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Science and Humanity.

To look back over the century's record of the achievements of the British Association for the Advancement of Science is to be reminded once again of the disparity between the achievements of science and its actual control or direction of public affairs. A century which has witnessed the growth of the meeting of 350 enthusiasts at York in 1831, organised by Harcourt, Brewster and others, " to give a stronger impulse and a more systematic direction to scientific enquiry ; and to promote the intercourse of those who cultivate science in different parts of the British Empire " into a powerful Association that the Empire is now proud to honour in its capital for the first time, has seen indeed an immense advance in the respect with which men of science are held by the nation. The disparagement or opposition which the early efforts of the Association encountered, sometimes in unexpected quarters as from Carlyle, have long since passed away, but the brilliant achievements in pure and applied science during the last century have availed scarcely at all to increase the power of science to direct or influence national policy in matters which involve questions of science. While almost all the major problems of administration involve the assessment of scientific factors, lack of appreciation of science remains characteristic of our administrators. Many of Thomas Huxley's persuasive addresses on science, education, and politics remain as pertinent to-day as when they were uttered half a century or more ago.

This situation is one so fraught with danger to civilisation that on this ground alone inquiry into its causes is urgent. Essentially we are faced with a gap between knowledge and power ; a contrast between the comparative freedom with which scientific knowledge and development influence industrial development, and their almost negligible influence in the control of national and international policies which are largely responsible for the development or stagnation of industry and society.

One of the commonest views as to the cause of this situation is that the intense specialisation demanded in scientific work renders the man of science incompetent to undertake administrative work or assess the value of facts outside the narrow sphere of his specialised work. Fundamentally this view is probably an unconscious assertion of the distinction between knowledge and method or use. There is little in our educational system to enable those who receive no scientific training to distinguish science from the mere knowledge of a mass of undigested facts. Knowledge, as a matter of experience, as Sir Arthur Quiller-Couch has said, cannot even be counted upon to educate. The science graduate is no exception to the general tendency of our universities to neglect to teach the use of knowledge—or in other words to relate knowledge and power—and to devote to competitive examinations the energy that were better spent in the production of graduates whose trained judgment as matured by experience we could trust to choose the better and reject the worse.

The mere fact that the growth of knowledge has made selection both more imperative and more difficult lends no support to the plea that we should call a halt in our quest of knowledge, that scientific research might well take a ten years' holiday and our energies be devoted to the utilisation or correlation of knowledge that is already ours. Merely to consider how much mankind might have lost had some such truce to discovery been declared at any time in the last fifty years is to realise the futility and impracticability of that plea. Nature does not lightly reveal her secrets to those who miss their opportunities, and we might still be without the knowledge of radium, of insulin, vitamins, broadcasting, and the motion picture—to mention only recent contributions of science to the relief of suffering or to the amenities of life. To interrupt the quest for knowledge might rob mankind for a generation or more of some vital clue to the control of such a scourge as cancer or to the real causes of the present unemployment and industrial depression.

What is required is not less research but more wisely and widely directed research. Huxley's words in 1854, on the science of society, "a higher division of science which considers living beings as aggregates—which deals with the relation of living beings one to another, the science which observes men, whose deductions lead to our happiness or our misery—and whose verifications often come too late", are strangely echoed in Prof. McDougall's recent plea for the direction of our most powerful intellects from the physical sciences into researches on the biological, the human, and the social sciences, and thus to build the social sciences, especially the science of economics, on the basis provided by anthropological research.

It is admittedly a fundamental defect of our present university training that while teaching the appreciation of facts it frequently fails to impart scientific method, and largely in consequence of this its graduates are sometimes quite unable to assess values, especially human values. The suggestion that the technical expert tends to ignore the human element in a situation and looks exclusively at the functional results of his work, may, in consequence of his imperfect training, be true of the newly graduated, but in the opinion of the Committee of the British Science Guild on the Position of the Technical Expert in the Public Services and Industry, it is completely contradicted in experience. Under industrial conditions, the scientific worker rapidly and readily learns to assess the human factors involved in his projects, and acquires experience in co-operation, compromise and accommodation which early fit him for administrative duties. Abundant evidence could be furnished to show that in spite of defects in their academic training, many scientific workers when afforded the opportunity are in no way inferior in administrative capacity to their fellows who have graduated in arts or classics.

Unfortunately, this defect in the present system of training for the appreciation of scientific values inevitably tends to obscure both the human value of the study of science and what is equally important, the defective teaching of general science to those pursuing a career in arts, law, medicine, commerce, or industry generally. On the first point it is pardonable to recall once more Huxley's emphatic conviction that for the attainment of real culture an exclusively scientific education is at least as effective as an exclusively literary education. The science student at least acquires some elementary knowledge of scientific method, of some habits of accurate observation and the rudiments of deductive reasoning. These are the habits and methods which are essential not only to the administrator but also to all who by skilful selection arrive at their own judgments whether on questions of art, science, history, or life. The emphasis on discovery and on verification implicit in all true teaching of science is an invaluable corrective to the bias towards authority which it is so difficult to avoid in the teaching of literary subjects. That alone would justify the claim that a knowledge of science and of scientific method is essential if education is to confer real balance and the power to assess human and other values.

Largely because of our unscientific teaching of science, the human value of science is only slowly being recognised, and biologists are still reiterating the pleading of Huxley two generations ago. To science and to scientific workers more than to any other factor is due the immense improvement in the conditions of work in industry and the elaboration of methods which adapt the machine to man instead of viewing, as the early Victorians did, the operatives as mere cogs in the industrial machine. Beyond this, as Prof. A. V. Hill pointed out in his Henry Sidgwick memorial lecture, we are now glimpsing in psychology the experimental application of biology to problems of national and international conduct, racial relations, including the administration of the backward races, the evolution of co-operation in place of competition, upon the solution of which the fate of civilisation largely turns. Nor have we yet utilised the human values which lie latent in the history of science itself. Scientific workers themselves are apt to neglect unduly the inspiration and teaching which a knowledge of the growth and development of their own science can often give.

It is probable that we here come close to one of the causes of the defective teaching of science to those pursuing other careers. We are still far indeed from Huxley's ideal that

"no boy or girl should leave school without possessing a grasp of the general character of science and without having been disciplined, more or less, in the methods of all sciences, so that they shall be prepared to face scientific problems, not by knowing at once the conditions of every problem or by being able at once to solve it; but by being familiar with the general current of scientific thought and by being able to apply the methods of science in the proper way when they have acquainted themselves with the conditions of the special problem".

The rapidity with which scientific discoveries in the intervening seventy-two years have transformed the conditions of life make that ideal an objective essential for the security of civilisation. Had scientific workers themselves realised more fully the human value of scientific history, especially biography, much more might have been done to secure a wider and more effective teaching of science. The records of science are full of episodes of courage and endurance, patience, heroism, and resource as stirring as any culled from chronicles of war, politics, or religion. Without the spirit of adventure even in his laboratory the scientific worker would make little progress, and it is among the merits of science that it equips mankind for its migration across uncharted seas of adventure, and assists man to master his surroundings and not merely adapt himself to them.

The neglect of history by scientific workers is, however, completely overshadowed by the neglect of science by history, to which attention was directed at the recent International Congress of the History of Science and Technology. Pointing out that the very success of the application of scientific method and discovery has deflected attention from the process itself, Dr. Singer urged the value of watching its application under other conditions in the past for a full understanding of the process. More than this, it was eloquently urged by Prof. A. V. Hill that if science is to deal with human greatness, with things which have given man control of himself and of his surroundings and have freed him from superstition, ignorance, ill-health, and incompetence in the face of natural forces, the great figures of science and their discoveries deserve a prominent place in all history books.

The service which history can render to science may indeed prove decisive. While, as already suggested, scientific workers themselves might make far more effective use of the opportunities which biography affords them of bringing home to the general community the human aspects of science and its effect on and expression in personality, to the professional historian largely must be left the task of correlating scientific advances in different fields and the main stream of human progress. Only when this task is attempted and the history of science becomes an integral part in the training and discipline of general historical study can science assume her just position in education. It will then no longer be possible for administration to remain exclusively in the hands of those who have no first-hand knowledge of science or any independent capacity to sort the issues when scientific questions are involved in an important administrative decision. We shall have travelled a long distance towards the fulfilment of Huxley's ideal when the extensive science discipline advocated by Sir David Prain finds its place in the arts faculties of our universities and training colleges.

There is perhaps no greater service that the British Association can render to society at its centenary celebrations than by its attention to the human values of science. In looking back over a century of honourable progress, the Association is entitled to point out the high achievements of many of those with whose names it has been associated, the inspiration which their spirit of adventure, of service and of devotion, can give to society, and the part which science has played in shaping the social and intellectual environment in which we live. In the impressive programme of the meetings there is ample evidence of the attention which science is giving to the improvement of conditions of work, and to the application of scientific methods to problems of industrial management and distribution, as well as to the government of native races. Problems of population and of education are to be discussed from the scientific point of view, including the value of such new methods as the cinematograph film both in general and in industrial education, and the application of eugenics in education.

The Association provides scientific workers with an unrivalled opportunity for presenting a constructive programme indicating the contribution which the teaching of science, and especially of scientific method and achievement, may make to education. By emphasising the positive side of science, the inspiration which man derives from its achievements in the conquest of Nature, the assistance which scientific method and scientific knowledge confer in handling not only industrial problems but also social, economic, and administrative problems generally, rather than the defects of our present methods of education with their tendency to encourage premature specialisation, the pursuit of knowledge rather than method and to discourage the development of personality and independence of thought, scientific workers will do much to prepare the way for a century of even greater advances in science. If this is undertaken, seeking, as Colet wrote to More, " not for victory in argument but for truth ", and attempting to set in order the facts of experience, it may well happen that under the leadership of science there may be ushered in a truly scientific age in which personality finds its full play, science and art and literature make their fitting contribution to general culture, and the application of scientific methods enables man to pioneer into yet wider realms in search of truth and mastery over Nature.

When scientific achievements in the conquest of Nature have received their full meed of acknowledgment, it is the spirit of science that is all-important to mankind. The accumulation of knowledge signifies little. The science of one age, as Dr. Singer wisely says, becomes the nonsense of the next, but the spirit of science leads man forward continually to fresh conquests over his changing environment. From the labours of scientific workers as of others may we hope some day to understand better what is involved in the toilsome path which humanity still has to tread towards the goal of civilisation—in Seebohm's phrase the art of living together in civilised society—and to finding that, as in More's " Utopia ", a fearless faith in the laws of Nature consorts well with a profound faith in man's noblest ideals.

Problems of the Mineral Industry.

Minerals in Modern Industry. By Dr. Walter H. Voskuil. Pp. ix + 350. (New York : John Wiley and Sons, Inc. ; London : Chapman and Hall, Ltd., 1930.) 18*s*. 6*d*. net.

THE industrial revolution which began in England spread to the western countries of the Continent and developed because of favourable conditions of mineral resources. These natural conditions were found to be reproduced on a larger scale on the other side of the North Atlantic and the new industries became transplanted there also. Three centres—northern England, the Franco-German district bordering the Rhine valley, and the north-eastern United States—became the world's workshops : they embrace more than ninety per cent of the world's iron and steel-making capacity. Once established, the inertia of invested capital helped to maintain production. Other types of industries, notably the chemical, found it convenient to locate close to the steel centre. The increasing density of population enhances the local market for manufactured products. Raw materials, including accessory minerals, flow to these three centres from all over the globe.

The demand for minerals becomes ever greater, producers have been supplying a market which each year exceeded the year preceding in its demands. The needs of the War and the post-War expansion period were met by expansion of production and of capacity to produce to such a degree that, first with a return to normality and now to a condition far below normal, heroic measures must be attempted to find outlets for the products of the mines and even to save them financially.

The urge to consume, the use of every form of persuasion and advertisement, have been directed towards trying to keep in motion as much and as many as possible of the material goods that have been produced. One of the effects of this campaign has been to increase the costs of distribution in greater and greater proportion so that often they exceed those of manufacturing, not only absorbing all the profits but also imposing a greater dead-weight of oncost when production is slack. The salesman has become more important than the technician.

The remedy, to fit production to the needs of the market, implies control of output in minerals as in other products, but the problem is simpler to suggest than to solve.

The question of control of production leads directly into the broader problem of the conservation of mineral resources. Minerals are wasting assets, and although, taking the world as a whole, there is no need to be alarmed at the depletion of natural stores, yet the acceleration of production during the last twenty years is sufficient to indicate the wisdom of taking stock. The living generation may always be expected to take all it needs, and deliberate curtailment of any particular mineral is only brought about by raising the price to a point when some alternative is favoured. There is a duty, however, to eliminate needless waste and to initiate research into economy of use.

Work to this end is going on with every mineral; more efficient methods of mining, of extraction, of utilisation, of recovery and re-use, are brought forward every day. In coal alone the progress is enormous: electric energy is produced to-day with half the weight of coal per unit required ten years ago and it will be halved again. It is safe to forecast that the same effect could be gained with half the coal at present burnt in England if it were used in the most up-to-date apparatus. Every coal strike, every increase in price, give new impetus to such a movement.

Gold and tin are the chief minerals of which the prospect of a declining output is admitted. The former is the foundation of a monetary system which, judging by to-day's chaos, has failed and will perhaps be replaced. Tin is mainly used for containers in contact with foods, but it is certain that the march of research and invention will find substitutes for this, either aluminium or possibly even cellulose acetate or lacquered containers. Indeed, we are only at the beginning of the potential discoveries in connexion with the addition of small quantities of so-called rare elements to metal alloys, whilst we shall not be content very much longer to make structural steelwork of a metal which rusts so quickly as to require regular painting. Research will prove a certain palliative for possible mineral shortage.

The critical minerals are the energy resources—coal, oil, natural gas: these at least must not be wasted. A close control on their use is imposed, however, by each fractional increase in price, and a period like the present when wasteful competition is causing them to be sold at entirely uneconomic prices is not likely to last. Water power, energy from the sea and from the sun, are all available when real economy is necessary.

No one nation contains a full variety of the essential minerals. Those missing can be obtained by the vigilance of governments or of manufacturing interests in securing control of concessions in other lands, but whilst insuring the domestic position, no nation can deprive its neighbour of needed minerals without inviting trouble. The War was fought above the coal and iron mines of France, Belgium, and Lorraine; the unequal geographical and political control of mineral resources forms a background of menace to the maintenance of peace.

Such are the problems envisaged by Dr. Vosguil, his book containing an exposition of the facts relating to the chief minerals: it will well repay careful reading throughout by all connected, in whatever way, with them.

E. F. Armstrong.

A Chinese Alchemist.

The Travels of an Alchemist: the Journey of the Taoist Ch'ang-Ch'un from China to the Hindukush at the Summons of Chingiz Khan. Recorded by his Disciple, Li Chih-Ch'ang. Translated with an Introduction by Arthur Waley. (The Broadway Travellers.) Pp. xi + 166. (London: George Routledge and Sons, Ltd., 1931.) 10*s.* 6*d.* net.

MR. WALEY provides an English translation of the "Hsi Yu Chi", made directly from the Chinese text. In a valuable introduction of 40 pages he deals with Mongol history and philology, and illuminates the history of medieval Taoism with the light of the Taoist Canon, which has become freely available to European scholars since its re-publication in 1923–25. He points out that the new Taoism, created by Chang Tao-ling in the second century A.D., rendered a great service by preserving texts and doctrines of philosophy, astrology, alchemy, hygiene, etc., which Confucianism rejected as heterodox. He sums up the connexion between Taoism and alchemy in the following words:

"In one branch of study the Taoists were unique. To them alone is due the vast body of alchemical literature, which makes the Chinese sources more important than even the Mohammedan to the historian of this strange subject. The Chinese had inherited from the remote past the belief that certain substances such as jade, pearl, mother-of-pearl, cinnabar, were life-giving, and that if absorbed into the body they would prevent the gradual deteriorations of old age. As they exist in nature, however, these substances, it was thought, are always 'impure'. Only when made artificially can they be safely and efficaciously ingested. In early China gold was not highly valued. When through contact with the gold-prizing nomads of the north-west the Chinese, in the three or four centuries before the Christian era, began to accept gold as their highest standard of value, the ideas previously attached to other 'life-giving' and consequently valuable substances became associated also with gold. Thus arose various distinct forms of alchemy: (1) the attempt to produce a liquid gold that could be drunk and so produce longevity; (2) the so-called 'Gold-cinnabar' alchemy. To the recipes for making artificial cinnabar and thus producing an elixir of life was arbitrarily added the further clause that 'when the cinnabar is made, gold will easily follow'. We thus see the new life-giving substance gold tagged on to the beliefs connected with the older substance, cinnabar. (3) An attempt, parallel to that of the earliest Western alchemy, to produce gold from baser metals such as lead."

These ideas are of particular interest to students of the origins of alchemy, who, during recent years, have devoted increasing attention to the nature and scope of Chinese alchemy.* According to Mr. Waley, an alchemy of gold existed in China so far back as the first century B.C. In extant alchemical treatises of the fourth century A.D., Pao P'u Tzu discriminates between the three kinds of alchemy quoted above. In the tenth century exoteric alchemy (*wai tan*) merged into esoteric (*nei tan*), the 'souls' or 'essences' of mercury, sulphur, lead, etc., bearing to the common metals the same relationship as the Taoist, adept, or perfected man, bears to common mortals. A further evolution had been reached at the end of the eleventh century, the transcendental metals having become identified with various parts of the human body. Thus,

"alchemy comes to mean in China not an experimentation with chemicals, blowpipes, furnace and the like (though these survive in the popular alchemy of itinerant quacks), but a system of mental and physical re-education. It was in this sense that Ch'ang-ch'un, whose travels are here recorded, was an alchemist, and it is a mysticism of this kind that is expounded in his 'Straight Guide to the Mighty Elixir'."

The reader who takes up this book in the expectation of gathering at first hand the views of the adept Ch'ang-Ch'un upon orthodox alchemy will thus be disappointed: the narrative contains little of alchemical interest. There is ample compensation, however, in the light it throws upon the character of the 'Master', and in the picturesque glimpses it affords of varied Eastern races, manners, and customs, in the early thirteenth century. "Leaving the crowded Chinese plains, we see the Mongol nomads with their waggons and flocks, their fur-trimmed coats and strange head-dresses, then the turbaned Moslem ploughman, the cosmopolitan crowds of Samarkand and the wild tribesmen of Afghanistan."

