essential industries to war production is necessary in the United States as in Great Britain, and the whole field of war economy offers possibilities of pooling experience that should promote co-operation and understanding for peace purposes as well as for those of war.

This is notably true in certain special fields such as those of food policy and social security, to which particular attention is directed in the P E P broadsheet. It was increasingly recognized before the War, on both sides of the Atlantic, that the provision of a minimum diet and standard of life ought to be a first charge upon the national income. The supply of milk to all children in schools and junior instruction centres in Great Britain under the Milk Act of 1934 has been followed by war-time measures designed to prevent the fall in food standards from affecting the diets of poorer people. The American Food Stamp plan was an ambitious experiment with the same end in view of increasing the consumption of the protective foods, dairy products and fruit, of which the poor consume so much less than the richer classes.

Wide adoption of certain of the measures, such as school feeding, introduced in Great Britain, might effectively raise the low dietary standards in some parts of, and among certain classes in, the United States. Moreover, as Mr. Winant emphasized in his valedictory report to the International Labour Organisation, war increases the need for social services to cushion the shock of reductions in consumption and drastic changes in popular modes of life. The creation in peace-time of a comprehensive system of social security services is a great asset both to Great Britain and the United States, and one of the really solid achievements of the New Deal has been the application of the principles of British social legislation in a thorough and promising way.

The importance of developments in this field, notwithstanding the controversy persisting on both sides of the Atlantic on the administrative and financial problems involved, should not be overlooked. The extension of the unemployment and health insurance schemes in Britain, for example, removes one of the causes of lower middle-class insecurity which in Germany contributed to the rise to power of the Nazis, and may also facilitate a new social and political solidarity apart from its contribution to the establishment of the third freedom of President Roosevelt's speeches. Beyond this, the compromises which have been reached at different points reflecting the different balance of forces in the two communities cannot disguise the common pattern leading up to and flowing from every new social measure in Great Britain and the United States.

Many of the developments which have taken place on both sides of the Atlantic are scarcely more than improvisations to deal with urgent needs. This is notably true of education, where neither of the two great democracies has an entirely satisfactory record. In both countries, however, there have been developments, such as the country schools established as a result of evacuation in Great Britain, and the Civilian Conservation Corps in the United States, which hold great promise for the future integration of town and country and afford opportunities for pooling experience and for the growth of mutual understanding.

These wide fields over which Anglo-American co-operation is already proceeding, and the immense range of common experience, are a powerful reason against hastily forcing the organization of formal co-operation into any set mould or union. That effort should be deliberately directed to the examination of the possibilities and the testing of alternatives is all to the good, but the utmost care should be taken to avoid any step which might impede rather than promote effective collaboration. For this reason with such investigation a nation-wide campaign of education should proceed even in the stress of war, supplementing the brilliant efforts of leaders on both sides of the Atlantic, to interpret and understand the differing interests and points of view of the two peoples as well as their common ideals, traditions and heritage. Even the domestic post-war reconstruction plans in Great Britain under the Ministry of Works and Buildings and the Cabinet Committee on Reconstruction and War Aims are being followed with keen interest in the United States, where the resolution before the Senate proposing the establishment of a "Post-Emergency Economic Advisory Commission" to plan for full employment indicates that people in the United States are also beginning to think and plan in response to the same challenge.

If there is interest in questions of domestic reconstruction, this is even more true in international planning, where many thorny questions will require much thought and careful consideration. The visits of leading British citizens to the United States and the dispatch of American missions to Britain on such varied questions as economic mobilization, scientific co-operation, health services, A.R.P. and fire-watching may help to cross-fertilize opinion and prepare the ground for what must be comprehensive plans. The presence of many European refugees in both countries and such developments as the transference of the headquarters of certain international trade unions to Britain, and the recent conference of representatives of Allied Governments in London should also assist in the formulation of sound proposals for European reconstruction.

The Eighth American Science Congress in May 1940 favoured an inventory of world natural resources and the formulation of a general policy and specific programme of action to promote mutual conservation and prudent utilization of natural resources for the welfare of all nations in the interest of permanent peace. The report of a round-table conference in February at Princeton, New Jersey, under the auspices of *Fortune*, indicates that influential American opinion already recognizes that American help is essential to eliminate the growing burdens of an armament economy. The majority favoured the acceptance of commitments on behalf of a New Order of Free Peoples resting on recognition by the State of the unique value of human personality, restriction of national sovereignty, and creation of effective international institutions.

The report went on to outline a programme of war-time co-ordination, including the formation of an Anglo-American Technical Board to work out common specifications, the creation of a United States Department of Economic Defense, and joint purchase and storage of raw materials by the two Governments, the gradual creation of an Anglo-American Economic Council, and the appointment of an official commission to prepare a programme of post-war demobilization. The problems of the latter period are considered at length, and suggestions advanced for American contributions to the restoration of a world economy include the continuance of the low tariff policy and the resumption of foreign lending on behalf of a general reconstruction policy.

Whatever form the organization of the new order of free peoples may take, this report suggests that the United States should at least participate in machinery for the settlement of international disputes and in a system of effective sanctions against aggressors, accept the responsibilities of a creditor

nation, conclude agreements regulating domestic policies that might injure other peoples, and participate in agreements for the reduction of armaments. This is weighty evidence of American support for the Atlantic Charter.

Both in Britain and in the United States scientific workers were among the first to realize the true nature of the Nazi menace and its attack on freedom of thought and investigation. They will appreciate the enduring values which community of tradition and doctrine give to the Anglo-American co-operation now so rapidly developing. They will not be the less zealous in their efforts to evolve in scientific and technical matters the machinery of effective co-operation, and to assist in the educational work which makes for understanding between the two communities for this growing evidence of some greater and more enduring co-operation after the War, in the tremendous task of establishing a world order to serve more abundantly man's noblest heritage and highest aspirations as well as his material needs.

A JERSEYMAN AT OXFORD

A Jerseyman at Oxford
By Robert Ranulph Marett. Pp. xi+346+4 plates. (London, New York and Toronto: Oxford University Press, 1941.) 15*s*. net.

TO-DAY it is increasingly the custom among men and women, if they count themselves to have done or seen something, to write their autobiographies, and honesty compels the critic to own that they are seldom successful. But this book is an outstanding exception. Here is a man who has "warmed both hands beside the fire of life", and in his seventy-fifth year that fire has not yet shrunk. He writes with zest and gusto *currente calamo* out of the fullness of a mind produced not only by reading and disciplined study, but also by knowledge of many friends and many countries, together with many and varied experiences such as come to a man who prefers the struggle to the prize, and can throw himself wholly into what he happens to be doing.

Dr. Marett in comparison with the vast majority of his fellow-countrymen, as he would himself be first to confess, has been a fortunate man from the start. Born of good family, reaching back through many generations of service in Jersey, he was brought up in a good home with wise and cultured parents in a beautiful place set fair in the freedom of sky and sea. Nature in her kindness endowed him with good brains, good memory, lively imagination and abounding physical vigour. He has been excellent in games which have interested him, particularly golf: he has been, and is, a good shot. Eyesight, strength and nerve have not failed him in more than seventy years. When as a young man just down from Oxford he was free to travel abroad, he enjoyed long spells in France, Germany and Italy. If Paris and an aristocratic home, poor but proud, bored him, in Germany he was able to move in the Junker set, to dine once in the Kaiser's presence, to frequent the universities, and to be adopted by the American colony. In Italy he was under the patronage of Lord and Lady Dufferin, and all doors were open to him. Antiquities, pictures, the best company, rides over the Campagna, Rome, Naples, Sorrento —"a rapturous year" he rightly calls it. And what a mixture of interesting people for a young man to meet—Lord Dufferin and Lord Hartington, Lanciani and Dr. Axel Munthe, Buffalo Bill and Prince Napoleon Bonaparte, even King Umberto and the Pope himself—the last in compromising circumstances. Some will pretend to look down on this sort of thing, but these advantages are very real for a young man who knows how to mix, and does not allow his head to be turned.

Not only has he been fortunate, but also lucky: in the lottery of life luck counts too. Lucky, when as a child of eight he was rescued from his burning house, lucky when on the Riffel Alp he fell off a cliff into a dead pine-tree which held, and on the Langdale Pikes off a crag forty feet into soft snow; lucky again when, feeling ill in Oxford, he pulled by chance the door-bell of a doctor who could diagnose meningitis at sight, lucky in the last war when in a black-out he fell between a moving train and the platform, and escaped hurt, but not maimed, and twice when he came very near to German bombs; lucky when but the other day he received thirty-seven pellets at close range in his leg, and did not lose it. In all these cases the dice might so easily have fallen otherwise.

This book begins rightly with his island, his ancestors and his home: there emerges the picture of a boy with sport in his blood, but sport going along with natural history. A good preparatory school, and Victoria College in a good period follow, the picture now of a boy picking up classics without taking too much trouble. A Balliol Exhibition is won, Benjamin Jowett enters his life, he becomes in his own words a "smug", or "a natural extrovert imposing upon himself an

introverted character by sheer will". A strange type of introvert, who made hosts of friends, became secretary of the Union, and belonged to eighteen societies. By dint of reading by the light of nature he got a first in Mods. and the Chancellor's Latin Verse. A whole chapter is rightly given to Greats, for it made him finally what he is: Jowett and Lewis Nettleship between them made him a Platonist, and Strachan-Davidson set him to read "Custom and Myth". In spite of meningitis he got his first for his brilliant promise, and passed on to his *Wanderjahre*, then a year as maid of all work at Balliol, and finally his Exeter fellowship. The interest of autobiography lies not in telling what a man is, which in this case all the world knows, but how he came to be what he is. Exeter has been his life since: he has held all offices there, and is now its rector, unanimously elected, unanimously prorogued to the full limit. In this book the whole of his wonderfully interesting activities is written at length. For two-thirds of his time he has taught philosophy, in the remaining third he has made a world-wide name in anthropology; but whether he has done his more valuable work as a famous pioneer in a new science, or in the quiet guidance and shaping of the minds of successive generations of young men is unknown to him, as to all.

Here at the very end fortune has proved adverse. Almost in the same hour he lost his eldest son in the *Glorious*, and his home and all his possessions in Jersey. It shows what manner of man he is that he has in bereavement and loss written this delightful book, full of happiness, crowded with interest, and without one unkind word spoken of any—the splendid record of one who through a long life has set himself "to strive, to seek, to find and not to yield". CYRIL NORWOOD.

DEVELOPMENT OF MATHEMATICS IN THE UNITED STATES

(1) A Semicentennial History of the American Mathematical Society, 1888–1938

With Biographies and Bibliographies of the Past Presidents. By Raymond Clare Archibald. Vol. 1: History. Pp. x+262. Vol. 2: Addresses. Pp. v+315. (New York: American Mathematical Society, 1938.)

(2) Bibliography of Mathematical Works printed in America through 1850

By Louis C. Karpinski. Pp. xxvi+697. (Ann Arbor, Mich.: University of Michigan Press; London: Oxford University Press, 1940.) 33*s*. 6*d*. net.

(1) THE American Mathematical Society anticipated its semicentenary, which fell in 1938, by appointing a celebration committee ten years in advance of that date. The semicentenary was a great social event; it was also the occasion for the issue of two handsome volumes, a history of the Society and a set of addresses.

In Prof. Archibald's history, a detailed account of the birth and growth of the Society is followed by biographies and bibliographies of the secretaries and the presidents. The early chapters describe an amazing advance, of which the character is revealed most clearly in abortive negotiations with the *American Journal of Mathematics* which preceded the establishment in 1900 of the *Transactions* of the Society. To the older men, America was an intellectual dependency of Europe, and the ambition of an American journal was to attract contributions from the great scholars of the Old World; a younger generation was confident of its native powers. A stroke of diplomatic genius on the part of Maxime Bôcher drew the sting from the dispute, no resentment remained, and when in 1925 the great depression threatened the existence of the *Journal*, the Society came willingly to the rescue.

Written before 1939, the story of the struggle to maintain international collaboration in mathematics makes heart-rending reading to-day. We must derive what comfort we can from knowing that it was a story of Anglo-American co-operation, for the London Mathematical Society, in our more intoxicated country, was a partner with the American Mathematical Society in protest against the blind French vindictiveness which organized an allied congress at Strasbourg in 1920 and would have excluded Germans from Bologna so late as 1928 if the committee arranging the latter congress had not defied the ban. But success too long delayed is illusory. "You shall not come" of 1920 and 1924 became "We will not come" in 1936. It is only in the most formal sense that Prof. Archibald's assertion that "No political taint marred the delights of the congress at Oslo" is to be interpreted. The Germans made no pretence at co-operating, the Russians decided at the last minute not to attend and rapid changes of programme became necessary in consequence, and the time of

year was exceptionally inconvenient, we were given to understand, for the French. The Congress was international in constitution, and its delights were truly unmarred, but there were few beside Americans, British and Swiss to share the unmarred delights with their Scandinavian hosts. In all but name the series of international congresses which began at Zurich in 1897 came to an end there in 1932, for the epilogue of Oslo in 1936 was less in the spirit that inspired the early meetings than was the prologue of Chicago in 1893.

Prof. Archibald's story of the rise of the American Mathematical Society is a model of exact information attractively presented. He was fortunate in the completeness with which records had been kept ; with the best will in the world, few historians can hope to imitate him. More remarkable as a personal achievement is the compilation of biographies. Regarding men of the standing of G. W. Hill and Simon Newcomb, Oswald Veblen and G. D. Birkhoff, sources are plentiful and the biographer's task is selection and composition ; bibliography always presents countless little problems, but these are meat and drink to Prof. Archibald. Where his passion for accuracy and completeness has found full scope is in the reconstruction of the characters and doings of the less distinguished of his subjects ; there are no gaps in his series, and even his collection of photographs is complete.

Enjoyment of an art is one of the good things of life. If ignorant and facile it cannot be rated highly, but if it is informed, critical and appreciative it is the very stuff of which civilization is made. It is not to be measured by creative ability ; to react to the subtle cadences and alliterations of great prose is better than to feel smug satisfaction in composing a scrap of doggerel. If the artist covets the praise of his peers, that is because their judgment involves an understanding of technical success, not because it is they only whose receptive emotion is worth arousing. Perhaps no one has seriously maintained that poetry should be read only by poets, ballet watched only by choreographers. The view that higher mathematics has no contemplative side but exists only for its practitioners may be less demonstrably absurd, but it is certainly ungrateful. For the past hundred years, the societies through which mathematicians have reached a public outside their own lecture-rooms have been utterly dependent on the support of long-forgotten members who have no place in the history of mathematics and who asked in their time nothing more than to promote the study of mathematics and to facilitate the work of mathematicians. From London and Palermo to New York and Madras the story is the same, not of a few great men supplying each other's needs, not of braggart mediocrities indulging in mutual admiration, but of sincere and modest enthusiasts. Prof. Archibald has conferred on the devoted servants of the American Mathematical Society that measure of survival to which they are entitled, and in doing so he has not attempted to exaggerate their importance as mathematicians. It must be confessed that in one sense his own kindly disposition and his familiarity with almost all the men of whom he writes have disqualified Prof. Archibald : he is not the impartial biographer, recording faults and foibles as well as merits and achievements ; we cannot learn from everybody's friend that this man was vindictive, that man conceited, and a third an amiable but inflexible dictator. But mathematicians are as liable as other people to disagreeable traits, and when the nearest approach to censure in twenty-six sketches is in the quotation "For the apparent eccentricities of his private life there must have been some sound reason, creditable to him", we know that only one aspect of each sitter is being drawn. None the less, the portraits that emerge are differentiated and vivid.