The translator points out that the "Hsi Yu Chi" is true to type in the highly impersonal treatment of its theme. Notwithstanding this, we are able to build up from it an intimate picture of the 'Master', Ch'ang-Ch'un. In Sun Hsi's preface, written in 1228, we read that "he sat with the rigidity of a corpse, stood with the stiffness of a tree, moved swift as lightning and walked like a whirlwind"—further, that (in words which remind us of the celebrated Macpherson) "he was by no means an ordinary person". The Recluse of the Western Brook continues: "conversation with him showed me that his learning was tremendous; there seemed to be no book he had not read". In spite of his age, when Chingiz Khan's call for the long double journey came to him at Lai-chou from far-off Afghanistan,

"here was the Master setting out to cover thousands of miles of most difficult country, through regions never mapped, across deserts unwatered by rain or dew, in which, though he was received everywhere with the utmost honour, it was inevitable that he should suffer considerable hardship and fatigue. Yet whenever opportunity arose he was ready to loiter on the way, enjoy the beauties of the scenery in the most natural and leisurely manner, write a poem, talk or laugh."

Ch'ang-Ch'un arrived at Samarkand early in December 1221, and wintered there. When he reached Chingiz's camp, between the Hindukush and Kabul, in the following May, "Chingiz was delighted, begged him to be seated and ordered food to be served. Then he asked him: 'Adept, what Medicine of Long Life have you brought me from afar?' The Master replied: 'I have means of protecting life, but no elixir that will prolong it.' The Emperor was pleased with his candour, and had two tents for the Master and his disciples set up to the east of his own." The central incident of the narrative thus has a bearing upon the alchemical doctrine of the elixir of life. "A temporary compound of the Four Elements," says Ch'ang'-Ch'un in another place, "the body at last must suffer decay. The soul, composed of one spiritual essence, is free to move wherever it will."

More direct than the alchemical references are those to astronomy and astrology. At Talas, near the modern Aulie-ata, notice was taken of "a number of great mounds, set like the stars in the Polar Constellation". At Samarkand, the Master held a conversation with an astronomer about a recent eclipse of the sun.

* Reference may be made here to Mr. Waley's "Notes on Chinese Alchemy" (supplementary to O. S. Johnson's "A Study of Chinese Alchemy") in the *Bulletin* of the School of Oriental Studies, London Institution, vol. 6, part 1, 1930.

"The man said: 'Here the eclipse was at its full at the hour of the Dragon, when it covered three-fifths of the sun.' 'We were by the Kerulen River,' said the Master; 'the eclipse was total towards mid-day. But when we came south-west to the Chin Shan, the people there said that at the hour of the Snake it reached its greatest extent, covering seven-tenths. Thus in three places it was seen in three different ways. K'ung Ying-ta [574–648 A.D.], in his commentary on the *Springs and Autumns*, says that when the moon comes between us and the sun there is an eclipse of the sun. In the present case only those who were in a direct line with the sun and moon experienced a total eclipse. By those away from this line the eclipse is seen differently, the gradual change becoming considerable at a distance of a thousand *li*. It is just as though one covered a candle with a fan. In the direct shadow of the fan there is no light, but the further one moves to the side the greater the light becomes.'"

Mr. Waley explains that the Chinese believed that every point on earth was influenced by a corresponding point in the heavens. Thus, on a certain day the Controller Wang Chi appealed to the Master to avert the danger threatening the district of Pekin through the impinging of the planet Mars upon the constellation Wei. The Master hurriedly arranged a service, and upon the second night "the planet was now several mansions away . . . so swiftly had the Master's magic taken effect. . . . A large number of Taoists came from distant places with offerings of chrysanthemum-flowers. He made for them a poem in lines of unequal length, to the tune *Yü Shēng Hēn Huan Ch'ih*."

Many incidents are related which bring out traits in the Master's character. The governor of Samarkand gave a banquet in his honour. "Noticing that the Master drank very little, he begged to be allowed to press a hundred pounds of grapes and make him some new wine. But the Master answered: 'I do not need wine. But let me have the hundred pounds of grapes; they will enable me to entertain my visitors.'" Upon another occasion, stories were related of mischievous mountain spirits which had cut off the back hair and departed with the choicest provisions of the narrators. "The Master made no comment on these stories."

Among his varied accomplishments, the Master was skilled at rain-making and poetry. During the great drought of 1227, the authorities offered up prayers in vain.

"The Taoist congregations in the City came one day and begged the Master to perform the rain-bringing service. . . . The Master said quietly: 'I was just thinking of celebrating such a service. That you, sirs, should have come with the same suggestion is an example of what is called "spontaneous identity of ideas". There remains nothing for it but that you . . . should devote all your energy to the arrangements.' . . . And sure enough as the time for the service arrived, rain fell all day, and by next day a foot of it had fallen."

Upon occasion, the Master applied his poems with great effect.

"One day there was a dispute and the Master was asked which side he took. He remained silent, and thus settled the question in accordance with the spirit of Tao. Presently he gave them the following hymn:

Sweep, sweep, sweep!
Sweep clear the heart till there is nothing left.
He with a heart that is clean-swept is called a 'good man'.
A 'good man' is all that is meant by 'holy *hsien*' or '*Fo*'.

The disputants retired discomfited."

The narrative abounds in pleasant reading of this kind, and at the end our old Chinese alchemist leaves us to exclaim with bully Bottom: "I desire your more acquaintance, good Master!"

John Read.

The New Crystallography.

Strukturbericht, 1913–1928. Von P. P. Ewald und C. Hermann. *Zeitschrift für Kristallographie, Kristallgeometrie, Kristallphysik, Kristallchemie*, Ergänzungsband. Pp. iv + 818. (Leipzig: Akademische Verlagsgesellschaft m.b.H., 1931.) 47 gold marks.

THE publication in book form of the reviews which have been appearing for several years in the *Zeitschrift für Krystallographie* will be warmly welcomed by those interested in the structure of crystals. The book contains a survey of all work in this field from 1913, when the first analyses by X-ray methods were made, to the end of 1928. The older crystallography was mainly concerned with the external form and physical properties of crystals; its achievements are recorded in the five volumes of Groth's "Chemische Krystallographie". The present volume makes a first step towards fulfilling the same function in the new field as Groth's monumental work in the old, and we owe a great debt to the authors for the immense amount of labour which must have been put into its compilation. Their task has been no easy one. Not only is the output of papers increasingly great every year, but also it is often difficult to sort the wheat from the chaff, and estimate from an author's account the reliance to be placed on his conclusions.

The new crystallography probes more deeply, and attempts to give the arrangement of atoms in the structures. The centre of interest has shifted, and the external crystalline form, which has for long been the chief preoccupation of crystallography as a means of classification and examination, is now to be reckoned as a secondary and relatively unimportant manifestation of the underlying structure, dependent on elusive factors, and telling little about the crystal. The less ambitious aim of the investigations into crystalline form gave a precision and completeness to the results, and Groth was able to condense the data into a single account for each crystal. The new field is only partially explored ; early results are continually being modified and new crystals investigated. Hence the authors of the " Strukturbericht " have both classified, when possible, and also given summaries of all the individual papers in a form which is very convenient to consult.

The crystals are divided into the classes of elements and inorganic compounds, alloys, and organic compounds, and each class is subdivided into groups of types. For example, the elements are classified under the types $A1$ (face-centred cubic lattice), $A2$ (body-centred cubic lattice), $A3$ (hexagonal closest packing), and so forth. Compounds with formula AB belong to B types, those with formula AB_2 to C types. The descriptions of the types are very clear, and figures are numerous and cleverly drawn so as to give an appearance of perspective. A separate diagram shows the way in which each atom is surrounded by neighbours. After the description of the type, a detailed list of crystals belonging to it is given, with tables of parameters and interatomic distances. Then, at the end of the descriptions of types in each group, all relevant papers are briefly reviewed, the writers' conclusions being summarised and in some cases a critical paragraph added.

The description of the salient physical features of each structure is a model of completeness and conciseness, and is often a great improvement on the account in the original papers. The value of all the information in the " Raumgruppentabelle ", which lists the purely geometrical properties of symmetry of each structure, is not so apparent. To take an example, the structure of indium is based on a tetragonal space-lattice. A list of 35 space groups is given, of each of which the indium lattice may be regarded as a special case, and the corresponding atomic symmetry, " Hauptinseln " and " Minimum Inselsymmetrie " are faithfully recorded for each group. Not only is it doubtful whether such data have a physical significance or correspond to any property of the constituent atoms, but also, in the unlikely contingency that these symmetry properties are required, they can be readily seen from a glance at the structure.

The division into types is convenient in the case of the simple inorganic compounds and alloys, where many compounds containing different elements crystallise in a similar way. It is not so well suited to the organic compounds. Here one is dealing with a variety of structures in which the elements are the same, and there are practically as many types as compounds. Possibly a different method of classifying these structures will finally be adopted.

An excellent feature of the book is its indexing. There are four indexes, for authors, names of compounds, formulæ, and types ; it is easy to find any information one requires. The whole book is very successfully planned. The authors must be congratulated, both for their courage in tackling such a heroic task and for their skill in devising a scheme which is so sound and so easily extended to embrace new knowledge, and on which future reviews will no doubt be modelled. W. L. BRAGG.

Science in the Rabbit Industry.

The Scientific Aspects of Rabbit Breeding. By James N. Pickard and F. A. E. Crew. Pp. ix + 122 + 12 plates (Idle, Bradford ; and London : Watmoughs, Ltd., 1931.) 6*s.* 6*d.*

THIS little book affords welcome evidence of an increasing inclination on the part of the animal breeder to turn to science for guidance. For its publishers are also the publishers of the principal weekly paper dealing with the rabbit industry and fancy, and they must have scented an opening for such a work. Indeed, it is fully time that such a work appeared, for the cult of the rabbit has undergone profound changes since the War. Twenty years ago the only breeders of rabbits who mattered were the fanciers, and it was almost entirely for them that the literature catered. As compared with to-day, relatively few varieties were standardised, the object of breeding being solely for show purposes. Rabbit keeping was a hobby, and though from time to time enthusiasts would suggest the possibility of industrial exploitation, yet the author of " The Book of the Rabbit ", writing in 1889, stated that " as against all theories to the contrary, the stern fact remains that a modern instance of profitable rabbit farming is unknown".

It was only with the War that the rabbit began to come into its own. Thousands then realised that it was easy to keep and not too disagreeable to eat. Even so, the advent of peace, bearing cheap beef and mutton, might have led to renewed stagnation in the rabbit world had not another circumstance reacted in its favour. The general raising of the standard of life led to a greatly increased demand for inexpensive furs such as the rabbit alone could supply. Fortunately also, the rabbit had 'sported' several attractive new colours during the earlier part of the century, and these were available when the fur boom started. With good skins fetching up to 10*s*. apiece, and even more, rabbit farming at once became a profitable industry. Though, like other industries, it has suffered recently from the prevailing depression, there are sound reasons for expecting it to flourish once more when the general outlook brightens.

In the first place, it is clear that 'wild' furs must become progressively less able to cope with the world demand, with the consequent advantage to the pelt of the rabbit. Secondly, the new 'sports' in colour and texture of fur which have appeared during the past few years have added enormously to the variety of *natural* rabbit furs. In earlier days the choice was very limited, and rabbit pelts were generally dyed to render them more attractive. This naturally affected their durability, so that rabbit fur got a bad name, which it has not yet lived down. This prejudice must eventually pass away, for the natural fur, pelted at the right time and properly treated, lacks nothing in durability.

At present one of the obstacles to the spread of the new types of fur is the difficulty of producing a uniform article in sufficient quantities, and it is here that the breeder is beginning to make use of modern genetical knowledge. These new types are largely the result of recombinations through crossing, and in the hands of the ordinary breeder throw many unwanted forms, with consequent loss. This, of course, could be avoided if the breeder were to work in the light of what is already known about the genetics of the rabbit, and it is with the idea of assisting him that the present little book has been brought out.

No more competent guides could have been selected either from the point of view of scientific attainment or of practical experience. They have produced between them an excellent little treatise which covers the whole ground of the physiology, nutrition, genetics, and general management of the animal. The genetical part, as might be expected, is fully entered into, and an analysis in terms of genetical factors is given for all the principal breeds. At the same time, the breeder is initiated into the modern manner of recombining characters, and of the steps necessary to form them into fixed breeds with the least expenditure of time and energy.

The chapters on nutrition and management are eminently practical, and, though mainly devised for the industry, the book should prove of great service to all who make use of the rabbit for scientific purposes. It concludes with a serviceable bibliography.

Short Reviews.

(1) *Outlines of Physical Geology*. Prepared from the Third Edition of Part I. of Pirsson and Schuchert's "Textbook of Geology" by Prof. Chester R. Longwell. Pp. vi + 376. 1930. 15*s*. net.
(2) *Outlines of Historical Geology*. By Prof. Charles Schuchert. Second edition, rewritten. Pp. v + 348. 1931. 15*s*. net.
(New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.)

(1) The first of these "Pirsson-Schuchert Geologies" is a shorter form of the 1929 revision of Pirsson's "Physical Geology" (Nature, Oct. 4, 1930, p. 531) made by members of the Yale Department of Geology under the editorship of Prof. Longwell. The chapters dealing with the interior of the earth, ore deposits, and land forms have been omitted from this abridgment, and all the remaining chapters, except Chap. i., have been shortened. The book is authoritative and beautifully illustrated and can be confidently recommended to elementary students of geology and physical geography. The prospective buyer, however, would be well advised to pay the extra 3*s*. 6*d*. and acquire the more complete revision of 1929.

(2) Prof. Schuchert's "Outlines" is in its origin an abridgment of his much longer "Historical Geology" of 1924 (Nature, Sept. 13, 1924, p. 376), but in its present dress it constitutes practically a new book. It gives an admirable summary of "the archives of life's adventures". The continuity of the historical story is now less broken into by sections dealing with plants and animals, as the latter have been brought together to form two of the introductory chapters. More stress has been laid on evolution as the keynote of geological chronology and correlation. Considerably more attention has also been given to palæogeography, and the maps for which Prof. Schuchert is justly famous have been redrawn in accordance with the additional data now available. The book is more richly adorned with splendid illustrations than any other comparable work. Both students and teachers and also the ordinary reader who may be looking for a coherent account of the principles of earth history

will be amply rewarded by Prof. Schuchert's competent management of his vast subject.

We are informed by the publishers that the two works are now available as a single volume entitled "Foundations of Geology", price 25*s.* net.

Climatology. By A. Austin Miller. (Methuen's Advanced Geographies.) Pp. x + 304. (London: Methuen and Co., Ltd., 1931.) 12*s.* 6*d.* net.

THIS is an excellent book, well produced and well illustrated, and should be of great value to geographers both for reading and reference. After three introductory chapters on the scope of climatology, the elements, and the factors of climate, the major part of the book is descriptive. The author first sets out the modern ideas on the classification of climates, especially those of Köppen, and then arranges his material according to the major climatic provinces—equatorial, tropical, tropical monsoon, etc., ending with two chapters on desert and mountain climates. This logical arrangement is probably the best for teaching purposes, though it breaks up the unity of the continents. The various climatic types and subtypes receive clear treatment, illustrated by charts and diagrams, and completed by paragraphs on the associated vegetation and cultivation; and each chapter is followed by a short bibliography and by two pages giving averages of temperature and rainfall for a number of typical stations. The book ends with an interesting chapter on changes of climate, and a very good index.

The author's physical explanations are sometimes obscure: thus, a cooling breeze surely cannot promote radiation, as stated on p. 13, though it does promote conduction; and the explanation of the vertical decrease of temperature on p. 37 is very muddled. The diagram on p. 184 is also difficult to understand; the fact that the "highest mean monthly maximum on record" (whatever that is) at Cambridge in January is just higher than the "lowest mean monthly minimum on record" in July is not evidence that "the coldest July was actually colder than the warmest January", a statement which is, in fact, incorrect. These are small blemishes, however, and the book as a whole shows that the author has read with understanding as well as widely.

Commonwealth Bureau of Census and Statistics, Canberra. Official Year Book of the Commonwealth of Australia. No. 23, 1930. Prepared under instructions from the Minister of State for Home Affairs by Chas. H. Wickens. Editor: John Stonham. Pp. xxxii + 806. (Melbourne: H. J. Green, 1931.) 5*s.*

THE issue of this year book for 1930 is considerably smaller than for recent years, and yet a comparison with last year's volume suggests that nothing of real importance has been omitted. As usual, the book contains full statistics of every aspect of Australian activity, and, in many cases, the figures for recent years which enable comparisons to be made.

It has been the custom for the Year Book to contain at least one specially contributed article. This practice is continued with an article by Prof. Radcliffe Brown on the former numbers and distribution of the Australian aborigines. In making his estimates, for which data naturally vary in different parts, Prof. Brown has divided each State into districts which so far as possible are those recognised by the natives. The final figures give 251,000 as the lowest, and 300,000 as the highest, figure for the original population of Australia. This is equal to 12 per square mile for the continent as a whole with as many as 38 per square mile in South Australia and as few as 6·7 per square mile in Queensland. Prof. Brown admits that much of the evidence on which these figures are based, especially in regard to Queensland, New South Wales, and Tasmania, is not wholly satisfactory.

The Journal of the Institute of Metals. Vol. 44. Edited by G. Shaw Scott. Pp. xii + 880 + 56 plates. (London: Institute of Metals, 1930.) 31*s.* 6*d.* net.

THIS volume is the last of the present series. In future, the papers read before the Institute of Metals will appear, as before, in half-yearly volumes, but the abstracts will form a third volume, published annually. The papers read at the Southampton meeting include several on aluminium alloys, including an illuminating discussion of the methods of refining the grain size of aluminium by the use of volatile chlorides or of chlorine-bearing vapours. It appears that the entry of water vapour from products of combustion into aluminium and its alloys may be particularly harmful. An interesting monograph on the origin and development of rolled gold contains information which will be new to most readers, on a material in familiar use. Further work has been done on the atmospheric corrosion of copper, and a basic sulphate is shown to be the principal constituent of the product in ordinary atmospheres, largely replaced by the basic chloride in marine situations. Prof. Tammann has contributed a paper on the determination of crystallite orientation in metals, which will be found useful as a summary of numerous papers by that author which have appeared elsewhere. The plates are, as usual, excellently produced.

Exercices de mécanique. Par H. Beghin and Prof. G. Julia. Tome 1, Fascicule 2. Pp. iv + 337-577. (Paris: Gauthier-Villars et Cie, 1931.) 60 francs.

THIS part of the work, by M. Beghin and Prof. Julia of the Faculty of Science of the University of Paris, contains six chapters dealing with fundamental laws, general theorems, work and power, virtual work, impulsive motion, and Lagrange's equations as applied to this type of motion. Each chapter contains a short theoretical introduction and a collection of illustrative examples worked out in detail. These are usually of a fairly advanced type, and frequently deal with interesting physical or engineering problems. The book should be useful to the teacher in search of problems or to the student working alone from text-books.

Science in the City of London.

By Engr.-Capt. EDGAR C. SMITH, O.B.E., R.N.

TO the student of the history of science and technology London offers a field of inquiry of wide and unfailing interest. From Westminster Abbey to the docks, from Highgate to Clapham, all routes lead to some spot with scientific associations. Ever since the Romans came, bringing with them their measuring, surveying, and surgical instruments, London has owed something to scientific inquiry, and the construction of her gates and fortifications, her historic Bridge, and her great Tower were only rendered possible through the discoveries of the ancient world. But great as is our debt to Greece and Rome, it is within modern times that science has invaded every side of human activity, and many of the most important discoveries, many of the most notable inventions, and many of the most striking applications of science have been made in London. Thus it is that from one boundary of London to the other her streets and lanes, her institutions, hospitals, and workshops, her cathedrals and churches, the river and its bridges, her parks and gardens, all have some tale to tell relating to the increase of natural knowledge.

Obvious as are the many applications of science to practical affairs to-day, and numerous as are the records of men of science who have lived and worked in London, the annals of science in the City of London still remain fragmentary and scattered. The intrinsic interest in the story was well shown by Mr. H. G. Wayling in his articles on "The Romance of Science in Bygone London", published in *Science Progress* in January and April this year, and also in Dr. Charles Singer's address on "The First Century of Science in England", given during the recent International Congress of the History of Science and Technology. The subject, too, is happily claiming the attention of the British Association, which this year for the first time is meeting in London.

"The general attitude to Nature", said Dr. Singer, "which we nowadays call scientific was opened, as far as England was concerned, by the appearance of certain works of Giordano Bruno." These works were surreptitiously printed in London in 1584, probably in the Charterhouse. Fourteen years before that, however, Henry Billingsley, Sheriff of London in 1584 and Lord Mayor in 1596, had published the first English translation of Euclid. With "a very fruitfull Præface" by Dee, Billingsley's book was printed by John Daye, dwelling over Aldersgate beneath Saint Martins. Billingsley became a knight and a member of parliament, and died in 1606. If to him we are indebted for the earliest English translation of the "Elements of Geometry", to his famous contemporary Sir Thomas Gresham we owe the establishment of Gresham College and the founding of the earliest chairs of geometry and astronomy in the country. Some science had been taught at Oxford and Cambridge long before then, but the foundation of Gresham College was one of the most important steps taken in connexion with the educational facilities of London, and with its history the story of modern science in London rightly begins.

Gresham was born about 1519 and died in 1579. The son of a Lord Mayor, he was a servant of the State as well as a great merchant, and, during the reigns of Edward VI., Mary, and Elizabeth, acted as a sort of financial ambassador. In 1566 he founded the Royal Exchange, and, perhaps influenced by the establishment in Paris by Francis I. of the Collège Royale, now the Collège de France, he left his fine mansion in Bishopsgate to the London Corporation and the Mercers' Company for a college and endowed chairs in physic, geometry, astronomy, music, law, rhetoric, and divinity. His widow dying in 1596, the bequest then became available and the first lecturers were appointed. Briggs was chosen first professor of geometry and Brerewood first professor of astronomy. To them succeeded in turn Edmund Gunter, the inventor of Gunter's chain; Henry Gellibrand, who completed Brigg's "Trigonometria Britannica"; John Greaves, the first man in modern times to measure the Pyramids; Samuel Foster, the author of "The Use of the Quadrant"; Rooke, declared to be "the greatest man in England for profound learning"; Walter Pope, a contributor to the first volume of the *Philosophical Transactions*; and Barrow, Wren, and Hooke. Some of these, it will be recalled, were among the founders of the Royal Society, which from its foundation in 1660 until 1710, except for a few years after the Great Fire, met in Gresham College.

In the seventeenth century, London was also the home of Thomas Harriot, the algebraist and the first Englishman to observe sunspots; Walter Warner, Thomas Allen, Nathaniel Torporley, who is said to have acted as amanuensis to Vieta, and Dr. Wilkins, who "deserves more than any man to be esteemed the founder of the Royal Society". Many of these scientific worthies were buried in the City churches, although to-day, owing to the destruction by the Great Fire and to other causes, one may look in vain for memorials of them. Billingsley was buried in St. Katherine Coleman, Fenchurch Street; Brerewood and Hooke, like Gresham himself, in St. Helen's, Bishopsgate, "the Westminster Abbey of the City"; Gunter, Foster, and Gellibrand in St. Peter the Poor in Broad Street; Torporley in St. Alphage in London Wall; Rooke in St. Mary Outwich, Bishopsgate; Pope in St. Giles', Cripplegate; Harriot in St. Christopher le Stocks, a church which had to make way for the Bank of England; Greaves in St. Benet's, and Wilkins in St. Lawrence Jewry, of which he was one time rector. Of other old mathematicians, Thomas Digges was buried in St Mary Aldermanbury; and Collins, "the attorney-general for the mathematics", in St. James', Garlick Hill. Wren, of course, lies in St. Paul's; and Barrow in Westminster Abbey.

Bishopsgate, besides being the street in which Gresham College was situated, is the centre of a district abounding in scientific interest. In Winchester Street hard by, at his father's house, Halley, as a boy of nineteen, began his astronomical observations; in Austin Friars, Aubert had the first of his three observatories; and at the offices of the Magnetic Company, in Old Broad Street, in 1856, the electricians, Whitehouse and Bright, showed Morse that signals could be sent at the rate of 272 a minute through 2000 miles of wire laid to and fro between London and Manchester. Latimer Clark had shown Airy and Faraday the same experiment at Lothbury in the City three years before. In Bishopsgate also stands the little church of St. Ethelburga, which has recently been enriched with three beautiful windows erected to the memory of Henry Hudson, who with his crew took Holy Communion in the church on April 19, 1607, the day before he set sail in the *Hopewell*, Frobisher's old ship. Then, too, Birchin Lane and Finch Lane, at the back of the Royal Exchange, remind us of the work of Newcomen and Watt. For a year, Watt worked in Finch Lane learning to make sextants, all the time going in fear of the press gang. Farther to the east, the Tower, the Mint, and Trinity House all have links with modern science; with one or the other have been connected Sir Jonas Moore, Flamsteed; Drummond, the inventor of the lime-light; Forsyth, the inventor of the fuse; Newton; Graham the chemist; Sir John Herschel; Roberts-Austen, who was responsible for the quality of no less than £150,000,000 of gold coins; the engineers Barlow and Douglas; and Faraday, Tyndall, and Rayleigh. The City, too, was the home of the early clock makers, map makers, and instrument makers, and some of these were associated with the old Mathematical Society of Spitalfields, of which Major P. A. MacMahon gave some particulars in his presidential address to Section A of the British Association in 1901.

This old scientific society came to an end in 1845, but long before then the centre of London science had shifted westward. Just as the history of science in London in the seventeenth century is bound up principally with the district to the east of St. Paul's, so its history in the eighteenth century brings us to the west of St. Paul's and to Fleet Street and the Strand. St. Paul's itself, as Mr. Wayling has pointed out, Christ's Hospital, the Charterhouse, Child's Coffee House in St. Paul's Churchyard, the London Coffee House in Ludgate Hill, the Mitre Tavern in Fleet Street, and the Crown and Anchor in the Strand, all have some scientific associations, as also have the Temple and Somerset House.

Fleet Street abounds in both literary and scientific associations, and to-day the Newcomen Society frequently meets in Prince Henry's Room in a house which was familiar to Newton and his fellows who came to Crane Court in Fleet Street for the meetings of the Royal Society. On Sept. 8, 1710, Newton as president had summoned the council of the Society for the purpose of informing them that the house of the late Dr. Brown in Crane Court was to be sold, " and being in the middle of the Town, and out of noise, might be a proper place to be purchased by the Society for their Meetings ". The outcome of this suggestion was the purchase for £1450 of Dr. Brown's house and the next; and on Nov. 8, 1710, the Society held its first meeting in its own home, and Gresham College, much to its detriment, saw the Society no more. During the seventy years the Society met at Crane Court it had ten different presidents, among whom were Sir Hans Sloane, Martin Folkes, Sir John Pringle, and Sir Joseph Banks, the last of whom was just beginning his long period of office, when in 1780 the Society, through George III., was granted the use of apartments in Somerset House. Newton's last appearance in Crane Court was when he presided over a meeting on March 2, 1727, eighteen days before he died. To the period the Society was housed in Crane Court belong the labours of Halley, Bradley, and Hadley; the foundation of the Copley Medal and its award to Gray, Desaguliers, Bradley, Harrison, Canton, Franklin, Dollond, Smeaton, Cavendish, Priestley, and Cook; the promotion by the Society of the practice of inoculation; the controversy over lightning conductors, and the furtherance of expeditions to observe the transits of Venus of 1761 and 1769.

In those days several members lived quite close to Crane Court. James Ferguson, elected F.R.S. in 1763, a very remarkable self-taught man, had his home in Bolt Court, where Johnson lived, and he died there in 1776. From Ferguson's books Herschel gained his first knowledge of astronomy. Crane Court and Bolt Court are on the north side of Fleet Street. On the other side was Water Lane, now Whitefriars Street. Tompion, the famous watchmaker, had a shop at the sign of the Dial and Three Crowns at the corner of Water Lane. Here George Graham worked for Tompion, married his niece, and succeeded to his business, which, however, he moved across Water Lane to the Dial and One Crown. Graham's house was a workshop, a laboratory, and an observatory combined. He and Tompion to-day rest in the same grave in the nave of Westminster Abbey. Another famous Fleet Street instrument maker was Pinchbeck, and another, Troughton, who died at No. 138. Just below Whitefriars Street is Salisbury Court, leading to St. Bride's Church and Dorset Street. Salisbury Court once contained the " workhouse " of Captain Thomas Savery, " the most prolific inventor of his day ", and there in 1702 his steam pumps could be seen.

In St. Bride's Church is the monument to Dr. Wells, bearing representations of the Rumford Medal of the Royal Society, which was awarded him for his excellent memoir on dew. The church also recalls the names of Wren and of the chemist Delaval, who described the damage done to it by lightning in 1764. He also wrote an account of the damage to St. Paul's by lightning in 1772. About forty years after this, at No. 53 Dorset Street, lived Mr. Tatum, in whose house the City Philosophical Society met on Wednesday evenings.

After his trip to the continent with Davy, Faraday became a member of this Society and it was in this house he served his apprenticeship as a lecturer.

Such are a few of the scientific associations of Fleet Street and its neighbourhood. Were it possible to continue the story, the survey would take us into Chancery Lane and Gunpowder Alley and to the Middle Temple, where William Ball, the first treasurer, was buried, and Garden Court, the first home of the Geological Society, and thence back into the Strand and its surroundings, and so still farther westward. For the history of science in both the City of London and greater London during the nineteenth century, the birth and growth of our great scientific and technical societies and institutions, their work and influence, as well as university education, the volume on "London and the Advancement of Science", published by the British Association, should be consulted.

Altogether apart from the records of any organisation, however, there is much of an intimate and personal character awaiting the student of science in London. In the lives of men of science, as in the lives of others, are to be found those incidents, anecdotes, and observations which are the breath of biography and by which we are able in some degree to reconstruct the past. With a knowledge of the past, London becomes a place of memories, and in imagination we can join the company of Raleigh and the Earl of Northumberland and his 'three magi' in the Tower, or visit the lecture rooms of Hauksbee and Desaguliers or stand beside Voltaire at the grave of Newton. In fancy we can endeavour to break through the strange seclusion in which Cavendish lived and worked in his house on Clapham Common, watch Davy in the laboratory overcome with delight as he sees the first globules of metallic potassium form, assist Frank Buckland in his efforts to find the coffin of John Hunter in the crypt of St. Martin's-in-the-Fields, or travel across London with Kekulé on the evening he first saw the atoms linked.

This story is best told in Kekulé's own words. It takes us back to 1855, when Kekulé, at the age of twenty-six, was assistant to Stenhouse at St. Bartholomew's Hospital. Living in Clapham, he was returning home from a visit to Hugo Müller at Islington. "One fine summer evening", he says, "I was returning by the last omnibus, 'outside' as usual, through the deserted streets of the metropolis, which are at other times so full of life. I fell into a reverie, and lo, the atoms were gambolling before my eyes! Whenever, hitherto, these diminutive beings had appeared to me, they had always been in motion, but up to that time I had never been able to discern the nature of their motion. Now, however, I saw how frequently two smaller atoms united to form a pair; how a larger one embraced the smaller ones; how still larger ones kept hold of three or even four of the smaller; whilst the whole kept whirling in a giddy dance. I saw how the larger ones formed a chain dragging the smaller ones after them, but only at the ends of the chain. I saw what our Past Master, Kopp, my highly honoured teacher and friend, has depicted with such charm in his 'Molekularwelt'; but I saw it long before him. The cry of the conductor, 'Clapham Road', awakened me from my dreaming; but I spent a part of the night in putting on paper at least sketches of these dream forms. This was the origin of the Structurtheorie."

Modern Apparatus for the Reproduction of Speech and Music.

By Dr. N. W. McLachlan.

SOUNDS can be divided broadly into two classes: (*a*) transients, with which one is mainly concerned in speech, and to a lesser extent in music; (*b*) continuous sounds, which pertain chiefly to instrumental music and singing. Since a transient can be represented by an infinite frequency spectrum, the ideal apparatus should be capable of reproducing the entire range from zero to infinity. Fortunately for designers, the sensitivity of the ear is limited to the range 25-20,000 cycles (according to the individual). The widest range adequately covered by a single reproducer is from 50 to 7000 cycles, but this can be extended to 12,000 cycles by an additional reproducer. The range covered by the ordinary domestic loud speaker of the moving coil variety is roughly from 40 to 5000 cycles.

The energy of speech and music is conveyed by the frequency band below 500 cycles, whilst the interpretational and intelligibility characteristics reside in the range above this. Attenuation of the lower register is accompanied by a lack of body; for example, a pedal organ sounds like a harmonium. Attenuation of the upper register makes speech woolly, unnatural, and difficult to understand, music loses character and brilliance, whilst transients are travestied to a new type of sound; for example, the *rustle* of paper has never been heard over the microphone! The faithful reproduction of paper rustling and coin jingling involves frequencies greater than 10,000 cycles.

It is impossible to deal here with all forms of reproducing apparatus, but two representative types have been chosen, in both of which the driving mechanism is a circular coil immersed in a strong radial magnetic field. In the first or hornless type, the reproducing mechanism is a conical paper diaphragm 10-15 cm. in radius, to which the coil is rigidly attached (Fig. 1). The coil is constrained to move axially by a centering device, whilst the diaphragm is supported at its periphery by an annulus of leather, rubber, or other material. This arrangement is associated with some form of baffle to prevent interference between the pressure waves on each side of the diaphragm, since they are of opposite sign. The interference increases with the wave-length and is, therefore, greatest at low frequencies. To prevent appreciable reduction in output at, say, 100 cycles, the distance from centre to centre round the baffle should be half the wave-length, which makes the baffle about six feet round or square. In commercial apparatus for domestic purposes these dimensions are not realised. It is customary to use a cabinet which often introduces resonance effects. For talking pictures, however, a baffle is generally used.

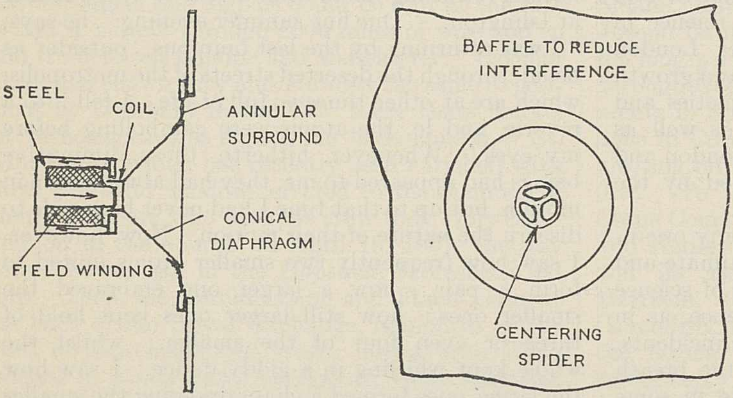

FIG. 1.

In the second type of reproducer, the diaphragm is within the coil and is used in conjunction with a horn, the cross-section of which increases exponentially (Fig. 2). The low frequency cut-off of the horn depends upon the rate of expansion and upon the length. A long horn permits a gradual expansion, whilst the diameter at the open end can then be greater than a quarter of the wave-length of the lowest frequency to be adequately reproduced. These conditions are concomitant with small reflection within the horn, whilst at the mouth the reflection is only serious for those frequencies below the cut-off point. For adequate reproduction below 100 cycles per second, an axial length of 15-25 ft. is required.

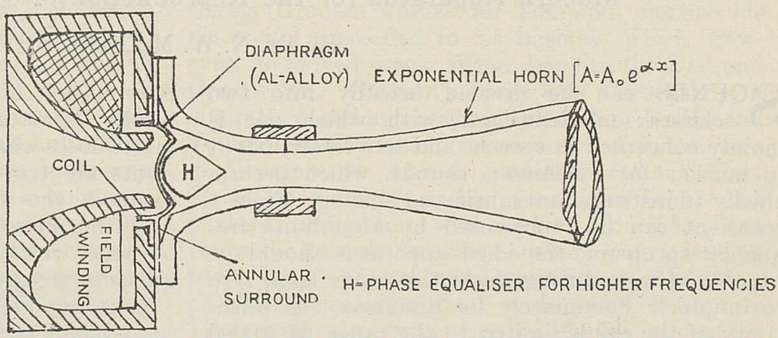

FIG. 2.

The coil and diaphragm (Fig. 2) is attached to a flexible annulus, the outer edge being securely clamped to the electromagnet. The natural frequency of the system on open circuit *in vacuo* is 400 cycles per second. The diaphragm is shaped to give rigidity, so that it moves substantially as a whole over a wide frequency band. The obstruction *H*, apart from reducing the throat area and thereby increasing the air particle velocity, acts as a phase equaliser. The clearance between the diaphragm and *H* gradually increases with the radius. Thus, during vibration the velocity of the air particles most remote from the horn aperture is increased, so that up to quite high frequencies the pressure from all parts of the diaphragm arrives in the main column in substantially the same phase.