Before we turn from this volume we must make mention of the preface, where all that is most likeable in Prof. Archibald and most admirable in his work finds uncalculated expression.

Of the volume of addresses little can be said unless each address is to have its own notice. The contributions are as follows : E. T. Bell : fifty years of algebra in America ; J. F. Ritt : algebraic aspects of the theory of differential equations ; N. Wiener : the historical background of harmonic analysis ; E. J. McShane : recent developments in the calculus of variations ; T. Y. Thomas : recent trends in geometry ; R. L. Wilder : the sphere in topology ; G. C. Evans : Dirichlet problems ; J. L. Synge : hydrodynamical stability ; G. D. Birkhoff : fifty years of American mathematics. The nine addresses all tell the same astonishing story of progress ; in the first and last we follow it step by step ; in the others we join the leaders in the forefront of their advance. The country which, if Hill and Newcomb must be ceded to the astronomers and Gibbs to the chemists, had produced by 1888 only one mathematician, Benjamin Peirce, had become in 1938 the equal of any country in the world, and is ready, if European civilization in its collapse buries England in the ruins, to fulfil alone the task of preserving and enriching the human heritage. The transformation was not the work of one man, but our historians agree that in the first twenty years of their half-century there was one dominating influence, that of E. H. Moore, of whom Prof. Bell says that his interests frequently changed, and with each change, mathematics in America advanced. Moore lived

to see the time when young European mathematicians were as ready to travel for inspiration to Princeton as to Paris or Vienna.

(2) The condition of mathematics in America forty years before the foundation of the American Mathematical Society is to be inferred from Prof. Karpinski's bibliography of American-printed mathematics 'through 1850', to use the convenient new idiom. In this exhaustive and handsome volume, in the preparation of which Prof. Karpinski has been helped by booklovers and librarians up and down the continent, some three thousand items are listed, and there are 908 photostatic reproductions, chiefly of title-pages. Prof. Karpinski could have spared himself much trouble by following the example of D. E. Smith's "Rara Arithmetica" and referring to figures when they are given instead of transcribing titles in these cases. It is not for the reader to complain except on the ground that there might then have been more annotations, and like all expert bibliographies this one perpetually arouses curiosity. What, for example, was the general solution to an algebraic equation which Jason H. Mahan published in 1847 under the title "Key to the Hitherto Impenetrable Secret"? Why does Prof. Karpinski assert that Hobart's "Mathematics Simplified and made Attractive, or the Laws of Motion Explained" is "doubtless a second edition" of an unlocated book which according to its copyright entry-title was "designed to shorten and make plain and easy nearly all the rules which are usually put into arithmetic"? Was Mark Duty a blind man?

In 1909 a story was current in Cambridge that a scholar of Trinity had attended the first lecture of Russell's announced course on the principles of mathematics in the belief that he was being offered intensive coaching for the impending Tripos; this story comes to mind when one finds Chittenden's edition of Motte's translation of the "Principia", which incidentally is one of the most eccentrically paged books ever printed, indexed under "General Works on Mathematics". The transcription of the title of this volume, on p. 491, illustrates how much hangs on accuracy in type, for no one without previous knowledge could interpret 'Newton's system of the world' correctly. Consistency may be the supreme bibliographical virtue, but should any rule be held proof against the exception in which the authors' names appear thus: "Todd, John, Jess, Zachariah, Waring, William, and Paul, Jeremiah"?

A few samples must be taken. The publisher who issued a primary arithmetic under the title "Hints to Mothers" not only provides evidence of the thoroughness with which Prof. Karpinski has done his work but also gives complete revenge to a famous if fabulous young coleopterist. Zerah Colburn—I take the story from De Morgan's "Budget"—pestered to explain his mode of instantaneous calculation, cried out in a huff "God put it into my head, and I can't put it into yours", but R. L. McLallen was not afraid to bring out in 1844 "A new and interesting Arithmetic, in which is explained the method that Zerah Colburn must have pursued". The word 'kindergarten' was as yet unnaturalized when the 'Chinese trangram', issued anonymously in 1817, suggested to Thomas Hill the "Puzzles to Teach Geometry" which appeared in 1848 with an approving letter from Peirce. In 1840 Peirce's interest in education took the practical and beneficent form of "An Elementary Treatise on Plane Geometry . . . printed for the use of the Blind"; we are not told whether the contents were conventional or if Peirce endeavoured to take into account the effect of blindness on the sense of form. A year later the Asylum Press followed this geometry with a table of logarithms, also printed on raised plates.

Enough has been said to show that Prof. Karpinski's bibliography is comprehensive as well as fascinating. In his very readable introduction he says: "My search, and particularly the check upon it given by various early lists, inclines me to venture the prediction that not fifty new titles which are strictly mathematical will come to light within ten years." In short, an ambitious plan has been well accomplished. The volume is indexed liberally, and an index of printers and publishers is specially to be welcomed, though there, alas, the insidious 'Pierce' is to be found.

When we look into Prof. Karpinski's bibliography not for entertainment but for evidence, when we ask the quality not of the record made but of the material recorded, what do we find? We find a devastating tale of trivialities, relieved only by translations of the "Principia" and the "Mécanique Céleste", to which, if we are generously disposed, we may add a score of minor undergraduate textbooks. We can speak with mathematical respect of the arithmetics produced in Mexico and Peru in the century and a half before 1703, the year of the first entry in English, but not of the hundreds of arithmetics that form, with surveyors' manuals, books on mensuration, sets of tables, and a few schoolbooks on algebra and geometry, American 'mathematics' until less than a century ago. North American civilization is coeval with that of Western Europe, and North America was colonized not by scourings and failures but by men of enterprise, intelligence and boundless energy. The ecological lesson is clear and menacing: the flowers of civilization flourish only in a garden, not on the fringe of a wilderness, against the walls of a factory, or in a corner of a battle-field.

E. H. NEVILLE.

THE RELATIONS BETWEEN SCIENCE AND ETHICS

By DR. C. H. WADDINGTON
CHRIST'S COLLEGE, CAMBRIDGE

THROUGHOUT most of history, man's concept of the Good has been rightly considered to have, or at any rate to require, a philosophical justification; that is to say, a justification dependent on the characteristics, not of a particular individual, or group of individuals, but of the world in general. This might be deduced from observation, as in the theory of Utilitarianism, or revealed by the voice of God or of conscience. During the last quarter of a century, four lines of thought have converged in an attack on this notion, and their combined effect has apparently gone far, at least among what may be called 'popular intellectual' circles, to rob ethical statements of any claims to intellectual validity. All four of these trains of thought had their origin in scientific movements. They were:

(1) The psycho-analytical, based on an examination of individual psychology, which seemed to imply that man's ethical system is a mere product of his early sexual reactions to family life, and has no more generality than that has.

(2) The anthropological, based on a comparative study of social systems, which tended to show that ethical beliefs differ extremely from culture to culture and can therefore have no general validity.

(3) The Marxist, primarily based on a study of the changing society of Western Europe, which appeared to assert that ethical systems are expressions of class forces and are epiphenomena which may be left out of account when we are considering the mechanism of social development.

(4) The anti-metaphysical of the Logical Positivists, based on the attempt to realize the 'unity of science' through a study of meaning, and issuing in the view that ethical statements have no meaning of a verifiable nature.

None of these summary statements of the four arguments is, I think, an entirely fair account of the contribution which the science in question has made to the study of ethics. But they do represent not too inadequately the sense in which these contributions have been understood among wide circles of the general reading public, including many of the younger men of science. Taken together, the four lines of attack were undoubtedly successful in persuading many people that science either has nothing to do with the formulation of ethical systems, or even is necessarily inimical to any such attempt. I wish to argue here the contrary thesis: That if these four contributions are correctly interpreted, ethical judgments are statements of the same kind—having, as the logisticians would say, the same grammatical structure—as scientific statements. I shall deny Carnap's argument that the typical ethical statement 'killing is evil' is merely a paraphrase of the command 'do not kill'[1], and "does not assert anything, and cannot be proved or disproved". I shall argue that an ethical judgment is better typified by a statement such as "You are an animal of such a kind that you must consume 7 mgm. of vitamin C per diem, and should consume 100 mgm.", that is to say, by a statement which has scientific significance.

An ethical belief must be believed by someone; and the psycho-analytical discoveries, which are concerned with the development of the ethical systems of individuals, are the most profitable basis from which to begin an examination of the scientific basis of ethics. Psycho-analytical literature is voluminous, and is couched in a somewhat anthropomorphic jargon which, while it may be an inevitable result of attempting to write in conscious language of mental processes which do not occur within consciousness, is undoubtedly not very perspicuous for the layman. But one may, with all due diffidence, mention two points which seem to emerge from it.

In the first place, ethics appears among psycho-analytical phenomena as the consciously formulated part of a much larger system of compulsions and prohibitions. Many of these remain permanently below the level of consciousness, but, all together, they make up a more or less isolable dynamic function within personality, known as the super-ego. By setting up the super-ego as the entity for investigation, psycho-analysts are abolishing, in a very radical way, the class distinctions which we commonly make among our inner compulsions, which lead us to hold that the prohibition on picking one's nose in public, for example, although often much stronger than that on lying, is less worthy of consideration. This is a piece of realism for which one can have nothing but gratitude. Moreover, it brings out clearly the very important point that one cannot avoid ethics; it is impossible to give them up like smoking in Lent. They are part of the super-ego, and the super-ego is inescapable among those present (accompanied by

the ego, the id, the ghosts of Œdipus, Narcissus and the rest) whenever we do anything.

The second of the psycho-analytical results which requires attention is more fundamental, but in some ways less straightforward. Put shortly and crudely, it is that the super-ego is formed as a result of experience of the material world, and that its propositional content has been verified in experience. There are two difficulties in the way of establishing this. First, the super-ego is being formed from the a of about six months onwards, and empirical observation at that time has a peculiar character which it later loses. "The baby", writes Joan Riviere, "cannot distinguish between me and not-me; his sensations are his world, *the* world to him."[2] The first crude notion of externality, of otherness, arises through the experience of an inability to control; and the objects which thus intrude into the baby's solipsistic day-dream are inevitably personalized, distinguished as "not-me but another person". More than that, they must appear to butt in from outside what had been thought of as all-embracing. It is, I suggest, because the development of ethics is connected with this break-up of solipsism that it has that character of other-worldliness, of absoluteness, which made plausible the anti-metaphysical comment that one can no more talk about it than about the ultimate reality behind the world's appearances. "Wovon man nicht sprechen kann, darüber muss man schweigen", said Wittgenstein in 1919, addressing philosophers[3]. His words would have been more apposite in the mouth of a mother talking to her child; but unfortunately one screams as though the devil were on one's tail; probably he is.

The second difficulty in establishing the dependence of the super-ego on experience arises in connexion with the distinction between the external and the internal, between the individual and his environment. There is first a simple confusion to clear out of the way. One finds, for example, the following sentence by Freud[4]: "Whereas the ego is essentially the representative of the external world, of reality, the super-ego stands in contrast to it as the representative of the internal world. . . ." But the context makes it quite clear that Freud is speaking here of the adult personality, at a time when the super-ego has already been formed. He is not, in calling that entity the representative at that time of the internal world, denying that at an earlier period, during its formation, it was dependent on the external world. In fact, in another place he states, fairly explicitly, the point which I wish to make: "The role which the super-ego undertakes later in life is at first played by an external power, parental authority. . . . This objective anxiety is the forerunner of the later moral anxiety."[5]

But the difficulty goes deeper than this. The author who has, perhaps, contributed most profoundly to our knowledge of the formation of the super-ego is Melanie Klein. Her view "lays emphasis on the importance of the impulses of the individual himself as a factor in the origin of his super-ego and on the fact that his super-ego is not identical with his real objects"[6]. But, she writes, "In thus regarding the impulses of the individual as the fundamental factor in the formation of the super-ego we do not deny the importance of the objects themselves for this process, but we view it in a different light." Now it may be pointed out that in emphasizing the importance of the external objects in the formation of the super-ego, the role of the innate impulses of the individual has not been denied. The question at issue is whether the ethical beliefs which form part of the super-ego are injected into the individual apart from and independently of his experience of the material world, or whether they are formed by the interaction of the personality and the world; there cannot be any question of the super-ego being impressed by external circumstances on to a merely receptive and featureless individual. The answer which I am urging is that the situation is actually parallel to that with which we are familiar in genetics; all characters are, as Goodrich put it, both inherited and acquired; they are products of the interaction between the genes, which we usually consider internal, and the equally necessary factors, such as oxygen, nourishment, etc., which we usually consider external. Strictly speaking, one cannot say that the propositions of ethics arise from experience of external, as opposed to internal, connexions; their origin is the observation that the world is such, and the personality is such, that the individual must follow certain rules.

Here, it may be urged, the word "must" in the last sentence may be going too far. Granted that the propositions of ethics are derived from experience, does that experience teach us more than techniques which lead to pleasurable results, and do we still need to invoke some non-experimental criterion to judge, not what gives us pleasure, but what *is* pleasurable or good and what bad? But if there were any such ulterior criterion, it would have to be of the most general and unspecific character. What we are considering is not the abstract entity 'ethics', but actual super-egos as they are effective in human personalities; and they are so variable from person to person, that, if their contents are taken to consist of rules for obtaining some ultimate objective, that objective must be of an extremely vague character. Further, there are many propositions for which it is clear that no ulterior criterion of value is necessary. The statement that it is as well not to put your hand in

the fire is not based on anything else except the fact that if you do it will cease to be a hand ; and existence is its own justification ; hands are the kind of things which do not go in fires. Self-destruction of an entity only comes into question when there also exists some large unit of which that entity is a part, and it only occurs when this more inclusive unit is more powerfully energized in the dynamic system of the super-ego.

According to some psycho-analysts, an urge towards self-destruction is, in actual fact, very early awoken in the young child. But there is obviously in existence an entity in which the child is only a part, namely society, and the facts which the child is learning and incorporating into its super-ego are very largely facts about the existence of society and his place in it. He discovers, for example, that if, in anger at being denied the maternal breast, he attempts to attack his mother, he is either restrained or at least disapproved of. That disapproval is ultimately based on nothing more than the existence of society, which would be impossible if aggression were uncontrolled. The child, of course, does not himself discover that the existence of the society of which he will be a member demands the control of aggression ; that knowledge can only belong to his parents, and may not be formulated even in them. But the disapproval which the child experiences is a result, mediated either by intelligent knowledge or by the unconscious processes of natural selection, of the requirements of human society. The ethical principle 'Be good, sweet child!' derives what validity it has from social facts as real as the calorie quota for human survival.