In the early days of broadcasting it was thought that the ideal diaphragm (10-15 cm. radius) ought to move as a whole. Some years ago I showed that, owing to interference, the power output above 1000 cycles decreases so rapidly that a rigid structure would be of no value for modern moving-coil loud speakers using a baffle. After the 'moving coil' made its début, it was believed in certain quarters that the diaphragm moved as a whole over a wide frequency range. When the apex or the coil is tapped, a complex sound corresponding to the natural frequencies of the diaphragm is heard, whilst during operation the output above 1000 cycles usually exceeds that at lower frequencies. Such effects preclude the possibility of rigidity throughout the acoustic register.

I have shown recently that the action of a moving coil loud speaker depends upon resonances throughout the frequency range. The lower register is due to resonance of the annular support, acting as an auxiliary diaphragm, or to resonance of the diaphragm as a whole on the support or on the centering device of the coil. The upper register is due to the centre moving symmetrical modes of the diaphragm. If the low frequency resonances are eliminated, the upper register is overpowering and the reproduction lacks body. Owing to transmission loss in the diaphragm and to interference in the surrounding space, there is an upper frequency cut-off and considerable attenuation occurs above 5000 cycles.

The reaction on the driving coil consists of two components in quadrature: (*a*) resistive due to the radiation of sound and transmission loss; (*b*) reactive due to the mass of the diaphragm including the accession to inertia caused by divergence of sound waves from the diaphragm as source. The mass reactance is a considerable proportion of the total mechanical impedance and reduces the amplitude of vibration considerably unless it is offset by elasticity of the diaphragm structure.

As in the case of a heat engine, the efficiency of an electrical-mechanical-acoustical apparatus can be stated in several ways. For the present we shall take the ratio η = acoustic output/electrical input. The value of η depends upon the magnitude of the resonances and the strength of the magnetic field. For a hornless type driven by a coil 2·5 cm. radius, 0·95 cm. long, and a radial field strength of $1 \cdot 3 \times 10^5$ lines per sq. cm., an efficiency of 10 per cent or more can be obtained over a certain frequency range.* By using a stronger field the efficiency can be increased. Where a permanent magnet is used, as in apparatus for domestic use, the efficiency is more likely to lie between 2 and 4 per cent.

When a horn is used, the radius of the diaphragm is usually about 2·5 cm. As in the preceding case, the reaction on the coil can be divided into resistive and reactive components. By means of the horn, however, the resistive component can be made relatively larger than in the hornless type of reproducer.

The horn acts as a coupling device which enables the high-pressure low-volume energy in the immediate vicinity of the diaphragm (the coupling chamber) to be transformed gradually and efficiently into low-pressure energy ultimately supplied to a large volume of air. This is very different from the large diaphragm type, where no attempt at impedance matching is made. The resistive load being relatively higher than in the hornless reproducer, means that the efficiency is correspondingly larger, whilst resonances are more heavily damped. Efficiencies of 30 per cent over a wide range can be obtained with a horn 15-25 ft. in axial length. Consequently, these instruments are invaluable for public address and entertainment purposes where an acoustic output of several watts is required.

With the same input, the reproduction of broadcasting by aid of a well-designed horn apparatus † is louder and better than that from a large diaphragm apparatus using a baffle. Although the lower register is more powerful in the latter case, the resonances are more marked and more sustained, ‡ whilst the upper frequencies are weaker. Moreover, the reproduction of transients is better with the horn type.

The operation of loud speakers for public address and entertainment purposes where the acoustic output runs into watts, requires a power installation. From a supply engineer's point of view the power is negligible, but in comparison with that required for domestic receivers it is large. In speech and music, peak values ten or more times the mean value occur in transients. To avoid distortion, it is essential that on the average the output valves are not worked to their limit. This necessitates applied voltages of from 500 to 1000.

In receivers for domestic purposes, it is seldom that the voltage applied to the valves exceeds 220. This combined with reproducers of low efficiency often means that in an attempt to get adequate volume, the output or power valve is worked beyond its normal capacity. On loud passages considerable distortion ensues, due to the creation of alien frequencies arising from operation beyond the linear limits of the valve characteristics. For undistorted output the general loudness level must be fairly low. Although this meets with approval in many households, it must be realised that with music it is desirable to have a reasonable loudness level, to simulate conditions in the concert hall or studio. The effect of loudness level is related to the physiological properties of the ear. If we listen close to a band in the park, the fundamental tones of all the instruments, from the bass drum upwards, are in evidence. But when we walk slowly away from the band, the pitch of the lower-toned instruments appears to alter, and ultimately the music sounds thin. This is due to the insensitivity of the ear to low frequencies. Beyond a certain distance from the band the air pressure due to the fundamental frequencies is below the audible limit for the human ear.

Applying this effect to indoor listening, it is clear that if the overture to the "Mastersingers" is reproduced at a level readily drowned by conversation, the musical balance is lost and the orchestra would be just as effective if it consisted of a flute and a few violins. Going to the opposite extreme, most of us have experienced the 'giant' voice of the announcer when the receiver is set to reproduce at a loud level for orchestral work. The voice is then projected at many times its normal loudness and air pressure distortion occurs. By virtue of the aural characteristics, the low tones appear unduly loud, thereby masking the naturalness of the voice. Sometimes this is due to diaphragm or other resonances, but undistorted reproduction at a much greater level than the original always accentuates the lower register. In this respect a violin reproduced very loudly might pass for a 'cello, and a flute for the diapason of a pedal organ.

As a general rule, there are one or more positions of a loud speaker which will give the best results in the average room. Here, as in the design of such instruments, one is often faced with 'Hobson's choice'. Thus reproduction is marred by resonances due to cabinets in which not only the loud speaker but also the whole receiving equipment is housed. The acoustic output is lavished mainly on the carpet, thereby causing attenuation of the upper frequencies and an inferior distribution of sound. When the time comes for a really high standard of reproduction in the home, the acoustic properties of rooms—amongst other things—will have to be taken into serious consideration.

* This estimate is independent of the power valve and transformer.
† It is assumed that the horn structure is substantially dead.
‡ Damping is greater, due to the restive load imposed by the horn. The magnetic field also assists.

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News and Views.

A PUBLIC and official celebration of the British Association centenary took place at Liverpool Cathedral on Sunday, Sept. 20, with the main object of paying tribute to the special associations which Liverpool can claim with the original formation of the Association. A special liturgy of thanksgiving for the works of great natural philosophers of all races and nations throughout the ages was read by Prof. J. L. Myres, one of the general secretaries of the Association, and responded to by the Dean and choir and the congregation. Special emphasis was placed on the public avowal of the debt of churchmen to science and an open recognition of common tasks and common aspirations. This great change in the relations between science and religion since the days of Darwin and Huxley was manifest in the Cathedral addresses of General Smuts and Sir Oliver Lodge and in the special sermon preached by the Bishop of Birmingham. Dr. Barnes remarked that the centenary coincides with the most magnificent period of scientific discovery in the history of humanity. Against this we have literature and art of which, according to Dr. Barnes, little will survive, ethical weakness testified by war, and religious decay. A hundred years ago, geological conceptions began to assail contemporary religious theory. As an antidote arose the Oxford movement. Such opposition still persists, but there are friends of science within the Church. Scientific workers are, like Darwin in the face of the antagonism of Wilberforce, then Bishop of Oxford, going steadily on, and are helping clergy to gain a richer certainty of God's existence and glory. The task before us, since the great advance in biological, physical, and all other sciences, is to make a satisfactory synthesis of man's religious aspirations and the conclusions of modern science.

SUFFICIENT interest has been aroused in the celebration of the centenary of the British Association for the general reader, as well as the student of the history of science, to desire a detailed and connected account of the events which have led up to the present commemoration. The need is admirably met by the issue of a second edition of Mr. Howarth's "The British Association for the Advancement of Science", originally published in 1922. Among the new features is a chapter on Down House—the home of Darwin—presented to the Association by Mr. Buckston Browne. The book contains excellent portraits of many of the Association's most distinguished members, taken at those periods of their lives when scientific discovery and achievement had produced a serenity of bearing, a pleasure to behold. In the first instance, the book was made possible through the generosity of the late Sir Charles Parsons, and its creditable compilation is the outcome of the labours of the secretary of the Association. The Association traverses all the domains of the realms of science, and treks to all the dominions of our Empire. Previously to this year it has regarded a visit to London in the nature of carrying coals to Newcastle; but now it has come and set the City ablaze. The British Association is a monument to the genius of our nation, and Mr. Howarth's book provides a brilliant floodlight to illuminate and advertise the fact. Copies are being presented to members of Association attending the London meeting.

MEMBERS of the British Association are also receiving a copy of "London and the Advancement of Science", a volume of some three hundred pages, compiled by ten contributors, each authoritative in his particular theme. As a preliminary classification of its contents, one might say that the scientific soul of London is revealed in such chapters as those on the learned societies, Government and scientific research, the development of medicine, and the history of education in London; while the more material aspect of the metropolis is dealt with in the sections on the Royal Observatory at Greenwich, Kew Gardens, the John Innes Institution, and the museums of London. There is also an introductory survey and a brief history of the London makers of scientific instruments. Among the authors' names are those of Sir Frank Heath, Sir Frank Dyson, Sir Daniel Hall, and Dr. F. A. Bather. Nothing so worthy of this phase of London life has ever before been attempted or achieved. There is a surfeit of good things for instructor and the instructed. In our youth we were told that the streets of London were paved with gold; we have only to turn to a random page of this book to discover treasures that historians of science, in their maturer years, might accept as precious metal. When Sir Humphry and Lady Davy, after a long stay abroad, arrived home, they mutually agreed that, although the Continent is a nice place to visit, London is the best place to live in. The more one becomes acquainted with the scientific history of London, the more one feels in spiritual contact with its glorious past, and in living union with its quickening present.

THE Faraday Commemorative Meeting, organised by the Royal Institution and the Institution of Electrical Engineers, was held at the Queen's Hall on Sept. 21. Representatives of forty-two countries attended this brilliant and dignified opening of the centenary celebrations in honour of the father of modern physics. In spite of the present crisis, the Prime Minister, the Right Hon. J. Ramsay MacDonald, honoured the meeting by his presence, and paid a warm tribute, in his opening address, to Faraday, the man who lived for his scientific convictions. The prominent speakers who followed laid stress on some particular points of Faraday's discoveries connected with their own special researches.

THE Duc de Broglie, well known for his investigations on X-ray spectra, contrasted the variety of Faraday's experiments with the unity of his purpose —a deeper knowledge of the laws of Nature. The Marchese Marconi explained how wireless and its

(*Continued on p.* 541.)

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The Scientific World-Picture of To-day.

By General the Right Hon. J. C. SMUTS, P.C., C.H., F.R.S., President of the British Association.

PRESIDENTIAL ADDRESS DELIVERED IN LONDON ON SEPT. 23, 1931.

THIS centenary meeting of the British Association is a milestone which enables us to look back upon a hundred years of scientific progress such as has no parallel in history. It brings us to a point in the advance from which we can confidently look forward to fundamental solutions and discoveries in the near future which may transform the entire field of science. In this second and greater renaissance of the human spirit, this Association and its members have borne a foremost part, to which it would be impossible for me to do justice. I shall therefore not attempt to review the achievements of this century of science, but shall content myself with the simpler undertaking of giving a generalised composite impression of the present situation in science.

I am going to ask the question: What sort of world-picture is science leading to? Is science tending towards a definite scientific outlook on the universe, and how does it differ from the traditional outlook of commonsense?

The question is not without its interest. For our world-view is closely connected with our sense of ultimate values, our reading of the riddle of the universe, and of the meaning of life and of human destiny. Our scientific world-picture will draw its material from all the sciences. Among these, physical science will—in view of its revolutionary discoveries in recent years—be a most important source. But no less important will be the contribution of the biological sciences, with their clear revelation of organic structure and function as well as of organic evolution. Last, not least, the social and mental sciences will not only supply valuable material, but also especially methods of interpretation, insights into meanings and values, without which the perspectives of our world-picture would be hopelessly wrong.

Can we from some reunion or symposium of these sciences obtain a world-picture or synoptic view of the universe, based on observation and calculation, which are the instruments of science, but reaching beyond the particular phenomena which are its immediate field to a conception of the universe as a whole?

That was how science began—in the attempt to find some simple substances or elements to which the complex world of phenomena could in the last analysis be reduced. The century over which we now look back, with its wonderful advance in the methods and technique of exact observation, has been a period of specialisation or decentralisation. Have we now reached a point where science can again become universal in its ultimate outlook? Has a scientific world-picture become possible?

Of course there can be no final picture at any one stage of culture. The canvas is as large as the universe, and the moving finger of humanity itself will fill it in from age to age. All the advances of knowledge, all the new insights gained from those advances, will from time to time be blended into that picture. To the deeper insight of every era of our human advance there has been some such world-picture, however vague and faulty. It has been continually changing with the changing knowledge and beliefs of man. Thus, there was the world of magic and animism, which was followed by that of the early Nature gods. There was the geocentric world, which still survives in the world of commonsense. There is the machine or mechanistic world-view dominant since the time of Galileo and Newton, and now, since the coming of Einstein, being replaced by the mathematician's conception of the universe as a symbolic structure of which no mechanical model is possible. All these world-views have in turn obtained currency according as some well-defined aspect of our advancing knowledge has from time to time been dominant. My object is to focus attention on the sort of world-picture which results from the advances of physical, biological, and mental science during the period covered roughly by the activities of our Association.

Science arose from our ordinary experience and commonsense outlook. The world of commonsense is a world of matter, of material stuff, of real separate things and their properties which act on each other and cause changes in each other. To the various things observable by the senses were added the imperceptible things—space and time, invisible forces, life, and the soul. Even these were not enough, and the supernatural was added to the natural world. The original inventory was continually being enlarged, and thus a complex empirical world-view arose, full of latent contradictions, but with a solid basis of actual experience and facts behind it.

Speaking generally, we may say that this is substantially still the commonsense view of the world and the background of our common practical beliefs. How has science dealt with this commonsense empirical world-view? The fundamental procedure of science has been to rely on sense observation and experiment, and to base theory on fact. Thus the vast body of exact science arose, and all entities were discarded which were either inconsistent with observed facts or unnecessary for their strict interpretation. The atomic view of matter was established. Ether was given a status in the physical order which is now again being questioned in the light of the conception of space-time. New entities like energy emerged; old entities like forces disappeared; the principle of the uniformity of Nature was established; the laws of motion, of conservation, and of electromagnetism were formulated; and on their basis a closed mechanistic order of Nature was constructed, forming a rigid deterministic scheme. Into this scheme it has been difficult, if not impossible, to fit entities like life and mind; and the scientific attitude has on the whole been to put them to a suspense account and to await developments. As to the supernatural, science is or has been agnostic, if not frankly sceptical.

Such, in very general terms, was the scientific outlook of the nineteenth century, which has not yet completely passed away. It will be noticed that much of the fundamental outlook of commonsense has thus survived, though clarified and purified by a closer accord with facts. This scientific view retained unimpaired, and indeed stressed with a new emphasis, the things of commonsense, matter, time, and space, as well as all material or physical entities which are capable of observation or experimental verification. Nineteenth-century science is, in fact, a system of purified, glorified commonsense. Its deterministic theory certainly gave a shock to the common man's instinctive belief in free will; in most other respects it conformed to the outlook of commonsense. It is true that its practical inventions have produced the most astounding changes in our material civilisation, but neither in its methods nor in its world-outlook was there anything really revolutionary.

Underneath this placid surface the seeds of the future were germinating. With the coming of the twentieth century fundamental changes began to set in. The new point of departure was reached when physical science ceased to confine its attention to the things that are observed It dug down to a deeper level, and below the things that appear to the senses it found, or invented, at the base of the world, so-called scientific entities, not capable of direct observation, but which are necessary to account for the facts of observation. Thus, below molecules and atoms still more ultimate entities appeared; radiations, electrons, and protons emerged as elements which underlie and form our world of matter. Matter itself, the time-honoured mother of all, practically disappeared into electrical energy.

> "The cloud-capp'd towers, the gorgeous palaces,
> The solemn temples, the great globe itself,"

yea, all the material forms of earth and sky and sea, were dissolved and spirited away into the blue of energy. Outstanding among the men who brought about this transformation are two of my predecessors in this chair: Sir J. J. Thomson and Lord Rutherford. Like Prospero, like Shakespeare himself, they must be reckoned among the magicians.

Great as was this advance, it does not stand alone. Away in the last century, Clerk Maxwell, following up Faraday's theories and experiments, had formulated his celebrated equations of the electromagnetic field, which applied to light no less than to electromagnetism, and the exploration of this fruitful subject led Minkowski to the amazing discovery in 1908 that time and space were not separate things, but constituent elements in the deeper synthesis of space-time. Thus time is as much of the essence of things as space; it enters from the first into their existence as an integral element. Time is not something extra and superadded to things in their behaviour, but is integral and basic to their constitution. The stuff of the world is thus envisaged as events instead of material things.

This physical concept or insight of space-time is our first revolutionary innovation, our first complete break with the old world of commonsense. Already it has proved an instrument of amazing power in the newer physics. In the hands of an Einstein it has led, beyond Euclid and Newton, to the recasting of the law and the concept of gravitation, and to the new relativity conception of the basic structure of the world. The transformation of the concept of space, owing to the injection into it of time, has destroyed the old passive homogeneous notion of space and has substituted a flexible, variable continuum, the curvatures and unevenness of which constitute to our senses what we call a material world. The new concept has made it possible to construe matter, mass, and energy as but definite measurable conditions of curvature in the structure of space-time. Assuming that electromagnetism will eventually follow the fate of gravitation, we may say that space-time will then appear as the scientific concept for the only physical reality in the universe, and that matter and energy in all their forms will have disappeared as independent entities, and will have become mere configurations of this space-time. This will probably involve an amplified concept of space-time. Einstein has recently indicated that for further advance a modification in our space-time concept will become necessary, and that the additional element of direction will have to be incorporated into it. Whatever change may become necessary in our space-time concept, there can be no doubt about the immense possibilities it has opened up.