During the very early months, when the main structure of the super-ego is being formed, the most important facts which come to the notice of the child are social facts, arising from its relations with its parents, nurse, etc. The anthropological discovery that systems of ethics differ in different cultures is therefore not only not surprising, but is indeed a necessary consequence, and a confirmation, of the view here put forward. The way in which these systems of social behaviour are conditions for the existence of the cultures concerned has been fully discussed by Malinowski and his followers. But we must, I think, go farther than this. Ethics, at this point in the argument, appears as a system of rules of action derived from the necessary conditions for the existence of society. They appear, that is to say, as simply conservative. It would be a sanguine man who would depreciate such a function at the present day, but we cannot in fact expect society to continue unaltered. A tendency to evolutionary or developmental change is a general characteristic of biological entities, including societies, and it is certainly true of Western European civilization that the ethical systems engendered within it are not simply conservative but are among the agents of this change.

The contribution which theoretical Marxism made to the study of ethics was actually not to debase ethics to the position of a mere epiphenomenon, but was a combination of this point with the anthropological argument mentioned above. The widespread misunderstanding of this is partly due to the very diverse, and sometimes regrettable, practical applications of the Marxist theses on ethics which have been made by various political parties ; and partly to a certain naughty-boyishness, a roguish delight in paradox *pour épater les bourgeois*, in the Grand Old Men themselves. Such a spirit is perhaps not unexpected in professional revolutionaries, but it has led to some remarkable confusions when interpreted by the more earnest of the true believers.

Marx and Engels urged, first, that ethical ideas are derived from the experience of social facts. This part of their argument is one of the almost innumerable meanings of the famous phrase 'freedom is the knowledge of necessity', an epigrammatic statement the highly complex ambiguity of which should commend it to the school of poetic criticism represented by Mr. Empson. Further, they asserted that different social classes, encountering different material conditions, form different ethical systems. They also showed that the differing conditions of the social classes bring about developmental changes of the society as a whole. Since they, of course, acknowledge the fact that "all the driving forces of the actions of any individual person must pass through his brain, and transform themselves into motives of his will in order to set him into action"[7], this implies that it is only through the systems of beliefs to which they give rise that the social conditions are effective. The point was somewhat obscured by their insistence on what was the newest and most controversial aspect of their doctrine, namely, that the social facts from which the ethical systems are derived could be ultimately reduced entirely to matters of economics. And it was, as mentioned above, also concealed by some of their more irresponsible utterances ; for example, by Engels : "it is precisely the wicked passions of man—greed and lust for power—which, since the emergence of class antagonisms, serve as levers of historical development"[8], in which he emphasizes the imperativeness of the socially determined Good by comparing it to unrestrained biological drives. But, in spite of the confusion caused by such verbal tricks, Marxism did provide the logical basis for the view that realist ethics can change society and not merely preserve it.

Having now reached the position of seeing a social system as something the existence of which essentially involves motion along an evolutionary path, we are confronted again with the question which was discussed five paragraphs above in terms of static existence: Do we need some external criterion to decide what is the 'good' direction of evolution, or is that implicit in the society? Again, I think, one can answer that no criterion external to the natural world is required. An existence which is essentially evolutionary is itself the justification for an evolution towards a more comprehensive existence; a society implies a direction of development into a society which could include the earlier stage, as, to take an exaggerated example, American culture can include that of the Red Indian, but not vice versa. One can put the same thing in another way by reference to the history of evolution; on the whole, the later products of animal evolution have capacities which include and transcend those of their ancestors.

But, it may be said, granted that the existence of a society does imply a direction of change, why should that direction be accepted as good? One could quote eminent authority against such a view. "Let us understand, once for all," wrote T. H. Huxley[9], "that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it." But he was writing under the spell of that extraordinary impulsion, so incomprehensible to us to-day, which forced the Victorians to transmute the simple mathematics of their major contribution to theoretical biology into a battle-ground for their sadism. To Huxley, the cosmic process was summed up in its method; and its method was "the gladiatorial theory of existence" in which "the strongest, the most self-assertive tend to tread down the weaker", it demanded "ruthless self-assertion", the "thrusting aside, or treading down of all competitors". To us that method is one which, among animals, turns on the actuarial expectation of female offspring from different female individuals, a concept as unemotional as a definite integral; and we can recognize that quite other, though equally natural, methods of evolution may occur when it is societies and not individuals which are in question. Moreover, being no longer hypnotized by the methods of evolution, we can see its results; and they cannot be adequately summarized as an increase in bloodiness, fierceness and self-assertion.

Huxley, in fact, was morally outraged by what he took to be the character of the cosmic process, and was therefore forced to exhort civilization to combat it. With our present ideas, the general character of the cosmic process, or as we should now say, of the course of evolution, does not seem so morally offensive that we cannot accept it. To return to our question, we must accept the direction of evolution as good simply because it *is* good according to any realist definition of that concept. We defined ethical principles as actual psychological compulsions derived from the experience of the nature of society; we stated that the nature of society is such that, in general, it develops in a certain direction; then the ethical principles which mediate the motion in that direction are in fact those adopted by that society. Of course the good is, as the anthropologists pointed out, different in different societies, and particular cultures which regress may be actuated by principles at variance with the cosmic process. But in the world as a whole, the real good cannot be other than that which has been effective, namely that which is exemplified in the course of evolution. It should be noted that this, if you will, cosmic fatalism, does not imply a fatalistic attitude to the evolution of any particular section of the world, for example, of the society of which one happens to be a member.

It is, then, finally clear that science is in a position to make a contribution to ethics, since ethics is based on facts of the kind with which science deals. And the nature of science's contribution is also clear; it is the revelation of the nature of the character and direction of the evolutionary process in the world as a whole, and the elucidation of the consequences, in relation to that direction, of various courses of human action.

But the practical difficulty remains. The fundamental features of an ethical system are formed, as part of the super-ego, in the very early years of life. A child learns at its mother's knee that aggression must be controlled; and it learns a very little later that taunting its younger brother's weakness is a form of aggression; but when does it learn that adopting an unscientific attitude to the social problem of nutrition is also aggression? Most of the scientific contributions to ethical thought are of a kind which seem, at the present time, difficult to convey in the early formative years in which the most effective features of the super-ego are being laid down. Perhaps this appearance is deceptive, and perhaps after a few generations the fundamental notions of the scientific outlook will be so deeply incorporated into normal life that they can be transmitted by the unconscious gestures of mothers and nurses. An adequate psycho-analytical study of people who have grown up in Soviet nurseries might tell us whether this is too wildly optimistic. But in any event we should do well not to neglect the second line of attack, but should study deeply how the intellectual content of the super-ego may be modified in later life, and the data which we can provide about the nature of the cosmic process

appropriately attached to the powerful general principles about love and aggression which are by that time already in existence. It is the profoundest of scientific principles that a theory must work in practice ; and that applies to scientific ethics no less than to the latest modification of the quantum theory.

[1] Carnap, R., "Philosophy and Logical Syntax", Kegan Paul (1935), 24.
[2] Riviere, J., "Love, Hate and Reparation", Hogarth Press (1937), 9.
[3] Wittgenstein, L., "Tractatus Logico-Philosophicus", Kegan Paul (1919), concluding sentence.
[4] Freud, S., "The Ego and the Id." Cf. "General Selection from the Works of Sigmund Freud", Hogarth Press (1937), 259.
[5] Freud, S., "New Introductory Lectures on Psycho-analysis", Hogarth Press (1933), 84.
[6] Klein, M., "The Psycho-analysis of Children", Hogarth Press (1932), 195, 197.
[7] Engels, F., "Feuerbach", Lawrence, n.d., 62.
[8] Engels, F., "Feuerbach", Lawrence, n.d., 47.
[9] Huxley, T. H., "Evolution and Ethics", Macmillan (1894), 83.

I FIND myself in fundamental agreement with Dr. Waddington, though I should base my argument on an epistemology more explicit than his own. To start off, I would aver, with Mach, that "bodies or things are compendious mental symbols for groups of sensations—symbols that do not exist outside of thought". The basis of all knowledge is experience. So-called external objects are constructs from experience : equally the doctrine of evolution and the view of the universe summed up in the Ten Commandments are constructs from experience. Of course, the experience may be partial : elements in it may be false (that is to say, unconfirmed by the majority of our fellowmen). The activity of the mind which links together elementary perceptions and fashions the constructed symbol may be inadequate to make a symbol which shall cohere with other symbols as we try to picture some wide region of the universe in which we find ourselves. But by a process of trial and error, in which the individual constantly checks his experience by that of others, the race has gradually created, among other ideas, those which we distinguish as external objects, laws of Nature and ethical principles.

We assume that there is an external world of objects to which our bodies belong. But, if that world exists, is our picture of it correct ? We cannot say, for we cannot transcend human limitations. Are our scientific laws accurate ? Probably not : they correspond, however, to humanity's present state of mental development. Can we say that our ethical standards and the commands by which we seek to make them effective are sound ? They, too, are as partial, as transitory, as our supposed knowledge of the spiritual character of the universe.

Are then our scientific laws and our ethical principles of no value ? By no means. They are approximations to truth, nearer than those which were reached in the past and later modified or even discarded by the growing wisdom of the race.

Unfortunately, the problem of the mind-body relation is so intractable that it is difficult to say how far intellectual and ethical tendencies are inherited. I would agree with Dr. Waddington in affirming Goodrich's conclusion that all characters are both inherited and acquired. The genes carry certain modes of reaction to environment. A relatively homogeneous community is built of the same stock of genes changed to some extent by recurring mutations ; and an individual born into it assimilates with especial ease the community's intellectual, social and ethical formulation of experience.

Is Dr. Waddington quite fair in his strictures of T. H. Huxley ? The evolutionary process on earth, until the rise of the placental mammals with their increasing parental affection, was non-moral. "Nature red in tooth and claw" is an actual fact. Huxley was right in asserting that between man and the cosmic process as it has been, there ought to be war. The strongest objection to ethical theism lies in the fact that the creative process has been non-moral. But just as evolution has been a creative process in that new things, and in particular man himself, have emerged in it, so it may well be that the process itself is being transformed : no longer, it may be, are new animal forms being evolved, but new levels of spiritual understanding are emerging. Boutroux died twenty years ago, but his "Religion and Science in Contemporary Philosophy" is not out of date. He said : "According to the results of science herself, there is nothing to guarantee the absolute stability of even the most general laws that man has been able to discover. Nature evolves, perhaps even fundamentally." He added that, if the remotest principles of things are thus transformed, that very transformation must obey laws which are analogous to the immediately observable laws of experiment. Are we wrong behind such change to find purposive activity, to postulate God as its source, and to see in the ethical change which results from the growth of human experience His progressive revelation of Himself ?

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COMMENT on Dr. Waddington's important and interesting paper is difficult because it raises so many questions which are highly controversial. Only a treatise could deal with them all. I must confine myself to some rather disconnected jottings. Frankly, I am not quite clear about the main

thesis. If it is that the natural sciences have a valuable contribution to make to the study of ethics, few would deny it ; if it is, as I think, the contention that the central problem for ethics can be solved by the method of natural science, that seems to me a disastrous error. No doubt science can throw light on the way in which minds come to apprehend values but, as it seems to me, it cannot determine whether they are truly values or only appear to be such, nor can it determine the scale of values, if any.

A certain scepticism about some of the alleged findings of science may be permitted. For example, the super-ego appears to me to be a piece of useful mythology ; probably it helps to "explain" the process by which we reach ethical maturity, but may it not be misleading to treat it as an "entity" ? The important fact is that mature and sane men have ideals which, as they believe, commend themselves to their reason, and sometimes they have imaginary pictures of themselves as they know they ought to be. Again, the diversity of moral codes at different levels of civilization can be exaggerated. Virtues which are honoured among us, such as courage or even kindness, are honoured in crude and more limited forms by people of lower cultures. The development of moral ideas is not determined wholly by social condition ; there is a dialectical development of the ideas themselves, and if it is true to say that societies create ideas, it is even more true to say that ideas create societies.

The use made of the psychological concept of "compulsions" perplexes me. As I understand it, a compulsion is an irrational and perhaps irresistible tendency arising from the unconscious. The moral experience in its authentic form is surely the opposite of a compulsion. The agent believes himself to have the responsibility of choice and the ethical "ought" is recognized not as something which must be obeyed but something which deserves to be obeyed, though it may be difficult and unpleasant. "Had it power (compulsion) as it has authority, it would absolutely rule the world." I am even more perplexed by what seems to be asserted about the goodness of evolution or even of all existence. "We must accept the direction of evolution as good simply because it *is* good." I think I must have failed to grasp this point, because in the preceding sentence we are told that revised ideas about evolution enable us to feel that it is not morally offensive, as T. H. Huxley thought it was. This seems to imply that Dr. Waddington has considered the course of evolution and found that it is not morally offensive. Now, how, on his own principle, could he possibly do that ? What criterion did he apply ? No doubt, as a theist I am bound to hold that there is a direction in evolution or rather that organic evolution is a part, perhaps a very small part, of the Divine purpose, but I see no reason to suppose that at any given moment the actual direction of evolution is towards higher values, and this is pre-eminently the case when the process is largely determined by human will.

There is a most fundamental problem raised for ethics by the evolutionary hypothesis. I wish that Dr. Waddington had said more about it. Shortly it is this : evolution appears to suggest that all moral ideas are relative, but the moral consciousness regards some of them as absolute and unless it does so the moral life is simply abolished. We are confronted with the situation now in every home. There are some things of such value that men ought to be prepared to die for them ; it is reasonable to be prepared to die for them. Why ? Men answer with action and, it may be suspected, deplorably confused notions of ethical theory ; but they act because, in their simple way, they believe that the voice of duty comes from a Source deeper and more intimate than the course of evolution.

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I JOIN issue with Dr. Waddington on two points. First, when he offers, as a typical example of a judgment that is at once ethical and scientific, the statement "You are an animal of such a kind that you must consume 7 mgm. of vitamin C per diem, and should consume 10 mgm.". I see nothing ethical here at all. The rules acquire ethical significance only when in a given case I judge the effort after survival, to which it prescribes the means, to be morally right or wrong. If I am the father of a family and there is only a limited supply of vitamin C available, it may be my moral duty to throw the rule to the winds and forego the means to my survival. The 'must' of the rule is not the unconditional 'ought' of morality, but the condition of attaining an end, as to the morality of which the rule says nothing. The 'should' in the last clause is ambiguous ; it may mean either 'you ought to' or merely 'you will have a better chance of surviving if you do'. The former meaning alone is ethical, but I fancy that Dr. Waddington intends the latter. He may reply that he sees no difference between the two, any more than when on a later page he identifies what is pleasurable or what leads to pleasurable results (two different matters, by the way) with what is good. We seem to be back in the dear old days of Herbert Spencer. Do fallacies never die, however often they are confuted ? If 'you ought' is identical with 'you'd jolly well better', and if 'this is good' is only another way of saying 'I find this pleasant', then the moral consciousness

is an illusion and a cheat, and the sooner we stop talking about it the better.

Dr. Waddington puzzles me, again, when he argues that the evolutionary process itself supplies us with a criterion of good, and that we need no other. I fail to see what he means by saying that this "cosmic fatalism does not imply a fatalistic attitude in the evolution of any particular section of the world", for example, of one's existing society. The 'psychological compulsions' with which he identifies ethical principles are surely, in his view, determinant of every act of every citizen in every race and age. If so, morals, whose business it is precisely to draw 'class-distinctions' among our natural impulses, vanish from the picture. Moreover, what ethical criterion can be derived from the scientific doctrine of evolution? Biology knows nothing of the qualitative distinction of higher and lower, better and worse; it can only display the continuity in the modifications of species through descent, showing what form of life succeeds what, and that certain more complex organisms have less complex organisms as their temporal antecedents. If the second law of thermodynamics should work its will and if all mind and all life should be eliminated from our planet, the process would be just as much an evolutionary process, in the sense relevant to biology, as that by which man has arisen from the ape. Apart from ethical presuppositions read in from other and non-scientific sources, evolution has no concern with value. The cosmic process is not indeed, as Huxley thought, immoral, save for those who indulge the 'pathetic fallacy' and interpret it in the light of their own emotions; but it is wholly amoral. The scientific study of it cannot teach us what is good or what we ought to do. It cannot even say 'must' in its predictions; it can tell us only what has been, what is, and what, in varying measure of probability, will be in the time to come. It cannot tell us that what will be is right or good.

These are my two grounds of dissent from Dr. Waddington, and I think they are fundamental to the issue. With much else in his article I cordially agree. But I venture to add a remark that travels a little beyond the scope of his discussion. It seems to me important to grasp the bearings of this amorality of Nature on our present world troubles. Are they not in large measure due to the fact that our knowledge of science, especially in its practical applications, has outrun, far outrun, our morality? Science has placed instruments of world-shaking power in the hands of rulers who abuse them for their own unrighteous ends. These instruments are in themselves, like physical Nature, non-moral. Neither Nature nor science is to blame for their misuse by man. Morality lies in the will to good, immorality in the will to evil, that is, in the choice of ends, not in the means to their attainment. Of those ends, whether they be good or whether they be evil, science, for all its glory, can tell us nothing.

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I PROPOSE to touch very briefly on those points in Dr. Waddington's article with which I agree, although, even where I agree, I cannot resist the temptation of entering a disclaimer against his uncritical taking over lock, stock and barrel of the pretentious jargon with which psycho-analysts disguise the commonplaceness of their observations upon the obvious. What, for example, does all this talk about the super-ego and its imposition upon the personality—is it, for example, upon "a merely receptive and featureless individual" or upon one who is "himself a factor in the origin of his super-ego" ?—really amount to? That there is an individual person exhibiting certain specific characteristics which distinguish him from others—my dislike, for example, of the taste of marzipan, or my delight in the smell of privet; that this individual is born and grows up in an environment and that his resultant beliefs, including his ethical beliefs, are the result of the impact of the environment upon the characteristics which distinguish him from others, as well as upon those which he shares with others. That, as it seems to me, is all that Dr. Waddington and Melanie Klein are saying, and, put like that, it scarcely seems to justify the fuss.

I agree again with Dr. Waddington's interpretation of Marxism. I agree, that is to say, that Marx *did* provide for changes in, as well as conservation of systems of, social ethics, while retaining my private opinion that the real agents of ethical change are to be found less in the factors that Marx and Dr. Waddington emphasize than in the appearance of an ethical 'sport' in the shape of a Christ, a Buddha, a Socrates or a Blake who points the way to new levels of conduct and new standards of value to which in course of time the accepted moral codes of society as a whole gradually creep up. Or don't creep up! If they don't, then, to adopt a biological metaphor, the 'sport' has failed to breed true. I deliberately employ the biological metaphor in witness to my belief that the process of evolution still proceeds by 'mutation', although the scene of its operations has now been largely transferred from the physical to the mental and spiritual spheres.

So much having been said by way of not very impressive agreement, I come to my two major quarrels.

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About the first I must say very little, not because it is not important but because it is subsidiary to Dr. Waddington's main thesis. He says that, if the contents of super-egos are taken to consist of general rules, they must be rules "of an extremely vague character". In more familiar language, the deliverances of men's moral consciousnesses vary so much that no general ethical principles as to what is good and right can be laid down.

I deny it, and claim that we do in fact all know, and always have known, that unselfishness is better than selfishness, kindness than cruelty. What is more, we can all recognize a case of cruelty when we see it and know that we ought to try and stop it—(the fact that we usually do not try is not to the point). I should go further and maintain that we do all of us know the sort of way in which we ought to live; that we know, in fact, that we ought to live very much as Christ enjoined. We may say that Christ's prescription for good living is wholly impracticable or is much too difficult; but that does not alter our conviction that it is the right prescription. The difficulty about ethics is not that we don't know what is right and know with a good deal of particularity, but that we lack the will or the ability to act in accordance with our knowledge.

Secondly, on Dr. Waddington's main point, I cannot understand how anything can be measured without a ruler which is external to and other than what it measures. Now to adjudge a movement as good or as bad—witness in this connexion Dr. Waddington's talk about "the 'good' direction of evolution"—entails that some meaning is understood to be conveyed by the words good and bad which serves as a standard of measurement by reference to which the movement is evaluated. Now this meaning cannot itself be part of the process which it is invoked to evaluate, any more than a ruler can be part of the length which it measures, or a man can lift himself by his own braces. Dr. Waddington points out that later stages of evolutionary development include the earlier. Certainly they do, but what of it? The later stages of a travelling snowball include the earlier, but that does not mean that the snowball's journey is ethically valuable or worthy of praise. It may not even be well advised; if it is heading for a precipice it is ill advised. The point is surely obvious enough. When Dr. Waddington affirms that evolution is moving in the right direction or is progressive—it is "good", he says, "simply because it *is* good"—he is applying ethical standards to it. Now all progress implies movement in a direction and direction implies a goal. If I put myself in the Strand and set my legs in motion, there is movement or process, but until I know whether I want to go to Charing Cross or Temple Bar I cannot say whether I am progressing or not. But the goal cannot be part of the process which seeks to realize it.

Once this is understood, it will be seen that the kind of question which Dr. Waddington is putting, when he applies the notion of 'right direction' to evolution and then proceeds to inquire whether our present direction is "right", is, *if we are to proceed on his premises*, like the question "Is it better to take the right fork or the left?" when asked by somebody who does not know where he wants to go; while further questions relating to the speed of the advance are like asking whether it is better to travel in a 40- or a 10-h.p. car, when you don't know where you are travelling, or whether it is good to travel at all.

C. E. M. JOAD.

Birkbeck College.

IN commenting upon Dr. Waddington's article, the need to be brief compels me to concentrate upon a single point and to say too shortly what requires to be argued with the help of detailed examples. The point I select for comment is that the contribution of science to ethics lies in its revelation of "the character and direction of the evolutionary process in the world as a whole", and that the examination of this direction will yield the criterion of human action. Although I am in agreement with much that Dr. Waddington says here and in his little book, "The Scientific Attitude", I find a serious difficulty in understanding his present argument. He maintains that the "real good" is that which has been effective, that is, that which has been exemplified in the course of evolution; accordingly, he argues that "we must accept the direction of evolution as good simply because it *is* good according to any realist definition of that concept". Presumably the word "must" in this sentence means "are logically compelled", so that our acceptance is an admission of what follows logically from the "realist definition" of good.

It is not, however, clear whether this is what Dr. Waddington means since he at once proceeds to drag in the notion of fatalism, in order to ward off a possible charge of being fatalistic. But such a charge would not make sense if I have correctly interpreted the phrase "we must accept". The difficulty is increased when we take note of the context in which the sentence I have quoted occurs. Dr. Waddington is disagreeing with T. H. Huxley's protest against accepting the cosmic process as the standard of ethical progress. The answer he makes consists of three parts, or—as I prefer to put it—he gives three different answers: (1) the method of evolution is to us—as contrasted with Huxley—"as unemotional as a definite integral";

(2) the results of evolution cannot be adequately summarized as an increase in bloodiness, etc.; (3) the course of evolution does not seem to us now "so morally offensive that we cannot accept it". But (3) seems to me to make a muddle of the argument. If good is defined as that which is effective, that is, that which is in the direction of evolution, what is the point of answer (2)? And if the concept upon which the method of evolution turns is unemotional, then why, again, bring in (2)? In short, it is not compatible with Dr. Waddington's "realist definition" of "good" to speak of the course of evolution as morally offensive or morally admirable. But his answer (2) suggests that he does think it necessary to show that Huxley was mistaken in his estimate of the blood-thirsty character of the struggle for existence. Suppose Huxley's estimate had been correct: would it make sense to say that the evolutionary process was morally offensive?

L. SUSAN STEBBING.

Bedford College,
London.

I HAVE read with great interest Dr. Waddington's lucid and well-reasoned essay in speculative metaphysics, into which he has ingeniously woven hypotheses derived from Freud and Marx, but I fail to see the alleged connexion between science and ethics. He says that the contribution of science to ethics is "the revelation of the nature of the character and direction of the evolutionary process in the world as a whole, and the elucidation of the consequences, in relation to that direction, of various courses of human action". (This might almost be a quotation from Herbert Spencer.) The direction of the evolutionary process may have been revealed to Spencer or Dr. Waddington, but not by science. It is said that Amœba and Hydra represent early stages in animal evolution, yet there are plenty of them alive still. For all we know they may survive long after Homo has perished by mutual slaughter. Would that make them better or worse from the scientific point of view?

The process of evolution has thrown up Hitler, Himmler, Goebbels and their like. If they were to win the War, would that show the direction of the evolutionary process? Evolution has produced the nightingale and the kingfisher we admire; also Sacculina, the parasite of the common shore crab, and also the matrimonial habits of spiders, which we do not admire. Does science tell us which is better? I select these examples because they are of no evident economic importance and our judgments may be considered disinterested. I am not arguing that these judgments of approval or disapproval are subjective or irrational, only that they are outside the scope of science. By reason of its method the only values within its scope are truth and error as judged by logical consistency and conformity to fact. If the logical positivists confined themselves to this assertion they would be on safe ground. I am not arguing, either, that Dr. Waddington's theory is wrong, only that, like every ethical theory (including the theory that there are no ethical distinctions or that they are meaningless), it rests on *a priori* presuppositions it is best to be honest about.

On a minor point, I must protest against the notion that it is a recent discovery that different societies have different moral codes. It seems to have been known to the author of the "Odyssey", and certainly to Herodotus a few centuries later. Lastly, may I recommend Dr. Waddington (and others interested in the relations of science and ethics) to read "Five Types of Ethical Theory" by Prof. C. D. Broad, where he will find his own type of theory labelled and docketted; and specially to read p. 284—the last page but one?

A. D. RITCHIE.

University of Manchester.

MUCH appreciation is no doubt widely felt for Dr. Waddington's statement that, if various modern theses are correctly interpreted, ethical judgments are allowed by them to be "statements of the same kind as scientific statements". One also agrees with his view that the putting forward of these theses has somehow persuaded many people of a lack of any link between science and ethical systems. This seems a natural temporary reaction belonging to what Samuel Alexander called the deanthropizing phase of thought. For millennia, men have sought authority for social codes in anthropomorphs created by their imagination outside the evolutionary sequence and empowered to insert into it new items—dispensations they have been called—from time to time. The comparative method in the study of man, outstandingly represented by Frazer, has vividly suggested that what were held to be impregnable rock-fortresses of traditional belief are, rather, erratics in the moraines of folk-lore. The old authority has gone. It withered too, at a time when an individualist age was obsessed with the idea of Nature red in tooth and claw, and even a Huxley could suggest that men's ethical systems must stand in antagonism to the cosmic process.

In their various ways Alexander, Lloyd Morgan, Smuts and Sherrington are trying to get us beyond the inevitable phase of disorientation. Unlike older systems, the work of science must not claim to give us something complete and unchanging;

it must have ever-recurring readjustment as its key note. Would that those who are busy making blue-prints of a better world would realize this; so many of their schemes are static! Perhaps a main contribution of the humanist at the present juncture is the thought that man is a social being, and that, within society, there is an unceasing and not always successful struggle towards freedom of conscience, towards replacement of external by internal factors. One may add that the survival-value of this freedom is related to the facts of observation and inference, namely that life's history on earth has been a process of ever-recurring readjustments, and that, with few exceptions, the fate of those forms which did not readjust has been extinction. At the same time, it should be remembered that these developmental adjustments are selective; if some features are enhanced, others are atrophied. So it is not very wise to suggest that the later include the earlier; that unduly simplifies the idea of change and suggests acceptance of the rather crude notion of the inevitability of progress.

H. J. FLEURE.

University of Manchester.

OUT of the breakdown of traditional systems of thought, glimmers of new light appear, islands of solid land emerge out of the chaotic flood. Dropping metaphor, the question is whether any new system of thought, sufficiently strong to provide the foundation for living, can be evolved in time to substitute reintegration for disintegration. As science has played a major part in bringing about the disintegration of the old, it should attempt to do at least as much in the new integration.

Dr. Waddington's interesting article is a valuable contribution to this. As he points out, psychology, anthropology and sociology have largely contributed to the breakdown of traditional views on ethics. He might have added many other sciences. Evolutionary biology is one, with all its implications as to human ancestry, the struggle for existence, and the abolition of the idea of purpose in evolution. All the physical sciences have contributed, by providing a mechanistic explanation of natural phenomena previously attributed to supernatural powers and often invested with an ethical aura—witness the legend of the rainbow in the Old Testament, or the frequent view of lightning, floods or earthquakes as expressions of Divine anger. Similarly, physiology and pathology have removed deformity and infectious disease from the ethical sphere; they are no longer considered as Divine retribution for moral lapses.

When it comes to the constructive side, I have little to add to Dr. Waddington's interesting thesis. He might, I think, have pointed out that in some cases science indicates a new ethic, or at least a new type of ethical approach to old problems. This may be illustrated by my last example. We can no longer believe that pestilence has any connexion with moral lapses in the conventional sense, or with the failure to observe certain rituals or to believe certain dogmas; but we can lay down certain new types of moral duty arising out of the nature of infection—duties both individual and social, concerning cleanliness and the prevention of disease and of its spread.

I have two specific comments. One concerns the basis for the quality of absoluteness and other-worldliness possessed by the super-ego and the systems of ethics for which it is the vehicle. Dr. Waddington makes what I believe to be the quite novel suggestion that this is connected with the breakdown of the solipsistic early phase of the child's existence. While this may be a contributory cause of the other-worldliness, I cannot feel that it accounts for the absoluteness, for the fact that certain aspects of morality are felt as a categorical imperative. The origin of this, as I have elsewhere suggested, must more probably be sought in the all-or-nothing method adopted in higher animals for avoiding conflict. This has been proved to operate to prevent conflict between antagonistic muscles and between competing reflexes. Observation shows that it must also normally apply to competing instincts in sub-human vertebrates. Finally, all we know of human psychology indicates the strong probability that it operates in repression in early life. Man is the only organism in which conflict is normal and habitual, so that some form for minimizing its effects is essential; and this will be of the greatest importance in early childhood, before sufficient experience has been accumulated to enable conflict to be dealt with empirically and rationally.

The antagonistic forces which hold down repressed ideas and impulses are kept away from the main body of consciousness; hence the apparent externality of ethical law. They are held there by the strong but automatic processes of repression; hence the compulsiveness of the super-ego. And repression is, or attempts to be, total, seeking to keep certain impulses wholly out of consciousness; hence the all-or-nothing character of the ethical prohibitions of the super-ego.

Some repressions are more complete than others; and in many cases the degree and method of repression can be modified or the prohibitions of the super-ego transferred in their operations from one field to another. Hence we may say that a great part of our ethical development will consist in diminishing the absoluteness and compulsive-

ness of our early categorical imperatives, and in altering the field to which they apply, in the light of reason and experience.