I pass on to an even more revolutionary recent advance of physics. The space-time world, however novel, however shattering to commonsense, is not in conflict with reason. Indeed, the space-time world is largely a discovery of the mathematical reason, and is an entirely rational world. It is a world where reason, as it were, dissolves the refractoriness of the old material substance and smoothes it out into forms of space-time. Science, which began with empirical brute facts, seems to be heading for the reign of pure reason. But wait a bit; another fundamental discovery of our age has apparently taken us beyond the bounds of rationality, and is thus even more revolutionary than that of space-time. I refer to the quantum theory, Max Planck's discovery at the end of the nineteenth century, according to which energy is granular, consisting of discrete grains or quanta. The world in space-time is a continuum; the quantum action is a negation of continuity. Thus arises the contradiction, not only of commonsense, but apparently also of reason itself. The quantum appears to behave like a particle, but a particle out of space or time. As Sir Arthur Eddington graphically puts it: a quantum of light is large enough to fill the lens of a hundred-inch telescope, but it is also small enough to enter an atom. It may spread like a circular wave through the universe, but when it hits its mark this cosmic wave instantaneously contracts to a point where it strikes with its full and undivided force.

Space-time, therefore, does not seem to exist for the quantum, at least not in its lower multiples. Nay, more: the very hitting of its mark presents another strange puzzle, which seems to defy the principles of causation and of the uniformity of Nature, and to take us into the realm of chance and probability. The significant thing is that this strange quantum character of the universe is not the result of theory, but is an experimental fact well attested from several departments of physics. In spite of the strange Puck-like behaviour of the quantum, we should not lightly conclude, with some prominent physicists, that the universe has a skeleton in its cupboard in the shape of an irrational or chaotic factor. Our macroscopic concepts may not fit this ultra-microscopic world of the quantum. Our best hopes for the future are founded on the working out of a new system of concepts and laws suited to this new world that has swum into the ken of science. The rapid development of wave mechanics in the last four years seems to have brought us within sight of this ideal, and we are beginning to discern a new kind of order in the microscopic elements of the world, very different from any type of law hitherto imagined in science, but none the less a rational order capable of mathematical formulation.

We may summarise these remarks by saying that the vastly improved technique of research has led to physical discoveries in recent years which have at last completely shattered the traditional commonsense view of the material world. A new space-time world has emerged which is essentially immaterial, and in which the old-time matter, and even the scientific mass, gravitation, and energy stand for no independent entities, but can best be construed as configurations of space-time; and the discovery of the quantic properties of this world points to still more radical transformations which loom on the horizon of science. The complete recasting of many of our categories of experience and thought may ultimately be involved.

From the brilliant discoveries of physical science we pass on to the advances in biological science which, although far less revolutionary, have been scarcely less important for our world-outlook. The most important biological discovery of the last century was the great fact of organic evolution; and for this fact the space-time concept has at last come to provide the necessary physical basis. It is unnecessary for my purpose to canvass the claims and discuss the views represented by the great names of Lamarck, Darwin, and Mendel, beyond saying that they represent a progressive advance in biological discovery, the end of which has by no means been reached yet. Whatever doubts and differences of opinion there may be about the methods, the mechanism, or the causes, there is no doubt about the reality of organic evolution, which is one of the most firmly established results in the whole range of science. Palæontology, embryology, comparative anatomy, taxonomy, and geographical distribution all combine to give the most convincing testimony that, throughout the history of this earth, life has advanced genetically from at most a few simple primitive forms to ever more numerous and highly specialised forms. Under the double influence of the internal genetic and the external environmental factors, life has subtly adapted itself to the ever-changing situations on this planet. In the process of this evolution not only new structures and organs, but also new functions and powers have successively appeared, culminating in the master key of mind and in the crowning achievement of human personality. To have hammered the great truth of organic evolution into the consciousness of mankind is the undying achievement of Charles Darwin, by the side of which his discovery of natural selection as the method of evolution is of secondary importance.

The acceptance of the theory of evolution has brought about a far-reaching change in our outlook on the universe and our sense of values. The story of creation, so intimately associated with the groundwork of most religions, has thus come to be rewritten. The unity and interconnexions of life in all its manifold forms have been clearly recognised, and man himself has had to come down from his privileged position among the angels and take his proper place in the universe as part of the order of Nature. Thus Darwin completes the revolution begun by Copernicus.

Space-time finds its natural completion in organic evolution. For in organic evolution the time aspect of the world finds its most authentic expression. The world truly becomes process, where nothing ever remains the same or is a duplicate of anything else, but a growing, gathering, creative stream of unique events rolls forever forward.

While we recognise this intimate connexion between the conceptions of space-time and organic evolution, we should be careful not to identify the time of evolution with that of space-time. There is a very real difference between them. Biological time has direction, passes from the past to the future, and is therefore historical. It corresponds to the 'before' and 'after' of our conscious experience. Physical time as an aspect of space-time is neutral as regards direction. It is space-like, and may be plus or minus, but does not distinguish between past or future. It may move in either direction, backwards or forwards, while biological time, like the time of experience, knows only a forward flow. Hence cosmic evolution, as we see it in astronomy and physics, is mostly in an opposite direction to that of organic evolution. While biological time on the whole shows a forward movement towards ever higher organisation and rising qualities throughout the geological ages, the process of the physical world is mostly in the opposite direction *—towards disorganisation, disintegration of more complex structures, and dissipation of energy. The second law of thermodynamics thus marks the direction of physical time. While the smaller world of life seems on the whole to be on the up-grade, the larger physical universe is on the down-grade. One may say that in the universe we witness a majority movement downward, and a minority movement upward. The energy which is being dissipated by the decay of physical structure is being partly taken up and organised into life structures—at any rate on this planet. Life and mind thus appear as products of the cosmic decline, and arise like the phœnix from the ashes of a universe radiating itself away. In them Nature seems to have discovered a secret which enables her to irradiate with imperishable glory the decay to which she seems physically doomed.

Another striking point arises here. Organic evolution describes the specific process of what we call life, perhaps the most mysterious phenomenon of this mysterious universe. When we ask what is the nature of life we are curiously reminded of the behaviour of the quantum referred to. I do not for a moment wish to say that the quantum is the physical basis of life, but I do say that in the quantum the physical world offers an analogy to life which is at least suggestive. The quantum follows the all-or-nothing law and behaves as an indivisible whole : so does life. A part of a quantum is not something less than a quantum ; it is nothing or sheer nonentity : the same holds true of life.

* No doubt there are exceptions to this broad generalisation. In astronomy stars and solar systems and galaxies are probably still being formed, while in physics syntheses of elements may possibly still be going on. In the same way we find in organic evolution minor phases of regression, degeneration, and parasitism.

The quantum is perhaps most easily symbolised as a wave or combination of waves, which can only exist as a complete periodicity, and the very concept of which negatives its existence as partial or truncated. In other words, it is a specific configuration and can only exist as such : the same holds true of life. The quantum does not fall completely within the deterministic causal scheme : the same seems true of life.

Significant, also, is the fact that quantum phenomena underlie secondary qualities such as colour and the like, which the older science in its mechanistic scheme ignored, but which are specially associated with life and consciousness. Life is not an entity, physical or other. It is a type of organisation ; it is a specific principle of central or self organisation. If that organisation is interfered with we are left, not with bits of life, but with death. The nature of living things is determined, not by the nature of their parts, but by the nature or principle of their organisation. In short, the quantum and life seem to have this in common, that they both behave as wholes.

I have before now endeavoured to explore the concept of life in the light of the more general concept of the whole. A whole is not a sum of parts, or constituted by its parts. Its nature lies in its constitution more than in its parts. The part in the whole is no longer the same as the part in isolation. The interesting point is that while this concept of the whole applies to life, it is according to the recent physics no less applicable to the ultimate physical units. Thus the electron within an atom is no longer a distinct electron. There may be separate electrons, but when they cease to be separate they also cease to be. The eight electrons which circulate in an oxygen atom are merged in a whole in such a way that they have lost their separate identity ; and this loss of individuality has to be taken into account in calculations as to the physical behaviour of the atom. The physicist, in fact, finds himself unable to look upon the entity which is one-eighth of eight electrons as the same thing as a single electron. At the very foundation, therefore, of physics, the principle or category of the whole applies no less than in the advanced structure of life, although not in the same degree. In the ultimate analysis of the world, both at the physical and the biological level, the part or unit element somehow becomes shadowy and incoherent, and the very basis of mechanism is undermined. It would almost seem as if the world in its very essence is holistic, and as if the notion of individual parts is a practical makeshift without final validity in the nature of things.

The general trend of the recent advances in physics has thus been towards the recognition of the fundamental organic character of the material world. Physics and biology are beginning to look not so utterly unlike each other. Hitherto the great gulf in Nature has lain between the material and the vital, between inorganic matter and life. This gulf is now in process of being bridged. The new physics, in dissolving the material world of common sense and discovering the finer structure of physical Nature, has at the same time disclosed certain fundamental features which it has in common with the organic world. Stuff-like entities have disappeared and have been replaced by space-time configurations, the very nature of which depends on their principle of organisation. This principle, which I have ventured to call holism, appears to be at botton identical with that which pervades the organic structures of the world of life. The quantum and space-time have brought physics closer to biology. As I have pointed out, the quantum anticipates some of the fundamental characters of life, while space-time forms the physical basis for organic evolution. Physics and biology are thus recognised as respectively simpler and more advanced forms of the same fundamental pattern in world-structure.

The older mechanistic conception of Nature, the picture of Nature as consisting of fixed material particles, mechanically interacting with each other —already rudely shaken by the relativity theory— is now being modified by the quantum physics. The attack on mechanism, thus coming from physical science itself, is therefore all the more deadly. Even in physics, organisation is becoming more important than the somewhat nebulous entities which enter into matter. Interaction is more and more recognised to be not so much mechanical as organic or holistic, the whole in some respects dominating not only the functioning but also the very existence of the entities forming it. The emergence of this organic view of Nature from the domain of physics itself is thus a matter of first-rate importance, and must have very far-reaching repercussions for our eventual world-view.

The nature of the organic whole is, however, much more clearly recognised in its proper sphere of biology, and especially in the rapidly advancing science of physiology. Here, too, the correct view has been much obscured by the invasion of mechanistic ideas from the physics of the nineteenth century. A crude materialism all but swamped biology for more than a generation. At the Belfast meeting of the British Association in 1874, a famous predecessor of mine gave unrestrained expression to this materialistic creed. All that is passing, if not already past. It must be admitted that up to a point mechanism has been useful as a first approximation and fruitful as a convention for research purposes. But if even in physics it has lost its savour, *a fortiori* has it become out of place in biology. The partial truth of mechanism is always subtended by the deeper truth of organicity or holism. So far from biology being forced into a physical mould, the position will in future be reversed. Physics will look to biology and even to psychology for hints, clues, and suggestions. In biology and psychology it will see principles at work in their full maturity which can only be faintly and fitfully recognised in physics. In this way the exchanges of physics, biology, and psychology will become fruitful for the science of the future, and lay the basis for a new scientific monism.

A living individual is a physiological whole, in which the parts or organs are but differentiations of this whole for purposes of greater efficiency, and remain in organic continuity throughout. They are parts *of* the individual, and not independent or self-contained units which *compose* the individual. It is only this conception of the individual as a dynamic organic whole which will make intelligible the extraordinary unity which characterises the multiplicity of functions in an organism, the mobile, ever-changing balance and interdependence of the numerous regulatory processes in it, as well as the operation of all the mechanisms by which organic evolution is brought about. This conception applies not only to individuals, but also to organic societies, such as a beehive or an ants' nest, and even to social organisations on the human level.

As the concept of space-time destroys the purely spatial character of things, so the concept of the organic whole must also be extended beyond the spatial limits of the organism so as to include its interaction with its environment. The stimuli and responses which render them mutually interdependent constitute them one whole which thus transcends purely spatial aspects. It is this overflow of organic wholes beyond their apparent spatial limits which binds all Nature together and prevents it from being a mere assemblage of separate interacting units.

It is time, however, that we pass on to the world of mind. From matter, as now transformed by space-time and the quantum, we pass step by step through organic nature to conscious mind. Gone is the time when Descartes could divide the world into only two substances : extended substance or matter, and thinking substance or mind. There is a whole world of gradations between these two limits. On Descartes' false dichotomy the separate provinces of modern science and philosophy were demarcated. But it is as dead as the epicycles of Ptolemy, and ultimately the Cartesian frontiers between physics and philosophy must largely disappear, and philosophy once more become metaphysic in the original sense. In the meantime, under its harmful influence, the paths of matter and mind, of science and philosophy, were made to diverge farther and farther, so that only the revolution now taking place in thought could bring them together again. I believe, however, their reunion is coming fast. We have seen matter and life indefinitely approaching each other in the ultimate constituents of the world. We have seen that matter is fundamentally a configuration or organisation of space-time ; and we have seen that life is a principle of organisation whereby the space-time patterns are arranged into organic unities. The next step is to show that mind is an even more potent embodiment of the organising whole-making principle, and that this embodiment has found expression in a rising series, which begins practically on the lowest levels of life, and rises ultimately to the conscious mind which alone Descartes had in view in his classification. I have no time to follow up the matter here beyond making a few remarks.

Mind is admittedly an active, conative, organising principle. It is for ever busy constructing new patterns of things, thoughts, or principles out of the material of its experience. Mind, even more than life, is a principle of whole-making. It differentiates, discriminates, and selects from its vague experience, and fashions and correlates the resulting features into more or less stable, enduring wholes. Beginning as mere blind tropisms, reflexes, and conditioned reflexes, mind in organic Nature has advanced step by step in its creative march until in man it has become Nature's supreme organ of understanding, endeavour, and control—not merely a subjective human organ, but Nature's own power of self-illumination and self-mastery : " The eye with which the universe beholds itself and knows itself divine ".

The free creativeness of mind is possible because, as we have seen, the world ultimately consists, not of material stuff, but of patterns, of organisation, the evolution of which involves no absolute creation of an alien world of material from nothing. The purely structural character of reality thus helps to render possible and intelligible the free creativeness of life and mind, and accounts for the unlimited wealth of fresh patterns which mind freely creates on the basis of the existing physical patterns.

The highest reach of this creative process is seen in the realm of values, which is the product of the human mind. Great as is the physical universe which confronts us as a given fact, no less great is our reading and evaluation of it in the world of values, as seen in language, literature, culture, civilisation, society and the State, law, architecture, art, science, morals, and religion. Without this revelation of inner meaning and significance the external physical universe would be but an immense empty shell or crumpled surface. The brute fact here receives its meaning, and a new world arises which gives to Nature whatever significance it has. As against the physical configurations of Nature we see here the ideal patterns or wholes freely created by the human spirit as a home and an environment for itself.

Among the human values thus created science ranks with art and religion. In its selfless pursuit of truth, in its vision of order and beauty, it partakes of the quality of both. More and more it is beginning to make a profound æsthetic and religious appeal to thinking people. Indeed, it may fairly be said that science is perhaps the clearest revelation of God to our age. Science is at last coming into its own as one of the supreme goods of the human race.

While religion, art, and science are still separate values, they may not always remain such. Indeed, one of the greatest tasks before the human race will be to link up science with ethical values, and thus to remove grave dangers threatening our future. A serious lag has already developed between our rapid scientific advance and our stationary ethical development, a lag which has already found expression in the greatest tragedy of history. Science must itself help to close this dangerous gap in our advance which threatens the disruption of our civilisation and the decay of our species. Its final and perhaps most difficult task may be found just here. Science may be destined to become the most effective drive towards ethical values, and in that way to render its most priceless human service. In saying this I am going beyond the scope of science as at present understood, but the conception of science itself is bound to be affected by its eventual integration with the other great values.

I have now finished my rapid and necessarily superficial survey of the more prominent recent tendencies in science, and I proceed to summarise the results and draw my conclusions, in so far as they bear on our world-picture.

In the first place we have seen that in the ultimate physical analysis, science reaches a microscopic world of scientific entities, very different in character and behaviour from the macroscopic world of matter, space, and time. The world of atoms, electrons, protons, radiations, and quanta does not seem to be in space-time or to conform to natural law in the ordinary sense. The behaviour of these entities cannot be understood without the most abstruse mathematics or, apparently, without resort to epistemological considerations. We seem to have passed beyond the definitely physical world into a twilight where prophysics and metaphysics meet, where space-time does not exist, and where strictly causal law in the old sense does not apply. From this uncertain nebulous underworld there seems to crystallise out, or literally to materialise, the macroscopic world which is the proper sphere of sensuous observation and of natural laws. The pre-material entities or units condense and cohere into constellations, which increase in size and structure until they reach the macroscopic stage of observation. As the macroscopic entities emerge, their space-time field and appropriate natural laws (mostly of a statistical character) emerge *pari passu*. We seem to pass from one level to another in the evolution of the universe, with different units, different behaviours, and calling for different concepts and laws. Similarly, we rise to new levels as later on we pass from the physical to the biological level, and again from the latter to the level of conscious mind. But—and this is the significant fact—all these levels are genetically related and form an evolutionary series; and underlying the differences of the successive levels, there remains a fundamental unity of plan or organisation which binds them together as members of a genetic series, as a growing, evolving, creative universe.

In the second place, let us see how common sense deals with this macroscopic world. On this stage common sense recognises three levels of matter, life, and mind as together composing the world. But it places them so far apart, and makes them so inherently different from each other, that relations between them appear unintelligible, if not impossible. The common-sense notions of matter, life, and mind make any relations between them, as well as the world which they form, an insoluble puzzle. The older science therefore attempted to reduce life substantially to terms of matter, and to put a question mark behind mind ; and the result was a predominantly materialistic view of the world. The space-time relativity concept of the world has overcome the difficulty by destroying the old concept of matter, and reducing it from a self-subsistent entity to a configuration of space-time—in other words, to a special organisation of the basic world-structure. If matter is essentially immaterial structure or organisation, it cannot fundamentally be so different from organism or life, which is best envisaged as a principle of organisation ; or from mind, which is an active organiser.

Matter, life, and mind thus translate roughly into organisation, organism, organiser. The all-or-none law of the quantum, which also applies to life and mind, is another indication that matter, life, and mind may be but different stages or levels of the same activity in the world which I have associated with the pervading feature of whole-making. Materialism has thus gone by the board, and the unintelligible trinity of common sense (matter, life, mind) has been reinterpreted and transformed and put on the way to a new monism.