Put in another way, we may say that primitive and absolutist ethics, based on the non-rational and unconscious processes of the mind, inevitably tend to limit human activity by locking up conflicting psychological 'energies' in the repressive mechanism of the unconscious. For constructive and truly humanistic ethics, we need to liberate these forces from their unconscious grappling, through reason and still more by appropriate education and by opportunities for fuller living.

The other point which I would like to make is perhaps even more fundamental. Dr. Waddington writes: "an existence which is essentially evolutionary is itself the justification for an evolution towards a more comprehensive existence". While this is true, it is so general as to smack of Panglossic optimism. It is an observed fact that the majority of evolutionary trends are either irrelevant to progressive change, or are even opposed to it in direction, or are inherently limited specializations. As I have set out at some length elsewhere (in the first essay in my book "The Uniqueness of Man") evolutionary progress can be objectively defined, and further is a rare phenomenon; the potentialities of further true progress now appear to be restricted to our own species, though there is no guarantee that we shall achieve them. The problem here is thus to study the possible directions of change; to decide which make for progress and which do not; which make for unlimited and which for limited progress; and to attempt to adjust our social systems and our ethical ideas in such a way that, as Dr. Waddington rightly points out is possible, they should form a mutually reinforcing whole, making for the maximum speed of progress in the correct direction.

Dr. Waddington points out the difficulties arising from the fact that the ethical systems of different societies differ enormously, one conception of the good often contradicting another. Here again there is an evolutionary parallel. Thanks to the work of Sewall Wright, we know that small and isolated animal and plant species will often show 'accidental' differentiation, which is not necessarily biologically advantageous, and may sometimes even be disadvantageous. The same appears to apply to the evolution of cultures.

Further, as Darlington has pointed out in his recent book, "The Evolution of Genetic Systems", certain evolutionary changes may be of immediate advantage, but of eventual disadvantage in robbing the stock of evolutionary plasticity and adaptability. Here again there are doubtless parallels from ethics. The short-term efficiency of ruthless State dictatorship as opposed to the inevitable long-term triumph of more humanistic systems is a case in point.

With such modifications, Dr. Waddington's thesis of ethical systems as indispensable social organs, derived from the impact of a changing external world on the minds of individuals via the social environment, but themselves then helping to effect changes in the external world and the social environment, appears to be a fundamental one, and worthy of the most careful study.

JULIAN S. HUXLEY.

Zoological Society of London.

SCIENCE AND MARXIST PHILOSOPHY

IT is a little more than ten years since the London Congress on the History of Science. It was there that the Soviet delegation first brought effectively to the notice of British men of science the contributions that Marxist thought had to make to the natural and social sciences. The symposium organized by Marx House held during August 16–17 has served to show that there is now a widespread and growing interest in this development, and that we are clearly on the way towards a more profound and comprehensive appreciation of science as a human social activity. The two days sessions of the symposium had as keynotes two of Engels' works, "The Dialectics of Nature" and "The Origin of the Family", illustrative of the scientific and sociological aspects of his work.

The first was introduced by Prof. H. Levy, who discussed the changes that the present century has brought about in the attitudes towards philosophy and science, contrasting the older tendencies towards pure science cultivated for its own sake with those of a planned science in the service of the community. He showed how the former tendency is working itself out in the direction of the claims of *a priori* knowledge, as evidenced in the recent discussion in NATURE between Jeans and Eddington. The majority of men of science, however, are coming more and more to see their activity as part of social enterprise, and to realize that science represents the achievement of human action in an infinite field of ignorance; indeed, that in a sense, the man of science creates new ignorance with every problem he solves. The old absolute views of knowledge and logic are giving way to one in which probability has a much greater part. We need for the advancement of

science a philosophy that will take all these tendencies into account; and the basis of that philosophy has been laid by Marx and Engels.

Dr. J. Needham provided an interesting analysis of Prof. Whitehead's philosophic opinions. Although Whitehead probably never read Marx, he was led, in attempting to achieve a unitary view of biological and physical phenomena, to an attitude essentially similar to that of the dialectical materialists. In his insistence on the close relation between succession in time and a series of envelopes in space, Whitehead developed a hierarchical series of organizations passing from the purely physical structures of atoms to those of animals, and ultimately societies. Whitehead failed, however, according to Needham, to push his arguments to any practical conclusions, not seeing that any further stages in organization were yet to come.

Prof. J. B. S. Haldane took up the question of the development of science since the writing of "Dialectics of Nature". In that book Engels stressed the chief scientific discoveries—notably the law of the conservation of energy and the theory of evolution—that led to the breakdown of the older and essentially static views of the universe. Haldane carried the analysis on through the achievements of present-day science. He laid particular stress on the fact that the breakdown of boundaries between the different sciences has progressed much further than in Engels' time. The development of modern physics, with its fundamentally dual aspects of wave and particle, fits in particularly well with the dialectical picture that Engels developed. Recent cosmological research has shown that even the laws of physics cannot be taken as fixed and unalterable, but are only so in relation to our very limited experience of time. Everywhere, the picture of the universe as a series of transformations brought about by internal instabilities is gaining ground. The great developments of biochemistry and genetics are providing new links in the chain that joins the inorganic and the organic worlds.

The second day of the symposium was devoted to social and anthropological subjects. Here, as in the natural sciences, a remarkable change has come about in the last few years. Emphasis on the importance of social and economic conditions in anthropological and historical studies has become almost universal. Prof. G. Thomson in his introductory paper provided a brilliant study of that neglected nineteenth-century pioneer, Morgan, the virtual discoverer of the universal form of society, based on clan organization and matrilinear succession, that has preceded our own individualist family organization. Engels took up Morgan enthusiastically in his "Origin of the Family", but more recent anthropological work seems to discredit many of Morgan's conclusions. Prof. Thomson discussed these criticisms in the light of the most modern evidence, and showed that though Morgan's view is necessarily limited by the comparatively undeveloped anthropology of his time, his main conclusions have only been confirmed and enlarged. Similarly in physical science, the reaction against the disturbing character of these views led to a sheer obscurantism and the denial of any principles in history or in social development.

Dr. Barbara Ruhemann discussed the economic origins of the universal totemism that accompanies the clan family organization, and further discussion on this subject was provided by papers by Mr. Lionel Naftalin on the relations between slavery and feudalism, and by Prof. Pascal on the *gens* in primitive Germanic society. All these went to show how rich a clue to the study of social origins is furnished by the work of Morgan and Engels.

The new unification of the sciences and humanities was brought out in a striking way in two papers on medicine presented by Prof. B. Farrington and Dr. Ruscoe Clarke, on the subject of the social significance of medicine in early times, and at the present day. Prof. Farrington traced the way in which medical practice has turned from primitive social health service embodied in practical healing lore to a pretentious and specialized medical practice for the benefit of the rich; showing how the emergence of a leisured class has distorted the development of medicine. He pointed out how from the period of the rise of the Greek City State to the eighteenth-century enlightenment, medicine consistently neglected a study of the diseases afflicting the common people, and even more of the special diseases which their conditions of work produced. The breakdown of this attitude began in the eighteenth century with the pioneer studies of industrial diseases by the Italian doctor, Rammztini. Dr. Clarke stated that economic factors in present-day society distort medical practice and theory. Here, again, the inability to solve the real problems of public health in a society which cannot provide basic nutrition and environment has led the older school into a complete denial of medicine as a science, and to the emergence of irrational and mystical elements.

The symposium, to judge from the unexpectedly large attendance and the animated discussions that followed each contribution, must have supplied a need that has existed for some time. There is room, however, for much more effective co-ordination of the different contributions, and for developments both in the direction of far more thorough discussion among experts, and clearer popular exposition. J. D. BERNAL.

NEWS AND VIEWS

Augustin Pyramus de Candolle, For.Mem.R.S.

ON September 9 occurs the centenary of the death of the famous Swiss botanist Augustin Pyramus de Candolle, the contemporary of de Saussure and Prévost and the father of Alphonse de Candolle (1806–93). Born at Geneva, February 4, 1778, he was the son of a magistrate of the republic of Geneva and received a good education. His taste for botany was stimulated by attending the lectures of Prof. J. Vaucher (1763–1841), a founder of the Geneva Natural History Society, and while still in his 'teens de Ca dolle went to Paris, residing at the house of Dolomieu and becoming acquainted with such as Vauquelin, Fourcroy, Cuvier, Lamarck and Desfontaines. In 1798 owing to the decline, through the political upheaval, of the family fortunes, he took up the study of medicine, but botany still remained his chief study, and in 1804 he began to lecture in the place of Cuvier at the Collège de France. In the summer of 1806 he began a series of official botanical journies through France and Italy, and in 1810 was appointed to the chair of botany at Montpellier with charge of the old botanical gardens.

In 1816 after the Restoration, de Candolle returned to his native land and was made professor of natural history at Geneva, a post from which he retired in 1834 through ill-health, when he was succeeded by his son. A man of the highest character, he was honoured alike by his fellow citizens and by foreign societies. His writings, which began with a memoir on lichens, were very numerous. His great work "Regni Vegetabilis Systema Naturale" was begun in 1818 but the too extensive scale of his work led to the commencement of his "Prodromus Systematis Naturalis Regni Vegetabilis", which was continued after his death by his son and other botanists. It is related that while at Montpellier, after the fall of Napoleon, he was instrumental in saving the Emperor's mother and sister Pauline from the danger of a mob by hiding them in the botanical garden. "Like all truly great men", it has been said, "de Candolle was modest; and the consciousness of his own worth is shown by the lenity with which he judged others, and in the heartiness with which he applauded their services."

Augusto Murri (1841–1932)

PROF. AUGUSTO MURRI, one of the most celebrated Italian physicians of recent times, was born at Fermo on September 8, 1841. He studied medicine at Camerino and Florence, where he qualified in 1864. After receiving post-graduate instruction in Paris, Berlin and Vienna, he returned to Italy, and after a period of private practice became assistant to Baccelli in the medical clinic at Bologna in 1871. Five years later he succeeded Baccelli as professor of medicine, and in spite of many tempting invitations from other Italian universities he remained at Bologna until the retiring age of seventy-five in 1916. His principal publications were devoted to the regulation of temperature, the theory of fever, the Cheyne-Stokes phenomenon, hæmoglobinuria from cold, tumours of the cerebellum, clinical lectures, medico-legal reports, organotherapy and glandular insufficiency. In 1912 he was the recipient of a *Festschrift*. Selections from his works were published by Gnudi and Vedrani in 1919. He died at the advanced age of ninety-one, and on the day of his burial the city of Bologna founded an Augusto Murri prize in medicine.

Contra-rotating Airscrews

MESSRS. ROTOL AIRSCREWS, LTD., have now completed the development, to the production stage, of a constant speed contra-rotating airscrew, the principle of which was mentioned in NATURE of May 17, 1941, p. 602. This model consists of two three-bladed airscrews mounted on the same centre line, normally the engine hub, rotating in opposite directions. The aerodynamic efficiency of this device is not appreciable at flight speeds of less than three hundred miles per hour, but above this it is worth while, and at five hundred miles per hour it gives an increase of about 7 per cent. One particular example weighs 497 lb., compared with 450 lb., for the normal airscrew. Metal or wooden blades of any detachable type can be used equally well. The de Havilland Aircraft Co., Ltd., and the Fairey Aviation Co., Ltd., have also announced the production of contra-rotating airscrews.

The development of this device is the logical answer to the peculiar conditions arising in war machines, in that the increasing powers given by the newer aero-engines are not used to equip larger aircraft, but rather to improve the performance of those of the present-day dimensions. It is not possible to obtain more blade area by increasing the diameter of the single propeller because of ground or water clearance, and also because the blade tip speed, being too high, would make that part increasingly inefficient. Reducing the rotational speed to counteract this would give more slip and make the rest of the blade less efficient, and would call for a considerable gearing down, as the higher-powered engine is usually of high speed itself. Obtaining extra area by increasing the number of blades is not practicable as the thrust of each blade is spoiled by the interference of the preceding blade. There are also other advantages in the flying operation of fighting aircraft which were discussed in the previous note in NATURE.

Architects and Post-War Reconstruction

THE Reconstruction Committee set up by the Royal Institute of British Architects to consider and formulate the policy of the Institute and allied societies in post-war reconstruction and planning in its widest aspects has organized its work in three sections. A small group has been appointed to carry out work involving analysis of the position of the architectural profession in relation to physical reconstruction, and also on practical considerations in connexion with

reconstruction on which the Government may seek advice from the profession. Consideration is being given to the question of professional status, particularly relating to a national planning authority and its regional and local administration, to town planning qualifications, covering an architect's qualifications for town planning and the possibility of including town planning in the curriculum of education of an architect.

A housing group, building legislation group, a building industry group and a building technique group which will consider building science and technique with reference to the probable shortage of certain building materials, and to the possibilities of standardization, prefabrication and the use of synthetic materials are also at work. These groups will record their findings in a concise report for submission to the main committee. A policy group has also been formed consisting of the chairmen of all these groups as well as of the publicity sub-committee which will deal with propaganda on broad lines to demonstrate to the public the immense opportunities underlying national reconstruction and the part the profession can play in this work. The groups are intended to concentrate on co-ordinating existing information rather than initiating new research and the committee has suggested that each group should submit a preliminary report within six weeks and progress reports thereafter at monthly intervals.

Great Britain and the U.S.S.R.

THE Executive and Social Relations Committees of the Association of Scientific Workers have transmitted the following resolution through the Soviet Embassy to men of science and technicians of the U.S.S.R. : "From the Executive and Social Relations Committee of the Association of Scientific Workers to the scientists and technicians of the U.S.S.R. : The Association of Scientific Workers, representing scientists in all branches of science in Great Britain, sends its wishes of goodwill and friendship to the scientific workers of the U.S.S.R. It considers that the closest collaboration in the technical and scientific spheres is essential to the speedy victory of the British and Soviet peoples in their common struggle against Nazi and Fascist aggression. To this end it urges the exchange of technical information and of delegations of scientists between the two countries, and the promotion of personal contact between workers in the same fields."

Monthly Science News (*M S N*)

THE British Council, at the suggestion of its Science Committee, has decided to issue a monthly broadsheet surveying scientific developments in popular terms. The broadsheet is being edited by Mr. J. G. Crowther, secretary of the Science Committee, whose name will be sufficient guarantee that the material presented will be both accurate and readable. The first issue is dated August, and contains paragraphs on the distance of the earth from the sun, a new breed of chicken in which sex is determinable at a day old, barrenness of fruit trees, the two types of diamond disclosed by X-ray examination, the hardening of insect cuticle, and measurement of the temperature of liquid steel. The Press is invited to reproduce any of the material without fee subject to acknowledgment by the initials *M S N*.

The Engineering Industry in the U.S.S.R.

AN informative article by V. A. Bary on "The Engineering Industry in Russia" is published in *Engineering* of August 15. He reminds us that until the eighteenth century, timber was the basic material of all Russian engineering works, and the skill of the carpenters who were the architects and builders of the old Russia was, and remained, of the highest standard of craftsmanship. The first Russian iron and steel industry was established in the central part of the Volga basin and in the Urals. Until the south of Russia developed its own coal and steel industry, the north was the only provider of these commodities and hence the priority of the northern carpenters among the Russian engineering trades. When the first steel tankers to carry paraffin from Baku up the Volga were built in 1880, the wooden-ship builders maintained a vigorous and for some time quite a successful rivalry, using wooden tankers ranging in displacement up to several thousand tons. Similar resistance was offered in bridge-building and other branches of structural engineering to iron and steel.

In 1913, the Russian iron and steel industry produced only about five million tons. In 1938, the output of iron and steel was in excess of 25½ million tons, as compared with the 35 millions produced in Germany. These commodities are the basic materials of engineering, and the comparative figures afford an idea of the growth of the engineering industry over the same period of time. Russia is still primarily an agricultural country, and one of the first directions in which intensive mechanization was pursued was that of providing tractors for farming purposes. There were in 1939 more than six thousand tractor stations distributed over the 540,000 square miles of cultivated land. Air transport of goods, passenger and mails has been extensively developed ; 69,000 miles of air routes were in operation at the outbreak of hostilities.

War-time Catering in Canteens

A BOOKLET has just been issued by the Ministry of Food for the benefit of 'British Restaurants', industrial canteens and other large-scale feeding-centres. This booklet has been compiled as a result of a nine-months investigation and experiment in industrial canteens in all parts of England, Scotland, Wales and Ireland, and all recipes have been tested in such canteens. Each day's suggested meal has been built up on the principle of the Oslo breakfast, to provide in one meal a high proportion of the day's requirements of essential vitamins and mineral salts. Averaged over six consecutive days, the analysis is as high as that of the Oslo breakfast.

The aim throughout has been twofold ; first to show how it is possible to provide attractive and palatable meals of a high nutritional standard under

the present difficulties of rationing and supplies; secondly, to take the present opportunity of food consciousness to change gradually the food habits of the majority of working-people in Great Britain so that the standard of the national diet is improved rather than allowed to deteriorate. For this purpose, it will be observed that all bread is given as national wheatmeal, a raw vegetable is included in every meal in some form or other, cooked vegetables are suggested in much larger quantities than is usual in canteens and oatmeal or wheatmeal flour is used freely in cooking. The booklet is being issued free to all 'British Restaurants', industrial canteens and Londoners' meal services. Copies can be obtained from the Nutrition Section, Food Advice Division, Ministry of Food, Vincent House, Vincent Square, London, S.W.1.

The Newcomen Society

THE Newcomen Society, which this year attains its majority, has recently issued its syllabus of meetings in Great Britain for the session 1941–42. The presidential address of Col. C. E. Davies will be read on November 12 after the annual general meeting. Thirteen papers are included in the syllabus. Among the subjects to be dealt with are automobiles, Suffolk windmills, spring balances, wood screws, and natural draught furnaces. Dr. Thurston is giving a paper on "The Evolution of Rider Planes for Aircraft", Dr. Herbert Chatley one on the "Development of Mechanism in China", and Dr. Dickinson is giving papers on Robert Stuart Meikleham and Joseph Bramah. Other papers relate to early engineering and iron-founding in Cornwall, the French civil engineers of the eighteenth century, and the famous firm of shipbuilders, Messrs. Normand of Havre. In the *Newcomen Quarterly Bulletin*, probably the last to be issued for the time being, are some interesting quotations from letters received from members in the United States.

Comet Okabayasi-Honda (1940*e*).

IN NATURE of March 29, p. 387, a note about this comet appeared, and it was stated that it was discovered at Tokyo on October 4, 1940. Dr. Issei Yamamoto has pointed out that an error has occurred regarding the place of discovery. Okabayasi is at Kurasiki Observatory, which is under the direction of Yamamoto, and early in the morning of September 30 he discovered the object in Leo, suspecting its cometary character at the time, though he was not able to confirm its motion until October 4. Honda is at the Zodiacal Light Station at Seto, Hirosimaken, also under the supervision of Yamamoto, and independently discovered the comet on October 4. From his long experience as an observer he was immediately convinced that it was a comet and reported his discovery to Yamamoto, who met both observers at Kurasiki on October 5 and cabled to Copenhagen. A telegraphic announcement was also made from Tokyo Observatory, and it is possible that some confusion was caused by this. It is very satisfactory to know that the Astronomical Society of the Pacific has awarded the Donohoe Medal to both discoverers.

Announcements

PROF. LANCELOT HOGBEN, F.R.S., regius professor of natural history in the University of Aberdeen, has been appointed Mason professor of zoology in the University of Birmingham in succession to Prof. H. Munro Fox (see NATURE, June 28, p. 800).

Dr. L. L. Bircumshaw has been appointed lecturer in inorganic chemistry in the University of Birmingham.

THE Minister of Agriculture and Fisheries has appointed the Hon. Mrs. Youard to be an additional member of the Committee set up on July 21, under the chairmanship of Lord Justice Luxmoore, to examine the present system of agricultural education and to make recommendations for improving and developing it after the War (see NATURE, August 9, p. 161).

AT the recent annual meeting of the U.S. National Academy of Sciences, a National Science Fund was established to administer funds for the support of scientific research. The Fund will be managed by a committee under the chairmanship of Dr. William J. Robbins, director of the New York Botanical Gardens, and consisting of seventeen members of the National Academy and twelve others well known in public life or industry.

THE report of University Extension Lectures and Tutorial Classes of the University of Leeds, for the year 1939–40, is a record of steady progress under adverse conditions arising from the War. In all, 78 tutorial classes and 5 sessional courses were attended by 1,063 students. The great majority of the lecture courses dealt with such subjects as literature, social philosophy, economic and political questions and current movements of the day. Of scientific subjects seven courses were held in biology, three in psychology and one each in physiology and geology. The marked absence of any lectures dealing with the physical sciences remains as a challenge to men of science to present their subject in a form acceptable to an ordinary unselected adult audience.

IN accordance with the trust deed governing the Harrison Memorial Fund, the Selection Committee consisting of the presidents of the Chemical Society, the Institute of Chemistry, the Society of Chemical Industry and the Pharmaceutical Society, will make an award of the Harrison Memorial Prize in December. The Prize, of the value of about £150, will be awarded to the chemist of either sex, being a natural born British subject and not at the time more than thirty years of age, who during the previous five years has conducted the most meritorious and promising original investigations in any branch of pure or applied chemistry and published the results of those investigations in a scientific periodical or periodicals. Further information can be obtained from the Secretary, Chemical Society, Burlington House, Piccadilly, London, W.1.

ERRATUM.—In a recent communication (NATURE, 148, 226; Aug. 23, 1941) the dissociation products of carbon dioxide were given as $CO(^3\Omega)+O(^3P)$. This was a printer's error and should read $CO(^3\Pi)+O(^3P)$.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. They cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

Post-mortem Darkening of Plant Tissues and its Relation to Respiration

THE darkening of plant tissue following extensive mechanical damage is a frequently observed phenomenon and is due to irreversible oxidation of polyphenols. The effect is particularly well marked in the tea-leaf, where the tannin oxidation results in the development of the characteristic copper-red colour of 'fermented' tea-leaf.

It is possible to effect a full fermentation of tea-leaf, that is, a complete oxidation of all the tannins present, while still preserving the cellular nature of the tissue. After fermentation, following extensive mechanical damage, the cell walls are largely intact; and it is observed that the tannins are no longer localized in the vacuoles but are distributed throughout the whole tissue. It follows that rupture of the outer cell wall is not essential for irreversible oxidation of tannins to take place.

The necessary damage to the tea-leaf is best achieved by subjecting the wilted leaf to a shearing force such as is obtained by rubbing it between the finger and thumb or between the palms of the hands. While such treatment has but little effect on the integrity of the outer cell walls, it has been claimed by Phillis and Mason[1] that comparatively small shearing forces have a disruptive effect on the continuous phase of the cytoplasm.

The effect of such shearing forces on the respiratory activity of the leaf is marked. The capability of undergoing anaerobic fermentation may be almost completely inhibited[2] and oxygen uptake under aerobic conditions is also suppressed unless an oxidizable polyphenol is present[3].

Results to be presented shortly interpret this effect in tea-fermentation as due to coenzyme inactivation. The disruptive effect on the cytoplasm may be considered as affecting the orientation of molecules in protein-phosphatide monolayers where adsorption of coenzymes I and II is a necessary adjunct to the transfer of hydrogen from respiratory substrates to carriers of the cytochrome type. The effect of the destruction of the organization of such monolayers will be to inactivate the coenzymes by restricting their sites of activity, and hence to reduce respiratory activity to low levels. If the vacuole originally contained appreciable amounts of polyphenols, these latter substances may now penetrate into the cytoplasm where they undergo direct oxidation by the oxidase system to form deeply coloured pigments. Until this oxidation is complete, the tissue may consume oxygen at a rate higher than that when undamaged, but when the polyphenols are oxidized the uptake sinks to the same low levels found for tissues free from polyphenols. The respiratory quotient during the rapid oxygen uptake is low.

There are other means of inducing irreversible oxidation of polyphenols in vegetable tissues including treatment with anæsthetics such as chloroform, and subjecting the leaf to a temperature of about 50° C. In both these cases it is observed that the cytoplasm is rendered freely permeable to the vacuole contents. Further, the solvent effect of the chloroform on the phosphatides or the denaturing effect of the elevated temperature may be expected to result in a destruction of the organization of protein-phosphatide monolayers fully equal to that brought about by shearing forces.

The effects of anæsthetics, moderate heat and mechanical damage involving shearing forces on the respiratory activity of vegetable tissues are therefore to be considered as essentially similar. Enzyme inactivation is not responsible for the diminution in respiratory activity, and the effects are to be interpreted as due to the inability of the coenzymes to couple the oxidase system and dehydrogenases in the disorganized tissue. Polyphenols present in the vacuole may then penetrate into the cytoplasm to undergo oxidation catalysed by the oxidases. Some secondary oxidation of respiratory substrates by the *o*-quinones may be brought about through the coenzymes now in homogeneous solution, but the respiratory quotient values observed (0·2–0·5) for different plant tissues indicate that the greater part of these *o*-quinones undergo further irreversible changes, with pigment production, before being able to function as hydrogen acceptors in this way.

E. A. HOUGHTON ROBERTS.

Indian Tea Association,
Tocklai, Cinnamara P.O.,
Assam.
May 6.

[1] Phillis and Mason, NATURE, **140**, 370 (1937).
[2] Deb and Roberts, *Biochem. J.*, **34**, 1507 (1940).
[3] Roberts and Sarma, *Biochem. J.*, **34**, 1517 (1940).

Blackening of Potato Tubers on Boiling

IT might be of interest to state one or two facts which may have some relation to the hypothesis advanced by Miss Ursula M. Robison[1], that the blackening of potato tubers on boiling is caused by the black oxide of iron produced by oxidation from ferrous iron liberated from a loose complex, probably in association with proteins, as the result of hydrolysis on boiling.

From an examination of potato samples derived from about forty modern replicated fertilizer experiments, designed in association with Dr. E. M. Crowther of Rothamsted Experimental Station, I found that the typical grey to black discoloration which develops after boiling was confined to tubers grown on potash-deficient plots in association with a relatively high nitrogen level in the soil.

It has been shown by various workers that in potash-starved plants the amino acids increase relatively to the protein, and it has been suggested that this is due, at least partly, to the breakdown of protein in the prematurely ageing plants. These changes may cause an abnormal distribution of iron in potash-deficient plants and produce a greater concentration in potato tubers. Hoffer[2] has shown that

maize plants grown under conditions of potash deficiency do accumulate iron compounds in the node tissue and that the tissue develops a dark purplish-brown coloration and breaks down. He actually developed from this observation a method of diagnosing potassium deficiency in the soil, based upon the application of an acid solution of potassium thiocyanate to the nodule tissues of corn stalks when cut open lengthwise.

It would have been interesting to know whether Miss Robison found any significant differences in the potassium content and in the potassium-iron ratios between normal tubers and those that went black after boiling.

G. A. COWIE.

Sauncey Crook,
Sauncey Avenue,
Harpenden.
Aug. 15.

[1] NATURE, **147**, 777 (1941).
[2] Purdue Univ. Agric. Exp. Sta., Bull. 298 (1930).

Vitamin C Content of Fresh, Canned and Dried Guavas

THE common guava, *Psidium guajava*, has not as yet received the recognition which it deserves as a potent source of ascorbic acid. Both in Hawaii[1] and in India[2], values as high as 300 mgm. per 100 gm. have been reported for the fresh fruit, although many lower values are to be found in the literature.

We have investigated the vitamin C content of guavas from various parts of the Transvaal and the Cape Province. Ascorbic acid has been estimated by titration with indophenol in aqueous or dioxane solution, after extraction of the material with a 2 per cent solution of metaphosphoric acid. Canned guava juice has been assayed biologically by Key and Elphick's modification of the Hojer tooth method, the results being in agreement with those found by the chemical method.

Condition of fruit	Ascorbic acid content in mgm. per 100 gm.
Green and hard	250–350
Ripe and firm	300–450
Over-ripe and soft	50–100

In the above table is summarized the variation of vitamin C content of the fruit as a whole with its condition. It will be seen that the amount of ascorbic acid present in the fruit increases as it ripens but soon diminishes as the guava becomes soft. Firm fruit of high vitamin content may be stored at room temperature for several weeks without serious loss of vitamin but where the guava is ripe or infected with fruit fly the value decreases rapidly.

There does not appear to exist a wide variation in the vitamin content of fruit of different varieties or from various districts. On the whole, however, white-fleshed guavas are usually slightly richer in ascorbic acid than those with pink flesh.

Of the different parts of the fruit, the skin has the highest content, the inner pulp contains little, and the stones none at all. The proportion of ascorbic acid found in skin, outer pulp and inner pulp may be as high as 12 : 5 : 1.

When selected firm fruit is canned the ascorbic acid present in fruit and juice reaches levels of 200–300 mgm. per 100 gm. The use of soft fruit is attended by a sharp decrease in the vitamin content, values as low as 18 mgm. per 100 gm. being found in some cases. These low values also obtain under conditions favourable to the oxidation of the vitamin such as pulping or overcooking.

The most successful procedure for the preservation of the vitamin has been found by us to be drying at low temperature. The unpeeled fruit is quartered, the central pulp and stones removed and the residue blanched for two minutes. Thereafter the fruit is dried at 130° F. for 10–12 hours and powdered. Powdered guava prepared in this manner contains 2,500–3,000 mgm. per 100 gm. (white) and 2,000–2,500 mgm. per 100 gm. (pink). Failure to blanch the fruit prior to drying results in lower values (1,000–1,500 mgm. per 100 gm.). Thus dried guavas compare favourably with other rich sources of the anti-scorbutic vitamin such as dried rose hips, reported by Lund, Spur and Fridericia[3] to contain 2,000 mgm. ascorbic acid per 100 gm. Moreover, the guava powder has a pleasant aromatic odour and practically no taste.

The above results, taken in conjunction with the wide distribution of the various species of guava and the ease with which they can be grown, justify their extensive cultivation and consumption. Full experimental details will be published later.

We wish to express our appreciation of the assistance and co-operation accorded us by officers of the Food Inspectorate (Q Service-Supplies) and the Mobile Laboratory Unit of the South African Medical Corps.

LEON GOLBERG.
South African Institute for Medical Research,
Johannesburg.
LEOPOLD LEVY.
Government Chemical Laboratories,
Johannesburg.
July 12.