In the third place, the iron determination of the older science, so contrary to direct human experience, so destructive of the free activity of life and mind, as well as subversive of the moral responsibility of the individual, has also been materially recast. It was due to the Newtonian causal scheme which, as I have indicated, has been profoundly shaken by recent developments. Relativity reduces substance to configuration or patterns, while quantum physics gives definite indications of indeterminism in Nature. In any case, life through the ages shows clearly a creative advance to ever more complex organisation, and ever higher qualities, while mind is responsible for the creation of a whole realm of values. We are thus justified in stressing, along with natural necessity, an increasing measure of freedom and creativeness in the world, sufficient at least to account for organic evolution and for the appearance of moral law and endeavour.

This liberation of life and spirit from the iron rule of necessity is one of the greatest gains from the recent scientific advances. Nature is not a closed physical circle, but has left the door open to the emergence of life and mind and the development of human personality. It has, in its open flexible physical patterns, laid the foundation and established the environment for the coming of life and mind. The view, to which Huxley once gave such eloquent and poignant expression, of a dualism implanted in the heart of Nature, of a deadly struggle between cosmic law and moral law, is no longer justified by the subsequent advances of science.

In the fourth place, however, another dualism of a wider reach has appeared, which makes the universe itself appear to be a house divided against itself. For while the stream of physical tendency throughout the universe is on the whole downward, toward disintegration and dissipation, the organic movement, on this planet at least, is upward, and life structures are on the whole becoming more complex throughout the course of organic evolution. From the viewpoint of physics, life and mind are thus singular and exceptional phenomena, not in line with the movement of the universe as a whole. Recent astronomical theory has come to strengthen this view of life as an exceptional feature off the main track of the universe. For the origin of our planetary system is attributed to an unusual accident, and planets such as ours with a favourable environment for life are taken to be rare in the universe. Perhaps we may even say that at the present epoch there is no other globe where life is at the level manifested on the earth. Our origin is thus accidental, our position is exceptional, and our fate is sealed, with the inevitable running down of the solar system. Life and mind, instead of being the natural flowering of the universe, are thus reduced to a very casual and inferior status in the cosmic order. A new meaning and a far deeper poignancy are given to Shakespeare's immortal lines :

> " We are such stuff
> As dreams are made of ; and our little life
> Is rounded with a sleep."

According to astronomy, life is indeed a lonely and pathetic thing in this physical universe—a transient and embarrassed phantom in an alien, if not hostile, universe.

Such are some of the depressing speculations of recent astronomical theory. But in some respects they have already been discounted in the foregoing. For even if life be merely a terrestrial phenomenon, it is by no means in an alien environment if, as we have seen reason to think, this is an essentially organic universe. In its organic aspects the universe is on the way to life and mind, even if the goal has been actually reached at only one insignificant point in the universe. The potencies of the universe are fundamentally of the same order as its actualities. The universe might say, in the words of Rabbi Ben Ezra :

" All I could never be
All man ignored in me,
This I was worth to God."

Then again, the very possibility of perception, of knowledge and science, depends on an intimate relation between mind and the physical universe. Only thus can the concepts of mind come to be a measure for the facts of the universe, and the laws of Nature come to be revealed and interpreted by Nature's own organ of the human mind. Besides science we have other forms of this inner relation between the mind and the universe, such as poetry, music, art, and religion. The human spirit is not a pathetic wandering phantom of the universe, but is at home, and meets with spiritual hospitality and response everywhere. Our deepest thoughts and emotions and endeavours are but responses to stimuli which come to us, not from an alien, but from an essentially friendly and kindred universe. So far from the cosmic status of life and mind being degraded by the newer astronomy and physics, I would suggest an alternative interpretation of the facts, more in accord with the trend of evolutionary science. We have seen a macroscopic universe born or revealed to consciousness out of a prior microscopic order of a very different character. Are we not, in the emergence of life and mind, witnessing the birth or revelation of a new world out of the macroscopic physical universe ? I suggest that at the present cosmic epoch we are the spectators of what is perhaps the grandest event in the immeasurable history of our universe, and that we must interpret the present phase of the universe as a mother and child universe, still joined together by a placenta which science, in its divorce from the other great values, has hitherto failed to unravel.

Piecing together these clues and conclusions, we arrive at a world-picture fuller of mystery than ever. In a way it is closer to common sense and kinder to human nature than was the science of the nineteenth century. Materialism has practically disappeared, and the despotic rule of necessity has been greatly relaxed. In ever-varying degree the universe is organic and holistic through and through. Not only organic concepts, but also, and even more so, psychological viewpoints are becoming necessary to elucidate the facts of science ; and while the purely human concepts, such as emotion and value, purpose and will, do not apply in the natural sciences, they retain their unimpaired force in the human sciences. The ancient spiritual goods and heirlooms of our race need not be ruthlessly scrapped. The great values and ideals retain their unfading glory and derive new interest and force from a cosmic setting.

In other respects it is a strange new universe, impalpable, immaterial, consisting not of material or stuff, but of organisation, of patterns or wholes which are unceasingly being woven to more complex or to simpler designs. In the large it appears to be a decaying, simplifying universe which attained to its perfection of organisation in the far-distant past and is now regressing to simpler forms—perhaps for good, perhaps only to restart another cycle of organisation. But inside this cosmic process of decline we notice a smaller but far more significant movement—a streaming, protoplasmic tendency ; an embryonic infant world emerging, throbbing with passionate life, and striving towards rational and spiritual self-realisation. We see the mysterious creative rise of the higher out of the lower, the more from the less, the picture within its framework, the spiritual kernel inside the phenomenal integuments of the universe. Instead of the animistic, or the mechanistic, or the mathematical universe, we see the genetic, organic, holistic universe, in which the decline of the earlier physical patterns provides the opportunity for the emergence of the more advanced vital and rational patterns.

In this holistic universe man is in very truth the offspring of the stars. The world consists not only of electrons and radiations, but also of souls and aspirations. Beauty and holiness are as much aspects of Nature as energy and entropy. Thus " in eternal lines to time it grows ". An adequate world-view would find them all in their proper context in the framework of the whole ; and evolution is perhaps the only way of approach to the framing of a consistent world-picture which would do justice to the immensity, the profundity, and the unutterable mystery of the universe.

Such in vague outline is the world-picture to which science seems to me to be pointing. We may not all agree with my rendering of it, which indeed does not claim to be more than a mere sketch. Even if it were generally accepted, we have still to bear in mind that the world-picture of to-morrow will in all probability be very different from any which could be sketched to-day.

Summaries of Addresses of Presidents of Sections.*

Education and Research in Physics.

SIR J. J. THOMSON devoted his presidential address to Section A (Mathematical and Physical Sciences) to a discussion of "The Growth in Opportunities for Education and Research in Physics during the Past Fifty Years". The limit of fifty years was inevitable, for organised facilities for teaching and research in physics were almost unknown until towards the end of the nineteenth century. Much of the physical work of Joule, Stokes, Spottiswoode, Huggins, de la Rue, Rayleigh, and E. H. Griffiths was done in private rooms or private laboratories. Instruction was also unorganised. These men, like Kelvin and Maxwell, were in regard to physics largely self-taught, but they had learned to use their hands. In the early 'seventies there were only six physical laboratories in England; now there are considerably more than three hundred.

Sir Joseph traced the history of scientific education in universities and schools. Cambridge determined to establish a natural science tripos in 1849 and the first examination, with six candidates, was held in 1851. This number increased to twenty-five in 1881 and to ninety-four in 1891. The great advance has been made in the last fifty years. "It cannot, however, be said that even now Science occupies in our systems of education a place commensurate with its ever-increasing influence on human thought and with its importance in the progress of civilisation." Canvassing the reasons for this important conclusion, he blamed the scholarship system in universities and public schools, with its undue preference to classics. It was true that the teaching of classics and mathematics had a long experience and tradition behind. But the scholarship system, in some cases, enticed boys along a path not leading to their true destinations.

Passing to post-graduate study and research, Sir Joseph commented on the lack of laboratories, of scholarships, and of opportunities for research workers as retarding influences during the earlier part of the period. He referred to the institution of the Ph.D. degree, and mentioned that there are now forty-five students taking physics at Cambridge in preparation for this degree. The year or two of research work thus provided was chiefly a means of training. If conducted under proper conditions its value could not easily be overrated, but under other conditions it might be positively harmful. This thesis was developed in an important passage on the *differentia* of research work in university laboratories as contrasted with governmental or works laboratories. The aim of the university laboratory should not be to turn out the largest number of small papers, to get results, to discover as many new facts as possible. It was necessary to avoid, even in university workers, over-specialisation and over-concentration. A little teaching might assist the research worker in this respect as providing an interruption. "It is, I think, a general experience that new ideas about a subject come when one is not thinking about it."

Sir Joseph discussed the question of careers for research workers, referring especially to the foundation in 1901 of the National Physical Laboratory, which now employs 160 research workers, and to the establishment in 1915 of the Department of Scientific and Industrial Research. Of the twenty research associations promoted by the Department, he remarked that at first there was plenty of money but no well-trained men, now there are plenty of men but no money; but there were good reasons for thinking that the financial gain to the industries had far exceeded the expenses of the laboratories. Considering research work as a profession, he observed that a worker might spend years without getting results of any very striking importance; he might therefore get depressed, lose hope, and try to transfer to administration or organisation. "The researcher, if he is to have a happy life, must regard the game and not the score as the chief thing."

The increase in the number of research workers had led to a corresponding increase in the number of papers on physics. *Science Abstracts* for 1930 contains abstracts of 4165 papers—very nearly a dozen a day. It was obvious that no one could read more than a fraction of these. He urged the need in physics for something corresponding to the annual report of the Chemical Society and for the publication monthly of the titles of physical papers. Progress in physics had been due in part to the improvement of instruments and appliances; in this way industry had repaid its debt to science. But the development had greatly increased the cost of physical research. Theories were the very life-blood of physics, but theory may be injurious if it makes the worker treat as an annoyance any anomaly which interferes with progress to the goal.

* The collected presidential addresses delivered in London are published under the title "The Advancement of Science, 1931". The volume is obtainable at 5*s*. net of all booksellers, or at the Reception Room by members attending the meeting, 3*s*. 6*d*.

"The anomaly may be the outcrop of a vein rich in new phenomena." He instanced the discovery of argon by Lord Rayleigh as arising from some vexatious discrepancies in a series of weighings. In conclusion, he said that there was no danger of the supply of new physical phenomena being exhausted and of physicists joining the ranks of the unemployed.

Faraday and Electrolytic Conduction.

In his presidential address to Section B (Chemistry), Sir Harold Hartley spoke on "Michael Faraday and the Theory of Electrolytic Conduction". Faraday was in a sense the discovery of a chemist, he was trained in a chemical laboratory, his early triumphs were in the field of chemistry, and he was one of the great masters of chemical technique. He presided over the chemical section of the British Association in 1837 and in 1846. Sir Harold Hartley gives a brief sketch of Faraday's early life and work, emphasising that the intensely personal character of Faraday's work depends on the fact that it was all done with his own hands, and that if he used the results of others he repeated their experiments.

The year 1831 was the turning point of Faraday's career, probably because of the success of an experiment on the production of a current by magnetic induction which he had tried before without results. The experiments on conduction came a year later, leading up to the publication in 1834 of the fundamental laws of electrolysis. In August 1833 Faraday had entered in his note-book a resolve to try "whether the same quantity of electricity always produces an equivalent of chemical decomposition"; a month later he was using the water voltameter for measuring currents; in December he had extended the law to fused salts, and had also made what Sir Harold calls "a remarkable anticipation of modern methods of electrolytic analysis" by suggesting that electrolysis may finally give rise to "a good principle of analysis". A suggestion that the atoms of bodies were associated with equal quantities of electricity was raised by Faraday, but was not developed, since he was not attracted by the atomic theory. Faraday was quite clear on the essential difference between quantity of electricity and electromotive force, a misunderstanding of which led Berzelius to an unjust criticism of Faraday's work.

During the century which has elapsed since Faraday's work there have been three main phases in the development of the problem of the conduction of electricity in solutions. The first was the discovery of the general relationships between conductivity and the concentration and nature of the dissolved substance, due mainly to the work of Hittorf and Kohlrausch. Hittorf in 1853 had realised that the two ions of a salt usually move with different speeds, and showed how the ratio of these speeds could be determined experimentally. Kohlrausch, in 1876, recognised that the ions of a salt move independently, and in 1878 he introduced the conceptions of equivalent conductivity and mobilities which are still in use, at the same time developing the experimental methods.

The second phase was the enunciation of the theory of electrolytic dissociation by Arrhenius in 1887. This was followed by many important applications in different fields of electrochemistry, such as the theory of the galvanic cell due to Nernst. From the beginning, however, Planck and van 't Hoff had shown that the law of mass action does not apply to strong electrolytes if the degree of dissociation is calculated by the Arrhenius method from the ratio of the equivalent conductivity to that at infinite dilution.

The third phase is the quantitative explanation of the properties of electrolytes, and the removal of the difficulty just mentioned, by the mathematical theories due to Milner and to Debye and Hückel. The new theory takes account of the great forces acting between the charged ions, the magnitude of which was clearly perceived by Faraday, and shows how, starting with the idea that electrolytes are completely dissociated in dilute solution, the empirical square-root law of Kohlrausch can be explained quantitatively. Each ion is surrounded by an atmosphere of ions of opposite sign, and the behaviour of this, and of the solvent carried by the ions, leads to the equations. The idea of the ion atmosphere, with a finite time of formation and dispersion, has been proved experimentally by Wien and others, and the extension of Debye's theory by Onsager has been found to represent the behaviour of a perfect electrolyte in dilute solution. In the case of non-aqueous solutions the chemical nature of the solvent and the affinities of the ions seem to be of great importance, and further developments may be expected in these directions.

Geological Problems Contemporary with the British Association.

In his presidential address to Section C (Geology) Prof. J. W. Gregory points out that the first thoughts of geologists at the centenary meeting of the Association are, naturally, homage to the group of geologists who gave it effective support at its foundation, and consideration of the problems on which they were engaged. In 1831 Great Britain held the hegemony of the world in stratigraphy, the nomenclature of which is permeated with English place-names ; and Macculloch declared in 1831 that " the study of Arran alone has taught us more than Asia and America united ". The British lead was maintained in the decade after 1831 by Lyell's classification of the formations above the Chalk, and by Murchison's foundation of the Silurian System—the first great step in the arrangement of the rocks earlier than the Carboniferous.

The greatest advance in the decade was the publication of Lyell's " Principles of Geology ", although they were condemned by some of his contemporaries. Geology at that time was harassed by three uncertainties. The first was the nature of sea-level. Von Buch's view that Scandinavia was being tilted upon a pivot was at first rejected by Lyell as a baseless and extraordinary notion : but he himself proved its truth to the Association in 1834, and thus established the local mobility of the earth's crust. Faith in that mobility has been confirmed by proof that the transference of a thin layer of sediment causes the rise or fall of the surface ; some isostacists now hold that the whole of the earth's surface is in delicate equilibrium, and that the oceanic depressions and continental masses are necessarily permanent in position. That conclusion is opposed to weighty geological evidence, and it appears that the parts of the crust that sink with a slight increase of load are limited to unstable bands or asthenostrophes.

Geological progress was hampered in 1831 by firm belief in the fixity of species. Lamarck's view of the transmutation or evolution of one species into another was rejected by Buckland and by Sedgwick, who denounced " all its train of monstrous consequences ". But the doctrine was added to the accepted principles of geology by a recruit of 1831. In that year Darwin began the study of geology and sailed as naturalist with the *Beagle*. The fixity of species was supported by theological influences which were then powerful. Buckland, though blamed by fellow-clerics as heterodox, held that each of the six days of Creation was a natural day. Murchison was the doughty pioneer of the freedom of scientific thought in his assertion in 1832 of the " entire disconnexion of our science with the inspired writings ".

The nature of mineral veins was discussed by the Association at an early meeting. Ore deposits were then generally attributed to igneous or electric agencies ; but their formation by solutions arising along fractures from the interior of the earth was supported by Fournet and by Daubeny in his address to the Association in 1836. This explanation was for a time discarded in favour of the lateral secretion theory ; but opinion has returned to the origin of most ores from a layer below the igneous rocks, and their introduction to the upper layers of the crust by the processes that also determine the ascent of the igneous rocks and the uplift of mountains.

The interpretation of mountain chains was advanced by Elie de Beaumont, whose classification of mountain systems was carefully considered by the Association at its early meetings. In 1842 H. D. Rogers expounded the asymmetric nature of mountain folding, a view developed later by Suess, whose demonstration of the frequent world-wide advance of the sea upon the land reconciled opinion to what the geologists of 1831 called " the dogma of universal formations ". Evidence from countries then geologically unknown has shown the world-wide range of the geological systems and of most of the great breaks between them ; and the century's work indicates that the main course of geological evolution is controlled by the slow deformation of the earth as the crust adapts itself to the contraction of the internal mass.

A Centenary of Evolution.

Prof. E. B. Poulton points out at the beginning of his presidential address to Section D (Zoology) that the fiftieth anniversary of the British Association, celebrated at York, marked a turning-point in evolutionary controversy. From 1860 up to 1881, evolution itself was the subject discussed, often with intense feeling ; in the second half-century, evolution has been generally accepted, and discussion has been concentrated upon its motive cause or causes, the size of the steps, and the rate of progress. Darwin's belief in evolution was the result of his observations on the *Beagle*—the five years' voyage, begun on Dec. 27, 1831, which he considered as by far the most important event in his life. The motive cause, natural selection, did not occur to him until 1838, two years after his return. Wallace's independent discovery, twenty years later, also followed his conviction that evolution was a fact.

It was very different with the two earlier originators of the theory, W. C. Wells (1818) and Patrick Matthew (1831), neither of whom realised the significance of his discovery. Robert Chambers'

"Vestiges" contains illuminating thoughts, and has scarcely received its due. Chambers, not known during his life to be the author, was the cause of the great debate at Oxford in 1860, for it was his persuasion which induced Huxley to be present. Canon Tristram, in his paper on the larks of the Sahara, accepted natural selection as the cause of animal colouring in the desert, following the Darwin-Wallace essay (1858) and before the appearance of the "Origin of Species".

One of the most important subjects discussed in the second half-century was the hereditary transmission of acquired characters, Francis Galton, Ray Lankester, Fairfield Osborn, and Weismann himself taking part in the debates. The re-discovery of Mendel's work on heredity, by emphasising germinal qualities, played an important part in the spread of Weismann's teaching, and also supplied an answer to a difficulty which had troubled Darwin —" the swamping effect of intercrossing ", as stated by Fleeming Jenkin. Mendelism does not conflict with Darwinian evolution as some have supposed. It is, as Miss E. R. Saunders stated at Cardiff, a theory of heredity, not a theory of evolution. One cause of the imaginary conflict was the mistaken belief that mutations were always large variations and evolution therefore discontinuous, also that small variations were not transmitted. American research has abundantly proved, as H. S. Jennings has stated, that extremely small variations are subject to Mendelian heredity and capable of providing material for natural selection, as maintained by R. A. Fisher in his recent work.

Darwinism is also consistent, discontinuity inconsistent, with the palæontological record and with the evolution, of which we see the stages nearly everywhere in the world, of geographical races into true species.

The age of the earth as determined by Lord Kelvin and Prof. Tait, at one time believed to be a great difficulty, made much of by Lord Salisbury at Oxford in 1894, was shown by Prof. Perry, and later by researches on radioactivity, to be mistaken.

The difficulty of accounting for the earliest stages of useful structures is met by Anton Dohrn's principle, 'change of function', a new use being taken over, by an existing organ, and, co-operating with this, by the 'organic selection' of Baldwin, Morgan, and Osborn—the power of individual adaptability (itself, it was maintained, a product of selection), enabling the species to exist until the needful variations have appeared.

Recent alternatives to Darwinian evolution are chiefly if not entirely manifestations of a supposed 'internal developmental force', a belief accounted for by H. W. Bates, in his classical paper on mimicry, by the prolonged " operation of selecting agents " producing " the impression of there being some innate principle in species which causes an advance of organisation in a special direction". The evolution of a mimetic resemblance being, as Bates maintained, " a problem which involves that of the origin of all species and all adaptations", is peculiarly suitable as evidence of natural selection—all the more so because the steps of evolution can often be traced.

The concluding section of the address is devoted to the description of examples of insect mimicry and protective resemblance, which, it is claimed, are wholly consistent with Darwinism but with no other theory of evolution.

Geographical Concepts of the Hydrosphere and Momentum.

In his presidential address to Section E (Geography), entitled "The Human Habitat", Sir Halford Mackinder lays stress on the distinction between the two answers to the question 'Why there?' If a man stand on a mountain top he is there in the first place because he climbed there; that is the genetic answer; and in the second place because he is upheld by the rocks; that is the dynamic answer. Sir Halford considers that in the development of geography during the last half century there has been excessive stress laid on the genetic side; in other words, on geomorphology and historical geography. As a result there is no unity of aim as between the two great branches of geography. It is suggested that if the hydrosphere rather than the lithosphere be treated as the main theme and business of the geographer, then a unity and a philosophy common to the whole subject emerge, and also a complete change in practical outlook, because dynamic considerations come to the fore.

Sir Halford starts from the astronomical fact that the liquid state of matter, in which alone life can exist, is limited to a minute part of the universe. A planet with a hydrosphere is therefore a unique object of study. This earth is important, not merely subjectively and because we men who inhabit it are the students; in the university of the impartial angels it would be an object of intense interest and speculation. May we not compare it with radium among the elements? Just as radium, almost infinitesimal in quantity, has by its activity revealed the energy locked up in the commoner atoms, so may not the hydrosphere of our earth present the infinitesimally rare conditions under which life becomes active which elsewhere through the universe is immanent, but potential and not active ?

In biogeography the essential unit is the natural region. This is no mere convenient generalisation. Both by origin and effect it is, when considered from the point of view of the hydrosphere, a fundamental fact. Whether high-lying or low-lying it has a certain area or spread, and the ultimate reason of this is that the surface of liquid water is level. The boundaries which separate it from other natural regions are, according to the new trend of hypothesis based on the study of isostasy, also of aqueous origin in that water is the agent redistributing the cargo carried on the floating granitic rafts which are the continents, and the stresses so caused lead both to mountain building and readjustments of coast level. The natural region is fundamental also from the point of view of life, because local varieties are thereby isolated and fixed as new species.

In regard to momentum, Sir Halford draws a distinction. Geographical momentum is a fact of the present and therefore an element in the dynamic analysis and not merely a subject for genetic consideration. Whether he study the present or the past, the geographer is primarily concerned with space and with time only in the sense that everything has momentum. The present consists of a coming out of the past and a going into the future ; there is a complex dynamic present in the sense of a balance of forces, all severally waxing and waning in different degrees. The student of the hydrosphere is concerned with water, sap, and blood, moving under sun power and life initiative. Water carries and stores energy, whether that energy emanate directly from the sun or be controlled by life. Two agents, the sun and life, work in the same medium, water, and must therefore obey the same conditions. These ideas of the hydrosphere and momentum are then applied in this address to a series of illustrations drawn from human geography.

Finally, the conclusion is reached that if our civilisation is not to go down in blind internecine conflict, there must be a development of world planning out of regional planning, just as regional planning has come out of town planning. The peaceful readjustment of treaties to differential growth will postulate an informed and delicate geographical judgment, for geography must underlie the strategy of peace if we would not have it subserve the strategy of war, and in the formation of such a judgment geomorphology cannot play the major part.

The Changed Outlook in Regard to Population, 1831–1931.

In his presidential address to Section F (Economics and Statistics) Prof. E. Cannan shows how changed is the outlook with regard to population in 1931 from that which prevailed in 1831. Modern science has dispelled the belief that no great progress is likely to take place in the arts of agriculture and other kinds of primary production, and birth-control has destroyed the fear that population is likely to increase sufficiently fast to counterbalance the effects of the progress, however great it may be.

At the meeting of the British Association at Ipswich in 1895, Prof. Cannan directed attention to the fact that the annual number of births in Great Britain, after a long period of rapid increase, was becoming stationary, and suggested that the increase of population might diminish and be nearly at an end by the middle of the present century. Subsequent events suggest that the verification of this forecast is nearly at hand, mortality and emigration having indeed diminished, but the number of births being now only about 650,000 per annum in England and Wales instead of the 880,000 which prevailed fifty years ago, and other countries either already showing the same tendency or being likely to do so shortly under the influence of modern knowledge and ideas.

The change requires the abandonment by economists and statesmen of the old emphasis on food production. This is requiring a smaller and smaller proportion of mankind's activity, and it should be recognised that it is more of the healthy luxuries rather than more of the necessaries of life that we want. Schemes for putting more people on the land, either near the centres or on the outskirts of civilisation, are misconceived. So also are all plans based on the belief that ownership of land is likely to take an ever-growing proportion of the whole produce of industry.

It is also wrong to suppose that cessation of the growth of numbers will cure, or at least alleviate, unemployment. The most powerful cause of unemployment is a rapid absolute decline in the demand for particular kinds of labour, and such a decline is more likely to occur in a stationary than in an increasing population. Mobility in regard to both place and occupation is the cure, and is more necessary when the growth of population slackens and ceases.

To the address as printed is appended a table of the births in England and Wales, showing rapid increase from 616,000 in 1851 to 888,000 in 1876, then little change for fifteen years, rather larger figures owing to the decline of the emigration of persons of the reproductive ages from 1884 to 1910, with a maximum of 948,000 in 1903, followed by a decline below the 1876 level before the War. The War sent the number down to 663,000 in 1918, and the return of men after it produced 958,000 in 1920, but this was a short-lived recovery, followed by a steady decline to 654,000, 660,000, 644,000, and 649,000 in the years 1927 to 1930.

Power.

At the outset of his presidential address to Section G (Engineering), Sir Alfred Ewing explained that it had to serve a double purpose, for it was also the Bramwell Lecture, delivered at this centenary meeting in fulfilment of a trust. Fifty years ago the late Sir Frederick Bramwell, who was then *pontifex maximus* in the world of engineering, had discussed the progress of mechanical invention at the jubilee meeting of the Association, and had prophesied that the internal combustion engine, then in its infancy, would displace steam as a means of producing power. In fifty years' time, he said, the steam engine would not be spoken of except as a curiosity to be found in a museum. Before his death he backed this opinion by giving the Association a sum to be paid as honorarium to a speaker who in 1931 should take this prophecy "as a sort of text" and deal with the then relation of engines of the two types.

Sir Alfred Ewing finds steam neither dead nor dying: on the contrary, it is actuating engines of vastly greater power than any that were even imagined when Bramwell spoke. But alongside of that we have wonderful achievements on the part of the internal combustion engine which go far to justify Bramwell's faith. Sir Alfred traced briefly the development of the internal combustion motor using liquid fuel, by Daimler, Diesel, and others; and went on to imagine Bramwell brought to earth again, "in an aeroplane, of course", to see for himself what had been accomplished. He would find, among many changes, his old haunt, the Athenæum Club, still a haven of rest for the mature, but now on the outer edge of a vortex of one-way traffic which made it difficult of approach —"a veritable inferno of internal combustion". Nevertheless, he would find steam continuing to do a great part of the work of the world both on land and water; and if he were taken to the Science Museum he would see there steam engines of a kind he never knew, enshrined not as relics of an obsolete past but as precursors of a modern era, the era opened to the world by the genius of Charles Parsons. Parsons's earliest steam turbine dates from three years after Bramwell made his prophecy. Since then the electric distribution of power has come on a big scale; and the work of power stations is almost wholly done by steam. Under modern conditions of high pressure and high temperature, steam furnishes the most economical means of generating power—except, of course, in countries favoured with hydraulic possibilities. In railway traction the dominance of steam is maintained, and electric traction—if it comes—will not affect that, for the central power stations will still use steam. On the roads the internal combustion engine is supreme, and a warm tribute is due to the constructive skill which has made such motors the convenient and reliable things they are.

In the field of ocean navigation, one finds sharp differences of opinion and of practice. For ships of the greatest size and speed, steam turbines are recognised as the best means of securing such a concentration of power as is essential. Many ships of a smaller type are driven by Diesel motors; but Sir Alfred doubts whether this preference is not, in part, a fashion that will pass. At the moment there is a distinct tendency to revert to steam, with, in appropriate cases, the use of pulverised coal.

In conclusion, Sir Alfred remarked that if we were to catch from Bramwell the mantle of prophecy we should be inclined to wear it ruefully. The cheerlessness of the present industrial outlook is in sad contrast to the heyday of Victorian confidence when Bramwell spoke. The world has learnt, through a severe lesson, that the gifts of the engineer are beneficial only if they are wisely used. They have brought obvious dangers through increasing man's ability to kill and to destroy. That is recognised, and now we are becoming aware of a more subtle social menace. We see the mechanised arts of production overreaching themselves, supplying commodities in a volume too great to be absorbed, and with a facility that tends to deprive man of his richest blessing—the necessity of toil. This raises problems, now conspicuously urgent, which the engineer, the economist, and the moralist must jointly set themselves to solve.

Present Position of Anthropological Studies.

In his presidential address to Section H (Anthropology) Prof. A. R. Radcliffe-Brown deals with the present position of anthropological studies. A realignment of these studies is taking place and should receive recognition. It is suggested that physical anthropology, which is largely confined to comparative racial anatomy, is due to be absorbed into a wider study of human biology which would include, besides physical anthropology and human palæontology, studies such as comparative racial physiology and psychology and human genetics. Prehistoric archæology has now become an independent subject, with its own special technique carried on by specialists. Its natural affinities are with history rather than with human biology or with sociology.

The science of comparative sociology differs from the older social anthropology in several vital respects. It rejects as being no part of its task the hypothetical reconstruction of the unknown past. It therefore avoids all discussion of hypotheses as to historical origins. It rejects all attempts to provide psychological explanations of particular social or cultural phenomena in favour of an ultimate psychological explanation of general sociological laws when these have been demonstrated by purely sociological inquiries. It endeavours to give precise descriptions of social and cultural phenomena in sociological terms, and to this end seeks to establish a suitable exact terminology, and seeks at the same time to attain to a systematic classification of those phenomena. It looks at any culture as an integrated system, and studies the functions of social institutions, customs, and beliefs of all kinds as parts of such a system. It applies to human life in society the generalising method of the natural sciences, seeking to formulate the general laws that underlie it, and to explain any given phenomenon in any culture as a special example of some general or universal principle. The newer anthropology is therefore functional, generalising, and sociological.

The new outlook in the study of cultures of non-European peoples involves the application of new methods both in field-work and in theoretical interpretation. The future of the subject lies with the field-worker. The day of the 'arm-chair' anthropologist is ended. The subject, however, suffers from the lack of anything like proper provision for research, and as the qualification for such research requires several years of special training and a great deal of special knowledge, the progress of the science is seriously hampered. What makes the situation almost tragic is that now, when by the gradual development of theory and the improvement of methods of investigation we are in a position to make the most important contributions to the science of man by the intensive and exact study of the less developed cultures of the world, those cultures are being destroyed with appalling rapidity. This process of destruction, through the combined action of European trade or economic exploitation, government by European officials, and missionary activity, is taking place with accelerated speed. Is there any other science, or has there ever been another science, faced with such a situation, that, just at the time it is reaching maturity, but while through lack of general interest and support it has few workers and very scanty funds, a great mass of most important material is vanishing year by year without the possibility of making any study of more than a minute fraction ?

Important developments in this branch of anthropology—the study of the cultures and languages of non-European peoples—are taking place as the result of the growing recognition of the fact that it can afford valuable and, indeed, indispensable aid in the practical problems of the government and education of dependent peoples. The British Empire, if it is to carry out with any honesty its self-imposed task of governing native peoples, must give much more support than it does at present to administrative anthropology.

Biological Nature of the Viruses.

Dr. H. H. Dale's presidential address to Section I (Physiology) takes the form of an introduction to a discussion on "The Biological Nature of the Viruses", in which investigators of the virus diseases of plants are to join those whose studies have been concerned with the viruses infecting men and animals. He reviews briefly the history of the position of physiology in the proceedings of the British Association, and the steps by which it attained independent status in a section which has become responsible for bringing before the Association advances of fundamental knowledge over a wide field of medical and veterinary science ; and suggests that the biological nature of viruses, the discussion of which raises questions as to the lower limit of size compatible with organisation as a living cell and as to the possibility of life and self-multiplication without such organisation, is a proper concern of the physiologist.

An attempt to define the term 'virus' reveals three generally recognised characters: (1) invisibility with the microscope, (2) failure to be retained by bacteria-proof filters, and (3) failure to grow in the absence of susceptible living cells. A definition on these lines must include bacteriophages and the agents transmitting certain tumours, which satisfy all three conditions. Strict application, however, of a definition by such negative characters must narrow its scope with the advance of technique. Already methods of rendering some viruses visible have been found, and conditions permitting their growth on artificial media may at any time be discovered.

Some viruses have apparently been shown to consist of submicroscopic organisms; some physical measurements, on the other hand, suggest that the units of other viruses approach the dimensions of protein molecules in size, or are even smaller. If the agents classed as viruses are all of one kind, it seems necessary to doubt either the validity of some of the physical data or the identity with the virus of particles demonstrated by microscopical methods. If the view is accepted that some viruses, at least, are unorganised toxic principles in a state of molecular dispersion, their apparent power of self-production is without biological analogy. If the explanation is adopted that this is not a true self-multiplication, the toxic principle being reproduced by the perverted metabolism of the cell which it infects, the immunity acquired by an infected animal presents serious difficulties of interpretation.

With reference to the difficulty of attributing organisation to particles of the minute size indicated by certain physical measurements, it is suggested that viruses, as prepared for such examination, are not vegetative. The particles measured may be adapted only for transmission of the infective agent to cells in which it can resume vegetative life, and may therefore consist of material so densely aggregated that comparison of their size with that of heavily hydrated protein molecules affords no true indication of their possible complexity.

In conclusion, it is suggested that the new century of the British Association's history may give us an epoch of advance in knowledge of the viruses not less important than the epoch of discovery of the visible bacteria in the century now closing.

On the Nature of Mind.

In his presidential address to Section J (Psychology), Dr. C. S. Myers points out that conscious experience can only be enjoyed by the active 'self'—the 'individual' (that is, undivided) mental activity of the living organism—and that at its earliest stage conscious self-activity is differentiated merely into (*a*) 'acts' of the self and (*b*) 'modifications' of the self. The latter become differentiated afterwards into (i) feelings *of* the self and (ii) presentations *to* the self, that is, 'contents' of consciousness. Thus we reach the final stage of distinction between (1) *feelings*, (2) the conscious *acts* of apprehending, recalling, deciding, inferring, etc., and (3) *what* is consciously apprehended, recalled, decided, inferred, etc. The last, the contents of consciousness, are, Dr. Myers suggests, the *un*conscious acts of relatively lower mental levels, which become *conscious* presentations to the self when they are accompanied and received by the self-activity of the highest mental levels.

The self is the highest controlling and directing power within the organism. Its direction, once consciously started, may be continued unconsciously: we may consciously but vainly try to recall some past experience or to solve some difficult problem; and after our giving up the effort, this directive activity may still persist unconsciously, until suddenly the forgotten object or the abandoned solution suddenly flashes full-born and unbidden into the self's consciousness. But purposive activity need not *originate* in self-activity: the inspirations of genius and the intuitive judgments and decisions which, crude as they are before submission to the self's judgment, arise apparently from the unconscious 'depths' of the mind with impulsive force and compelling conviction, afford striking examples of this fact.

The self implies a wide sphere of activity rather than a punctate, pineal gland-like soul. We cannot hope to localise any act of consciousness or any conscious content or feeling in some small region of nervous substance. Because vision ceases when the *area striata* in the occipital region of the cerebral cortex is destroyed, we are not justified in saying that this area is the *seat* of our visual consciousness. All that we are warranted in saying is that it is *essential* for our visual consciousness, that without it vision is impossible—a very different statement. It is impossible to localise consciousness. The higher forms of mental activity have a generalised localisation: even where 'essential' areas can be mapped out for lower conscious processes, such cortical localisation is only relatively definite, and other areas may in some cases assume the function of any particular area when the latter has been destroyed.

The fundamental purpose of consciousness is the preservation of the organism by guidance and direction, by the formation and satisfaction of ends and values. On the physical side, we can form no conception of that activity, throughout life and mind, which distinguishes evolution from the blind running downhill of a wound-up mechanism. We can at present find no metabolic basis for creative, directive activity; it appears, however, as if mental work makes far greater physiological demands than it should, according to the purely physical considerations of mechanical energy.

Both mechanical and directive activities are essential to conceptions of the struggle for existence and the conservation of the self. Mental activity involves the quintessence of the non-mechanical directive activity of life; and consciousness is but that activity raised to its highest power, limited to the highest level of psycho-neural activity—the self.

The Advancement of Botany.