[1] Miller, C. D., Bazore, K., and Robbins, R. C., Hawaii Agric. Exp. Stat., Bull. 77 (1936).
[2] Ranganathan, S., *Ind. J. Med. Res.*, **23**, 239 (1935).
[3] Lund, H., Spur, B., and Fridericia, L. S., *Biochem. J.*, **28**, 1825 (1934).

Intergranular Changes in an Iron Alloy

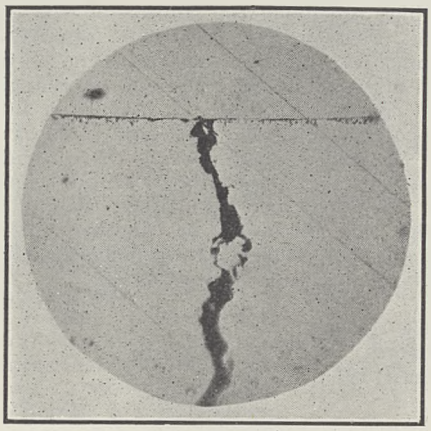
THE phenomenon of intercrystalline attack by liquid metals on solid metallic crystalline aggregates is well known[1], but the recorded cases which we have been able to find are chiefly of the attack of low-melting metals such as tin, solder, lead and cadmium on high-tensile steel, and mercury on copper, nickel and aluminium alloys.

An example has now been met of attack by mercury on high-tensile steel. The steel is of the following analysis and mechanical properties.

Analysis		Mechanical Properties	
C	0·28–0·32 per cent		
Ni	3·75–4·5 ,,	Ult. stress.	*c.* 105 tons/sq. in.
Cr	1·0 –1·5 ,,	El	*c.* 14 per cent on 4 $\sqrt{A}$
Mo	Nil	Red. of area	25 per cent min.
Mn	*c.* 0·60 ,,	Izod value	*c.* 25 ft.lb.
S	below 0·04 per cent		
P	,, ,,		

The above mechanical properties are obtained by air-hardening. In a certain application an oil-hardened nickel-chrome steel dowel pin *W* in. diameter is pressed into a hole in this air-hardening steel with a slight interference fit −0·0001–0·0002 in. A series of failures in service was met. In every instance the fracture had two easily distinguishable zones—an initial zone exhibiting what appeared to be brittle fracture and a secondary zone of well-marked fatigue type spreading from this. Microscopic

sections across the two zones showed no defects in the steel adjacent to the fatigue fracture, but the initial zone invariably showed break-up at the edge of the fracture which was connected with intercrystalline boundaries.



× 250.

Heat treatment, internal stress and mechanical factors were exhaustively explored and the whole workshop process of manufacture overhauled and improved, but no constructive light could be thrown on the problem until it was discovered that one of the operators engaged in making the parts used on occasions a 'mercury ointment' as an aid to fitting the dowels. This ointment is known by pharmacists as Ung. Mercuriale B.P.C. Its use as a lubricant is mentioned in some cheap popular handbooks of engineering, especially for tapping holes in difficult steel, easing tight fits, etc.

Special specimens incorporating a driven-in pin were fitted with the ointment between the surfaces, controls fitted dry being used. Specimens and controls were subjected to reversed bending on a Wöhler type of fatigue-testing machine. Specimen and control were run on the same machine simultaneously. Triplicate tests were made. In two cases intercrystalline attack as shown in the accompanying illustration occurred. In the remaining case early fracture occurred for mechanical reasons connected with the shape of the specimen.

Static tests were carried out by loading a specimen in tensile at 75 tons/sq.in. after amalgamating mercury on its surface. Brittle failure with intercrystalline attack occurred after 36 hours. A specimen without mercury withstood three weeks at 75 tons/sq. in without failure and five days at 90 tons/sq. in. without failure.

The withdrawal of the ointment from the workshops has up to the time of writing and over fourteen months stopped the failures.

It will be seen, therefore, that this seems to be a genuine case of intercrystalline breakdown of high tensile steel caused by the presence of mercury.

E. WOOD.
S. T. HARRISON.

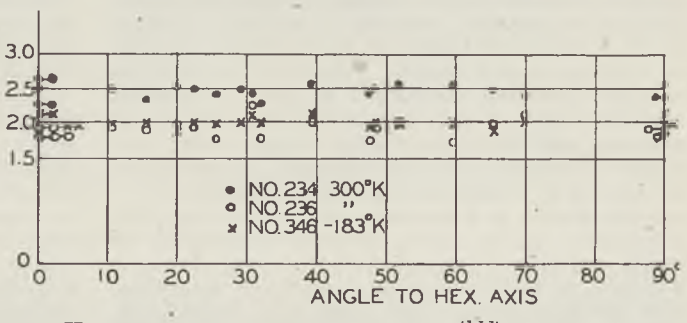
Armstrong Siddeley Motors Limited,
Coventry. July 25.

Dickenson, J. H., *J. Inst. Met.*, **24** (1920); van Ewijk, L. J. G., *J. Inst. Met.*, **56** (1935); Hartley, H. J., *J. Inst. Met.*, **37** (1927). See also discussion on van Ewijk's paper. There are many other references.

Electron Diffraction Intensities

UNDER this title, Fordham[1] has discussed the intensity anomalies observed by us in the electron diffraction pattern of zinc oxide. Fordham believes that "variations in extinction due to irregular crystal shape or to anisotropy will explain at least qualitatively many of the observed differences between calculated and observed electron diffraction intensities".

We have considered this possibility ourselves and have discussed it in some detail[2]. Such an effect as we pointed out would have to be dependent on electron energy. However, in the whole range 7–80 kv., no noticeable difference in the intensity distribution of the pattern has been observed, and therefore one must conclude that absorption does not account for the anomalities observed. Several years ago L. Pauling, in discussing this point, raised the question of the influence of the distribution of crystal size in the specimen. He pointed out that it might be possible that the absorption factor could be reduced to a product of a purely geometrical factor, depending on (*hkl*), and an absorption factor which remains the same for all planes. In this case no dependence on voltage is to be expected for the relative intensities. Calculations by Yearian with a suitable particle size distribution have shown that such a formulation is possible, but that the change in intensity obtained in this way would be too small to reproduce the observed anomaly. It is correct that the form of the zinc oxide crystallites consists partly of very thin filaments. However, the difference in sharpness of the (*OO*·1) as compared with the (*hk*·0) diffraction lines is only an apparent one. In the many micro-photometer traces taken in our work, the half-widths for the lines, corrected for background, do not show any appreciable variation as a function of the angle with the *Z*-axis.



HALF-WIDTHS IN mm. PLOTTED AGAINST (*hkl*), THE PLANES BEING ARRANGED AS A FUNCTION OF ANGLE WITH THE *Z*-AXIS

However, the most cogent proof of our hypothesis is found in the fact that it is possible to reproduce the main features of the electron diffraction pattern by determining the *F* factor with X-rays experimentally, and constructing the corresponding *Z*–*F* curve for the electron diffraction pattern[3]. This is also substantiated by the calculations of Johnson and James[4], who show that it is possible to account for this anomaly by assuming a distortion of the valence electron cloud. Some of the minor details of the diffraction pattern may very well be influenced by some second order effect, such as absorption or extinction or temperature-dependency, but the main features are reproduced by the distortion of the electron cloud.

As to the case of evaporated metal films, there is also considerable deviation from the calculated intensity, as we first pointed out some years ago[5]; these anomalies have now been reproduced by Ornstein and collaborators[6]. Therefore a full explanation cannot be made on some such simple assumption as difference in the shape of crystals or different absorption in different direction. Some other effects such as distortion of the electron cloud and dynamic effects of reflexion have to be taken into account.

K. LARK-HOROVITZ.
H. J. YEARIAN.

Department of Physics,
Purdue University,
Lafayette, Indiana.
August 7.

[1] NATURE, **146**, 807 (1940).
[2] *Phys. Rev.*, **48**, 631 (1935), particularly p. 634.
[3] See Lark-Horovitz and Ehrhardt, C. H., *Phys. Rev.*, **57**, 603 (1940).
[4] *Phys. Rev.*, **53**, 327 (1938); **56**, 119 (1939); **57**, 613 (1940).
[5] *Proc. Amer. Phil. Soc.*, **76**, 5 (1936); *Phys. Rev.*, **48**, 381 (1935).
[6] *Physica*, **5**, 693 (1938); **7**, 685 (1940).

Social Functions of Science

IN recent discussions on the social functions of science not every contributor has escaped the pitfall of confining the role of science to improving material conditions. I venture to offer the following as a restatement of the more fundamental social function, which is presupposed by the purely material function.

The pursuit of natural science may be regarded as a type or microcosm of all rational life. For, first, scientific work employs reason working upon sensible experience; it requires careful seeking of evidence, and constructive interpretation thereof; and consequently demands respect for fact, for logic, for insight and for imagination. Second, it exhibits a rational unity of thought and action, in the continual interplay of experiment and theory. Third, it is a social as well as a personal enterprise; as such, it demands respect for the human person and tolerance for diverse opinions, and favours a mental climate which is a balance of appreciation and criticism. It would not be difficult to work out in greater detail the rôle of natural science as a representative type of rational behaviour. All the above characteristics are to be observed also in the running of a business, a farm, or a family, or in any rationally conducted enterprise. The special methods used, and the results, are different in each case, but the spirit defined by these characteristics is common. Moreover, natural science prepares the mind for other rational disciplines, including metaphysics and ethics, which likewise employ both reason and experience; it shares with them the rational spirit, though dealing with a more restricted aspect of experience.

Now natural science, through its influence on daily life, is becoming for many the most easily recognized form of rational behaviour. Further, so long as it remains alive at all, it cannot fail to exhibit rational standards; false science is easily detected by experiments accessible to all men of science, and moreover, would lead to failures if applied. The most menacing fact of the present time is that the fundamental principles of respect for truth and for the human person (integral elements in the culture bequeathed to us by Christendom) are not everywhere recognized. In the intellectual chaos of our times, natural science may therefore be an important influence in holding many to rational standards. If men will carry the *spirit* learned in pursuing natural science into other and more personal activities (without trying to carry over also the special methods of natural science into fields which are much too subtle and too complex for them), we may hope for a more rational world.

The influence of science in this way is no less important than in providing the technique for changing the material conditions of life—indeed it is infinitely more important, since the wise application of science requires *direction*, which cannot be provided by natural science itself, but only by ethical science and insight. Whether men of science should try to undertake this direction, or whether this social function does not rather stop at propagating the spirit of rational living, is another argument.

E. F. CALDIN.

Queen's College,
Oxford.
August 12.

Social Education in the Services

AMONG the three thousand lecturers to the Forces included in the panels of our twenty-three regional committees there are many who offer one aspect or another of science as their subject. The choice of lecturer and topic is, under the agreement made by the Central Advisory Council for Adult Education in H.M. Forces with the Services, dependent upon the expressed wishes of the men and women themselves. It is the function of the Service education officers to ascertain what these interests are. A considerable number of lectures on scientific subjects and classes in either pure or applied science have been provided. The resources of the universities, local education authorities and voluntary bodies have been placed fully at the disposal of the Services for this purpose.

The article in NATURE of August 16, p. 173, appears to overlook the existence of all this co-operative activity on the part of the Services and the civilian educational bodies. It might perhaps surprise the writer to learn that on the estimate of the Director of Army Education, a million men and women in the Army attended lectures in the course of a recent month. The demand for educational facilities of all sorts has been maintained right through the summer and may well develop still further during the coming autumn and winter. At a recent conference of regional committee secretaries it was agreed that scientific subjects ought to take a larger place in the programme; but it was pointed out that those who offer them do not always present either attractive titles or an exposition which makes scientific facts and theories relevant to the interests and the thought of ordinary men and women. From this point of view the suggestions made in the article are particularly valuable and I hope that they will be very widely followed by lecturers, actual or potential, to the Forces.

BASIL A. YEAXLEE.
Central Advisory Council for Adult Education
in H.M. Forces,
Rewley House, Wellington Square,
Oxford.
Aug. 23.

ELECTRICAL DEVELOPMENTS IN MADRAS

IN a paper published in the *Electrician* of August 1, by J. Meek, the resident electrical engineer to the Madras Presidency, interesting projects are suggested about new developments in the Madras Presidency. This Presidency covers an area in South India of 142,000 square miles and supports a population of about 48 millions. An idea of the size may be obtained by comparison with that of England, which has an area of about 50,000 square miles and a population of about 38 millions. The people in the Presidency are mainly engaged in agriculture, and most of them live in villages. The capital, Madras City, has a population now approaching 800,000, but the next biggest town, Madura, has a population of less than 250,000. Four main languages are spoken—Tamil, Telugu, Canarese and Malayalani—and efforts are now being made by the Congress Government to introduce Hindi with the ultimate object of providing India with a common language. Among the educated classes English is widely spoken.

Some idea of the climate of Madras can be obtained from the following significant clause which usually appears in Madras Government electrical specifications : "The temperature in the shade will vary from 50° F. to 110° F. The max. temperature in the sun may be assumed to be 150° F. The relative humidity will vary from 60 to 80 per cent."

Although for the greater part of the year there is very little rain in most parts of the Presidency, there is considerable rainfall during the south-west and north-east monsoons, especially in the eastern and western Ghats, where more than 400 in. is registered in some places.

Until comparatively recently the only supply system of any importance was that of the Madras Electric Supply Corporation, which has held a licence from the Government for the generation and distribution of electricity in Madras City for the last thirty-one years. This Corporation has a steam-turbine power station with a capacity of more than 53,000 kva. The Presidency has no coal or oil deposits but is fairly well provided with water-power in the south. In 1924 the Madras Government decided to take charge of all hydro-electric surveys and projects and bought back concessions previously granted to private concerns which had not been developed.

The Pykara Scheme in the Nilgiri Hills was taken up first. It is situated at a distance of 280 miles to the south-west of Madras. Pykara is a high head scheme with storage utilizing a fall of 3,000 feet. When the great Mettur Dam was built some years ago for irrigation control, hydro-electric pipes were left ready in the dam, and this development was the next to be taken up about five years ago. The present installed capacity of plant is 37,500 kva. operating on a head which varies from 60 to 160 feet. In addition to these schemes the Madras Government has provided two steam stations in the north. There are many miles of feeder lines and also a considerable mileage of 33 kv. and 11 kv. The length of these transmission lines has necessitated the introduction of synchronous condensers at Trichinopoly and Madras.

The demand for power has greatly exceeded the most optimistic estimates, and additional plant and extensions to lines and substations had to be installed several years in advance of the original programme.

The grid supplies power direct to many tea factories, ginning factories, oil mills, chemical works, and even to farmers in outlying districts. More than a thousand small pumping sets are connected to the systems for pumping water from wells into the fields. The ryot has found it cheaper and more convenient to water his fields by means of electricity than by using bullocks as his forefathers have been doing for centuries.

UNIVERSITY OF THE WITWATERSRAND

New Engineering Building

ON June 18 at the University of the Witwatersrand, Johannesburg, General the Right Hon. J. C. Smuts, Prime Minister of the Union of South Africa, opened the new Wolf and Hirsch Hillman Building, which forms an important and substantial addition to the accommodation provided for instruction in engineering. Its site, lying to the west of the central block and south of the older engineering block, stands higher than these, and in its lay-out this has been utilized to permit of the formation of terraces and rock-gardens and the provision in an economical manner of a range of garages.

The building consists of two wings running east and west, the larger, about 210 ft. long, being devoted to laboratories and placed on the north side so that it receives the maximum light. The shorter south wing, about 130 ft. in length, provides accommodation for a model analysis laboratory, drawing halls and lecture theatres. The east wing connecting these other two contains the entrance hall and staff offices.

The Department of Civil Engineering provides a four-year course for the degree of B.Sc. (Engineering) which is recognized by the Institution of Civil Engineers as exempting its holders from Sections A and B of its associate membership examination. In the Union, it offers a qualification for those entering the higher technical services of the Irrigation and Public Works Departments, National Road Board, South African Railways and Harbours and other equally important administrations and undertakings.

The new Hillman Building will greatly enhance its facilities by providing spacious and well-equipped laboratories with workshops and stores and ample accommodation for lectures. It has been designed to serve a threefold purpose : (i) to promote the course of training already referred to ; (ii) to provide for research into fundamental problems of civil engineering ; and (iii) to assist in the solution of problems arising in practice.

The main features of the Hydraulics Laboratory are a level flume, 3 ft. wide, 2 ft. 6 in. deep, with an overall length of 82 ft. and glass sides to allow of easy observation; a smaller flume with one end capable of being given a maximum tilt of 1 in 20; a river model table 10 ft. wide and 70 ft. long for the study of river and tidal flow; and a general purpose bench for experiments on the flow of water in pipes.

In the Structures Laboratory, a 350,000-lb. precision hydraulic testing machine has been installed for compression and bending tests. This is fitted with an automatic loading device giving ten different rates of loading and reading to the nearest 10 lb. A 75,000-lb. machine for tensile tests and permitting of compression and bending tests on short struts and beams is on order and will have autographic load-deformation recording apparatus. There are also several test-beds for testing members and structures, and the accessories provided are of the latest types.

The investigation of structural problems by various methods of mechanical analysis employing small-scale models will be carried out in the Model Analysis Laboratory, the equipment of which includes a Continostat apparatus for the experimental determination of influence lines using spline models and a Lobban deformeter. In the Highway Engineering and Materials of Construction Laboratory the main space has been divided into three sections: (i) tar, bitumen and asphalt; (ii) soils and aggregates; (iii) cement and concrete. Each has been suitably provided with apparatus and equipment which will enable tests and investigations to be carried out in conformity with present-day practice in this field, in which there is so much scope for development.

IRISH SALMON, SEA TROUT AND EELS

THE Fisheries Branch of the Irish Department of Agriculture has published a brief summary of the catch of salmon, sea trout and eels in Eire between 1927 and 1939*. Alternate years only are given, the figures are neither averaged nor compared, and no comments are made or inferences drawn. But the statistics themselves are of no small interest, as the following epitome of part of them is enough to show.

	1927	1929	1931	1933	1935	1937	1939
Salmon							
Total catch (wt.)	100	48	75	68	78	45	46
do. rod only	100	24	53	31	50	38	34
Average wt. per fish (lb.)	12·9	13·5	9·7	11·8	9·8	10·7	10·2
	100	105	75	91	76	83	79
Value per rod (shillings)	189	77	85	66	84	69	72
	100	41	45	40	49	37	38
Sea Trout							
Total catch (wt.)	100	101	101	91	100	96	101

The period is not long enough, nor the data complete enough, to let us speak of any lasting *trend*; but it is clear that the catch of salmon has greatly diminished of recent years. Since 1927, the annual catch (as shown in alternate years) has never reached 80 per cent, and has three times out of six been less than 50 per cent, of that year's catch. The catch by rod is worse still; for it has been so low as a quarter, and has only once been more than a half, of the catch of 1927. On the other hand, the catch of sea trout, while it has its ups and downs in the various rivers, averages out over all to a nearly constant total, year by year.

More remarkable than the diminished catch of salmon is a diminution in the average weight of the same fish. From 1931 onwards the average weight has been much below that of 1927–29; and in the last five annual periods it has only averaged about four-fifths of the weight in the first two.

The returns from the several rivers or fishery districts show many interesting things. We have seen that the salmon catch of 1939 was only 46 per cent of that of 1927; but the decrease, though it extended well-nigh all round the coast of Eire, was very far from uniform. The three contiguous east coast districts, Dundalk, Drogheda and Dublin, had in 1939, 90, 99 and 90 per cent of the catch of 1927; but the next succeeding regions, on the south-west and south coasts, namely, Wexford, Waterford, Lismore, Cork and Bandon, show only 34, 38, 26, 21 and 19 per cent, in the same comparison. The commercial importance of all these statistics is, as usual, the least interesting part of them. D. W. T.

* Eire: Roinn Talmhaidheachta (Department of Agriculture), Brainse Iascaigh (Fisheries Branch). Statistics of Salmon, Sea Trout and Eels captured during each of the Years 1939, 1937, 1935, 1933, 1931, 1929, 1927. (P. No. 4658.) Pp. 20. (Dublin: Stationery Office, 1941.) 6*d*.

ELECTRIC STRENGTH OF SOLID DIELECTRICS

IN a paper, by W. G. Standring, of the National Physical Laboratory, which is published in the Power Engineering Section of the *Journal of the Institution of Electrical Engineers*, of August, a discussion is given of the behaviour of a number of insulating materials under disruptive voltages. Experiments were carried out with the object of filling large gaps in our knowledge in a field which has only been partially explored. At the present time, a knowledge of electric strength is of twofold interest. It is of fundamental importance to the engineer, and values of electric strength should provide guidance to the mathematical physicist in developing theories to explain the mechanism of electric breakdown.

Measurements of the electric strength of solid dielectrics have been made on samples up to a few millimetres in thickness. The values obtained are of the same order as those maintained on thin samples under maintained voltages. They indicate that a solid dielectric has a characteristic strength or gradient which causes breakdown, independent of thickness and not greatly dependent on the rate of application, or on the duration of the stress. Continental physicists have formed a similar conclusion for liquids.

Secondary phenomena such as surface discharges and thermal effects are more easily eliminated under impulse conditions than under sustained voltages, since short time limits the production of effects such as the generation of heat, and because a wider range of liquids exists for the selection of a satisfactory immersion medium. In measuring the electric strength or gradient which causes breakdown of solid dielectrics, an immersion medium is necessary to avoid flash-over; also breakdown must not occur first in the medium of the electric field applied to the material under test, as the field is then disturbed and deduction of the breakdown stress from the applied voltage and the geometric configuration becomes impossible. It is not usually practicable to embed electrodes in a solid dielectric in such a way that only the material under test is stressed.

In general, gases have lower electric strengths than liquids and liquids than solids. Discharges may therefore occur in the surrounding medium before the breakdown gradient of the material under test is reached. These discharges act as pointed extensions of the electrode with high concentration of stress at their tips, and the solid test material may break down owing to the local incalculable stress or on account of the high local temperature of the discharge. It is therefore necessary to avoid discharges in the immersion medium. Glycerine has been found to be a suitable immersion medium for testing many dielectrics at atmospheric temperatures under impulse voltages.

Mr. Standring points out that in forming physical theories of the mechanism of breakdown, experimental data on crystalline materials such as mica are likely to be of most help. When maximum results were used, the highest value obtained on the thinnest light amber was nearly the highest obtained with the best mica, which was the same at all thicknesses. For purposes of physical theory, therefore, it may be desirable to take the highest experimental values obtained rather than the average value.

ACCRETION THEORY OF STELLAR EVOLUTION

BEFORE the advent of the accretion theory of stellar evolution, physical theory had progressed sufficiently to suggest the transmutation of hydrogen as providing practically all the stellar energy. Astronomical evidence, especially from double stars, led to the view that there must be a further potential source of energy from outside the stars which replenished the hydrogen in the stars. The existence of interstellar matter in gaseous form in certain regions of the galaxy was known but this knowledge did not simplify the problem. The chief constituent of the cloud was regarded as calcium, and possibly other similar elements such as sodium were also present, but accretions from such elements would merely increase the mass of the star and would not prolong its life.

The subject is dealt with in a recent paper by Messrs. F. Hoyle and R. A. Lyttleton (*Mon. Not. Roy. Astro. Soc.*, **101**, 4, 227), though most of the authors' work has been published elsewhere[1] on different occasions. In their discussion of the problem they postulate the presence of a hydrogen cloud and then consider the conditions which such a cloud must satisfy. The formula arrived at for the rate of change of mass when the motion has become steady is

$$\frac{\partial M_A}{\partial t} = 18\gamma^2 M^2 \rho \sqrt{\bar{v}^3},$$

where ρ is the density of the cloud in the neighbourhood of the star, M the mass of the star, γ the constant of gravitation and $\bar{v}$ the relative velocity of the star and cloud appropriately averaged to allow for the motion of the star in the galaxy.

Three hypotheses are stated as the requirements of the accretion theory formulated by the authors:

(*a*) That the cosmical cloud in its regions of highest density contains an appreciable proportion of hydrogen molecules—10 per cent by mass would suffice;

(*b*) That the cosmical cloud is not everywhere evenly distributed but possesses local small irregularities;

(*c*) That the cosmical cloud is irregularly distributed also on a large scale, and in particular it is strongly concentrated towards the galactic plane, where the density rises to the value of order 10^{-21} gm. per c.c.

In the solution of the problem of the source of energy of the bright stars the authors invoked a hypothesis which, they claim, has also solved the question of the dynamical evolution of binary stars, and hence the new process has unified the dynamical and physical evolution of stars. In the accretion process no question of a mechanism unknown to science is introduced and thus speculation is almost entirely absent in the theory—a remark that cannot be applied to other theories, for example, that of the complete annihilation of matter. Nevertheless if, as is possible, future investigation should disprove one or more of the three hypotheses previously referred to, the theory would require considerable modification or it might be necessary to abandon it.

Evidence is cited to show that there is support for the hypotheses. Thus, (*a*) requires an appreciable proportion of the cloud to be in molecular form, and Adams and McKellar have recently found the occurrence of vibrational-rotational transitions in the molecules CH and CH in the cosmical cloud. The hypothesis (*c*) may be doubted by many, but one very interesting result follows from the asumption, which is confirmed; namely, that the most massive and luminous stars should be concentrated to the galactic plane. As this agrees with observation a result is obtained for which theoretical astronomy has not previously been able to give any adequate explanation.

Many objections have been urged by Atkinson[2] and these are dealt with in the paper, but limits of space forbid a detailed consideration of these. One, however, is worth noticing. Atkinson considers that a density 10^{-21} gm. per c.c. near the galactic plane is too high. It is interesting to notice, however, that Jeans has obtained central densities of the order 10^{-21} for a number of extra-galactic nebulæ of the spiral type, and the objections could not apply to stars situated in

these external galaxies. Objections relating to the high rate of increase of mass given by the formula, the difficulties regarding the time-scale, the lack of any observable distinction separating stars of small velocity from those of slightly higher velocity, etc., are considered by the authors who, if they have not established their theory, have indicated certain lines along which investigations should be conducted. Reliable observations which supply information of the density distribution and velocities of the stars relative to the cloud will confirm, modify or disprove the theory.

[1] See *Proc. Camb. Phil. Soc.*, **35**, 405, 592 (1939); **36**, 325, 424 (1940); and also NATURE, **146**, 97 (1940) with earlier references.
[2] *Proc. Camb. Phil. Soc.*, **36**, 313 (1940); *Mon. Not. Roy. Astro. Soc.*, **100**, 500 (1940).

FISH OILS

PRIOR to the War, the fish oil industry was successfully applying to problems of production the results of recent research, particularly with respect to vitamins A and D. The liver oils from some species possess extraordinary potency, thus the blue-fin tuna or horse mackerel yields oil containing up to 400,000 I.U./gm. of vitamin A and 60,000 I.U./gm. of vitamin D as compared with 800 I.U./gm. (A) and 100 I.U./gm. (D) for average cod liver oil. The soupfin shark liver contains 40–70 per cent of oil the vitamin A potency of which is frequently more than 100,000 I.U./gm., but on the other hand it is very poor in vitamin D, the potency being only about 20 I.U./gm. This oil is produced on a large scale in California at relatively small cost, and is probably the cheapest source of vitamin A in a highly competitive market.

The discovery in 1937[1] that oils extremely rich in vitamin A can be obtained by extracting the intestines of fish like halibut, has been followed up commercially on the Pacific Coast, but the nature of the raw material demanded modifications in technique. These have been kept secret. According to Brocklesby[2] 126,000 dollars worth of halibut livers and 37,000 dollars worth of intestines were landed at Prince Rupert, B.C., in 1938. In 1939, 3,853 cwt. of halibut livers yielding 650 gal. oil compared with 688 gal. visceral oil were produced in British Columbia. Fishing for halibut in the Pacific is regulated by an international agreement between Canada and the United States, and the annual quota is about 46 million lb. of which about a quarter is landed in Canada. The viscera account for about 2 per cent of the weight of the fish and the oil content (1–5 per cent) is low. The vitamin A potency is, however, usually two or three times greater than that obtained from the liver. The characteristics of commercial halibut visceral oil are given in detail by Brocklesby and his colleagues.

The viscera from various species of salmon yield a few per cent of oil containing usually more than 5,000 I.U./gm. and 100 I.U./gm. of vitamins A and D respectively. Very large quantities of oil are extracted from salmon cannery waste and the commercial salmon oil is of considerable value for poultry feeding, as well as having other important uses.

[1] Lovern, Edisbury and Morton, NATURE, 111, 234, 276.
[2] "The Chemistry and Technology of Marine Animal Oils with particular reference to those of Canada", Bull. 59, Fisheries Research Board of Canada, 1941.

PLANKTON STUDIES

IN two important papers, Gordon A. Riley continues his investigations on the interaction of the plankton with its environment ("Plankton Studies. 3. Long Island Sound", *Bull. Bingham Oceanograph. Coll.*, Peabody Museum of Natural History, Yale University, 3, Jan., 1941. "Plankton Studies. 4. Georges Bank", *ibid.*, June, 1941). The preceding work ("Plankton Studies" 1 and 2, in the same periodical, 1938 and 1939) dealt with the Tortugas region and the western North Atlantic. Light and dark bottles filled with natural sea water and suspended near the surface were used to determine oxygen production and consumption, the utilization and regeneration of nutrients and the production and consumption of chlorophyll. Analyses were made of oxygen, chlorophyll and phosphates in the Long Island surface waters for a period of about a year. Counts were made of zooplankton and, during the last half of the investigation, nitrate determinations were made.

The quantity of chlorophyll in the phytoplankton was much higher than in the oceanic waters outside the sound. The nutrients, particularly phosphate, were also high; the ratio of nitrate to phosphate low. The amount of photosynthesis was influenced directly by the quantity of chlorophyll and by temperature and light. The similarities between experimental results and the events in the free water were considered sufficiently marked to permit the use of the former in making rough estimates of productivity.

In the latest paper an analysis was made of the methods of measuring phytoplankton, and it was found that the determination of plant pigments (after the method of Harvey, 1934) has the highest mean correlation with other types of measurement and is therefore the most nearly representative determination of phytoplankton. This portion of the work is a study of the quantitative aspects of the phytoplankton of Georges Bank in relation to the environmental factors which influence its growth and distribution. It is part of a general survey of Georges Bank by several investigators, the purpose of which is to obtain needed information about the spawning and larval development of the haddock.

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