In the first part of his presidential address to Section K (Botany), Prof. T. G. Hill gives a historical outline of the development of botany since 1831, and then considers present and future needs and policy, thus introducing a discussion on the training of botanists for economic and industrial positions.

The year 1831 marks the beginning of a threefold epoch in botany: the search for a natural system of classification; the emergence of morphology as a study separate from taxonomy; and the development of physiology. To the first, Great Britain contributed a full share; but in anatomy, morphology, and physiology, the tale of British activity during the succeeding fifty years, despite the brilliant lead given by Grew, Hales, and Knight, is indeed dismal. Against a battalion of continental workers we can barely range a section.

The brilliant generalisations of Charles Darwin, however, were an outstanding contribution to botany. The reasons for our deficiencies during this period (1831–1882) are patent. The classical traditions of our old universities dominated teaching, with the result that the approach to biology was, in the main, through medicine; botany was, indeed, of the faculty of medicine rather than of science, and the majority of British botanists were qualified medical men. Other reasons lie in the facts that the period was one of exploration, expansion, and development of the Empire, which meant a great inflow of plants for identification, and the labourers were few. Finally, the systematists did not entirely favour the new movement, and if not actively antagonistic, they looked upon it with amused tolerance.

The botanical renaissance in Great Britain began about 1875 and it happened in the Royal College of Science. The credit for it is due to Thiselton-Dyer, who, as Huxley's demonstrator, instituted and conducted the first laboratory classes in botany. The advance was accelerated by the translation of the great German text-books, and the University of London gave powerful aid by the high standard of its examinations and its insistence on practical tests. The volume and importance of British work in all branches of botany gradually increased and expanded in various directions: to take but two examples, the re-discovery of Mendel's work inspired a period of intensive investigations on plant breeding and certain aspects of metabolic physiology and cytology, whilst the development of ecology greatly stimulated the study of taxonomy, causal morphology, and physiology.

Notwithstanding past experience, it required a great war to force the lessons home that man is dependent on the green plant, and that the sustenance, development, and co-ordination of science is a prime necessity in the government of the modern State. These lessons were remembered when peace came, with the result that the systematised investigation of botanical problems became a settled policy not only with us but also with other nations. The immediate effect is a gross over-production of many essential commodities, which has caused a tendency in States and industries to curtail expenditure on research and expert advice. This is a wrong policy, for it is in times of economic depression that research is most essential. In Great Britain many of the problems involved are investigated in numerous research stations, old and new. In them lurk a few dangers: applied research can be over-organised; the tendency to justify their existence may tempt newly founded institutions to disseminate unripe fruit; and the value of pure research may be obscured. These dangers, for the most part, will be eliminated if there be co-operation between the applied workers and their academic brothers, which can be effected by a close connexion between the botanical departments of universities and research institutions, accompanied by an occasional exchange of the workers in both.

The British Commonwealth of Nations is, in the main, an agricultural empire; the need for trained botanists for administrative and technical service is patent: the problem is their supply and their training.

Educational Development, 1831–1931.

Sir Charles Grant Robertson, president of Section L (Educational Science), in his presidential address disclaimed his ability to defend a subject more vulnerable even than theology to the charge that "whatever is true is not new and whatever is new is flagitiously and demonstrably untrue". He dated the beginning of the reform movement with Castlereagh's death in 1822, emphasising three general points: first, the influence of the utilitarian group (the Benthamites); secondly, the Oxford movement started by Keble's sermon in 1833; and, thirdly, the organised and widespread campaign against ignorance, leading to the foundation in 1827 of the Society for the Diffusion of Useful Knowledge. But the fundamental question remained open: to whom was the duty of education to be left—to the individual conscience of the parent, to the Church as the depository of Christian truth, or to the State, with a compulsory power and the right to represent the civil mind?

The years from 1825 to 1840 were devoted mainly to discussion, and the following thirty years, ending roughly in Forster's Education Act of 1870, to Royal and Governmental commissions. This period saw the revolution in public school education associated with Arnold of Rugby, Kennedy of Shrewsbury, Thring of Uppingham, and Haig-Brown of Charterhouse, and saw also the nineteenth century 'renascence of science' inspired by Faraday's discoveries. That scientific renascence acknowledged both the importance of science as knowledge and its vocational or utilitarian value, but also, under the inspiring leadership of Huxley, "the Achilles and protagonist of the twenty years' battle for the capture of the classical Troy", its "cultural indispensability". Sir Charles referred also with feeling to another renascence—the education of girls and women—paying homage to the work of Frances Mary Buss, Dorothea Beale, and Sarah Emily Davies.

The Forster Education Act of 1870, though marking the culmination of a long period of effort and controversy, is not regarded by Sir Charles "as a revolutionary or a creative measure in the true sense of the term". It made no attempt to correlate elementary and secondary education. It was a compromise. No Government from 1831 to 1931 had tackled fairly and squarely the so-called religious issue, "because a courageous solution of it would be unlike successful operations in surgery; the operation would succeed, the Nation would recover, and the operating surgeon, the Minister, would die".

Proceeding, Sir Charles invoked a Rip Van Winkle who, having slept through the century under review, wakes to discover the new science of psychology. After commenting somewhat caustically on this new science, Rip Van Winkle remarks, "I observe with immense interest that after a hundred years you are still arguing precisely all the fundamental questions that perplexed us". But, as Sir Charles said, the science of psychology is only in its infancy. It may be possible in future to define the limits of educability and to come to an understanding of "the functional differentia between the sexes".

Concluding, Sir Charles acclaimed the social revolution, largely due to the educational progress of the last hundred years, steadily regrading and reshaping the whole Commonwealth that we call the British Empire.

The Changing Outlook in Agriculture.

Sir John Russell, in his presidential address before Section M (Agriculture), directs attention to the fact that agriculture as an art was already far advanced when the first meeting of the British Association was held in 1831. The great improvers of the eighteenth century wove the new crops into a rotation which provided both animal and human food, and was indeed the best system the world had yet seen, but it was in 1831 entirely empirical. Scientific work was, however, beginning, and round about 1840 three important events occurred: Liebig published his epoch-making essay on the application of chemistry to agriculture, Lawes began the famous Rothamsted experiments which almost at once led to the founding of the artificial fertiliser industry, and the Royal Agricultural Society began its beneficent work of fostering the application of science to practice. Economic conditions favoured the growth of the home agriculture, there was no serious competition from overseas, and from about 1850 until 1890 British agriculture flourished; it attained a high standard of technical excellence, it was financially successful, and it supplied the country with most of the food required. Then within a few years it collapsed. The chain of transport arrangements with the United States and Canada was completed and farm produce came on to our markets at prices with which British agriculturists could not possibly compete. The overseas systems were inferior to our own in production per acre, but the shortage of population necessitated the development of labour-saving machinery, so that the production per man was greater, and this higher efficiency of output won the day. British farmers suffered greatly; many became bankrupt.

Gradually it was realised that the way out of the difficulty was to specialise: to aim at producing, not everything needed, but the things that could be produced best and most easily; and this specialisation favoured the application of science to agriculture. From 1889 onwards, when the Board of Agriculture was founded, agricultural colleges began to grow up; about 1900 the system of county organisers was begun; and in 1909 the Development Fund was set up, out of which agricultural research was financed. A wise administrative policy has always been followed by the Commissioners, and probably no public money has ever been better expended. The relations between the scientific workers, the farmers and the Commissioners, and the Board of Agriculture have always been of the happiest, and as a result of this collaboration agriculture steadily improved and in less than twenty years after the deepest depression it had regained a considerable degree of quiet prosperity.

Then came the War, during which the whole civilised world strove to improve agricultural production. After the War the full force of the improvements was felt, and it was found that the world's power of producing food was far in excess of the power of consumption. There has therefore been a great fall in prices, and agriculture is once more in a state of deepest depression. The chief factors in the new situation have been the development of plant genetics, which has led to the production of new varieties of plants specially adapted to particular regions; improved methods of controlling insects and parasites; the internal combustion engine; and refrigeration. Many regions of the world which in 1840 were waste, and could be nothing else, are now closely cultivated and dotted with homesteads.

The problem now before the agriculturists of the world is to organise their production on a contract basis, so as to supply the world's need of food with a reasonable margin of safety, but without the excess production which benefits no one and only injures themselves.

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wonderful applications have grown out of Faraday's discovery when he produced electricity without actually putting bodies in contact. Dr. Elihu Thomson, the pioneer electrical engineer who invented electric welding, laid stress on the development of electrical power from Faraday's original conceptions. Prof. P. Debye showed the importance of Faraday's work for physical chemistry and the molecular theory of matter; while Prof. P. Zeeman paid tribute to Faraday's genius in conceiving a possible connexion between magnetism and light. The great physicist failed in his attempt to prove his hypothesis from lack of effective apparatus: Prof. Zeeman succeeded many years afterwards, and thus gave his name to the remarkable 'effect' of two magnetic poles on a source of light placed between them. Lord Rutherford referred to the importance of the discovery of the laws of electrolysis by Faraday, whom he honoured as a master in experimental work.

IT was left to Sir William Bragg, the present holder of Faraday's position at the Royal Institution, to deliver the commemorative address of the evening, in which he surveyed the remarkable discoveries of his predecessor, explaining their history and meaning, and showing how they illustrate his genius and his character. In his concluding address, the Right Hon. Lord Eustace Percy, M.P., president of the Royal Institution, pointed to the noble example of Faraday as an incentive for scientific education and research. It was by the courtesy of Sir John Reith and the British Broadcasting Corporation that the season of promenade concerts was interrupted to enable the Faraday Commemoration Meeting to be held in the Queen's Hall. But it was befitting to Faraday's memory that the nation and the world at large were able to follow by wireless these celebrations. The following day, Sept. 22, the Institution of Electrical Engineers held a conference at the Kingsway Hall on "The Place of Electricity in Transport, Communications, and the Household", which was attended by a large number of distinguished men of science and the delegates and guests to the centenary celebrations. Sir Josiah Stamp, Mr. J. S. Highfield, Miss C. Haslett, Mr. Ll. B. Atkinson, Sir Oliver Lodge, and Mr. C. C. Paterson, president of the Institution, outlined in turn the bearing of Faraday's discoveries on the amazing developments of modern electricity.

IN connexion with the Faraday centenary celebrations, a short talking film, presenting a few simple points concerning Faraday and his discoveries, has been made by the British Thomson-Houston Co., Ltd., and given to the Faraday Centenary Exhibition Committee of the Institution of Electrical Engineers. It has been shown at the Marble Arch Pavilion since Tuesday, Sept. 15, and will be included in the programmes of a large number of cinema theatres throughout the country during the next few weeks. In the production of the film the British Thomson-Houston Company was fortunate enough to enlist the co-operation of Sir William Bragg as narrator, and the audience is thus enabled to see and hear one of Faraday's most eminent successors.

BEGINNING with a reference to the humble origin of Faraday and his studies as a youth, Sir William Bragg shows in the film the manuscript book in which Faraday wrote out his account of Davy's lectures, and tells how he came to be engaged at the Royal Institution. Tracing his work further, he then shows the part of the "Diary" in which Faraday recorded his epoch-making experiment of Aug. 29, 1831; and after this comes a demonstration by "Faraday himself" with his famous iron ring and the magnetic needle. Then by means of more modern apparatus it is explained how magnets and coils, moving relatively to one another, lead to the production of currents, and reference is made to the experiments with iron filings and Faraday's ideas of lines of force. The connexion of these things with modern electrical development is explained, and the film ends with a series of pictures of electric trains, telephone exchanges, factories, giant magnetic grabs, and X-ray apparatus. The film will, we think, be appreciated by all who have read anything of Faraday's life and work, but it is probable that, in spite of Sir William Bragg's interesting talk, the film is too short and the action too rapid for it to leave any clear impressions on the minds of those unfamiliar with electrical discovery.

REFERRING to the article "Faraday's London Friends", in NATURE of Sept. 19, Mr. T. E. James writes: "Perhaps, after all, the best friend of Faraday was the sympathetic individual, generally referred to as 'a Mr. Dance —meaning the member of the Royal Institution who either gave tickets of admission or took Faraday in 1812 to hear four of the last lectures of Sir Humphry Davy. It has been possible to identify him as William Dance, who lived at 17 Manchester Street, London. He was born in 1755 and died in 1840. He was a son of James Dance, dramatist and actor with the stage name of Love, who was educated at Merchant Taylors' School and St. John's College, Oxford, leaving the latter before graduation. William Dance was a musician and composer; in 1813 he helped in the establishment of the Philharmonic Society, and acted as its treasurer. He was a brother of Commodore Sir Nathaniel Dance, whose strategic exploit with a French man-of-war in 1804 was the talk of the day."

To the man of science, discovery and the interpretation and correlation of discoveries are his ultimate aim. They mark an end in themselves; whereas to the industrialist such discoveries are only a means to an end, his ultimate aim being the exploitation of discovery and its application to industry. Perhaps there is no example quite so notable as that of Faraday's discovery of a century ago. It marked the inception of an industrial revolution which is still as active and progressive now as it has ever been. The development of electric lighting and power has attained such dimensions that the amount of capital invested in it throughout the world exceeds £5,000,000,000. The substitution of tungsten filament lamps for the old carbon filament in 1908 involved an annual world saving of nearly £50,000,000. Now, in this present stage of the electrical revolution, there are, apart from tube lines, more than 555 route miles of electrified railway in Britain; 200,000 tons of aluminium are produced annually by electrolysis; the 'grid' was brought into use in Great Britain in 1930, and when it is finished, at an approximate cost of £30,000,000, will supply cheap electricity to the country; and electric generating plant of the world has reached nearly 100,000,000 kilowatts. The present flood-lighting, too, is but another portion of the immense superstructure of invention which has been erected upon the foundation of Faraday's research. Such information is admirably presented in the *Times* "Faraday Number", a collection of splendid tributes to Faraday's memory from a number of eminent men of science, published on Sept. 21. The utilitarian value of science is well illustrated in the number; but, perhaps unconsciously, the supplement brings home the historical significance of this centenary and the ethical and cultural value of science, apart from its practical use.

IN the *Scientific Monthly* for September, Edith W. Stone writes an interesting article on Joseph Henry, the American physicist. His grandfather came from Scotland and changed his name from Hendrie to Henry. Henry was born in Albany, New York, in 1797, but stayed with an uncle at Galway, Ireland, from an early age until he was fifteen, when he returned to his mother at Albany. He was apprenticed to a watchmaker, but improved his knowledge by attending night classes. When twenty-eight years of age, he was appointed professor of mathematics at Albany Academy. It was during this period that he began to study and perfect the electromagnet. In 1832, Henry was appointed professor of natural philosophy at the College of New Jersey (now Princeton). He was the first secretary of the Smithsonian Institution, a position which he held until his death in 1878. The author points out the many points of resemblance between Faraday and Henry. Both were gentle and unassuming, yet deliberate and persistent, and each was filled with an unswerving and lifelong devotion to scientific research. That Henry was an independent discoverer of the fundamental fact of electromagnetic induction is not now disputed. Faraday, however, was the first to make public his discovery. Henry is reported to have said: "I ought to have published earlier, but I had so little time. I desired to get out my results in good form, and how could I know that another on the other side of the Atlantic was busy with the same thing?" His memory has been kept green by calling the unit of self-induction the henry.

"HISTORY", declares Prof. H. E. Armstrong, writing in the *Pharmaceutical Journal* of Aug. 29, on the dyestuff industry, "when you can test it, is more often than not perversion of fact." This is a characteristically hard saying, but Prof. Armstrong's contribution to the early history of that industry does not thereby lose anything in credibility or interest. We are bidden by an observant and critical contemporary to regard Perkin as the originator, but not as the founder, of the British industry. "Perkin did a giant's work and set a giant's example, but he only started the ball rolling. Hofmann, he, and Nicholson were a noble triumvirate; they together made the industry." We failed to develop it "just simply through lack of intelligence". Here is another hard saying; one which is easy to resent but difficult to refute. In such an industry strength and vitality were the fruits—in Germany—of scientific control, of shrewd business ability, and of an intelligent, inquisitive outlook based on wide training in scientific method; so the first prize went to the strong.

THE interest of Prof. Armstrong's observations lies particularly in their contemporary origin, but their importance depends on the fact that at this time of crisis they lead us to the root of things. To say that we need in our industrial life a greater measure of scientific direction and of scientific control is merely to say that we ought more often to base our actions upon that exact knowledge which could be, but may not have been, ascertained, and that we should less frequently be guided by guesswork; not that we shall necessarily escape our present difficulties by building a new laboratory, but that we should gain by giving greater authority and employment to intellects trained in the use of the methods of science. "To play the game successfully," says Prof. Armstrong, "management must be in technically competent hands, not of politicians; full support of users must be secured: unless users and producers can be led to see eye to eye the industry will soon be again lost to us. The great danger before us is overorganisation—so-called rationalisation—with its consequent elimination of individuality and talent and lessening of employment."

ALTHOUGH the meteorological records for August received by the Meteorological Office showed that for almost all parts of England the month was a wet one, the figures for the different districts expressed as a percentage of the average were not such as to make the month so remarkable as some others of recent years. Apart from the Channel Islands, the largest excess was 84 per cent for the south-east of England, the Midlands and eastern England following with 57 and 52 per cent respectively. The feature that was most notable was the number of exceptional downpours in limited areas. Some of these were associated with thunderstorms in a sultry spell early in the month, but many occurred in one or other of the windy, cyclonic, and almost wintry spells that followed. Examples of the former were furnished by a fall of 113 mm. in one and a half hours at Langford, Salisbury, on Aug. 4, 74 mm. near Petersfield in about an hour on Aug. 5, and 56 mm. at Greenwich in a short time on the same date. Heavy cyclonic rains include 82 mm. at St. Heliers, Jersey, on Aug. 24, 72 mm. at Cromer on Aug. 8, and 51 mm. at Tynemouth on Aug. 19. Many of these downpours represented the equivalent of a month or more of normal rainfall and gave rise to flooding. Monthly totals were seldom of such exceptional character, but mention may be made of St. Heliers, 214 mm., which is three and a half times the average, and of the total of 200 mm. at Oldham Road, Manchester. In contrast to these, Lerwick had only 5 mm. altogether; for Scotland and Ireland generally there was a deficiency compared with the average.

It is not often that we hear of West Indian hurricanes visiting British Honduras, but the records of former years show that at long intervals one of these storms, like that which devastated Belize on Sept. 10, has travelled sufficiently far west in a low enough latitude and has at the same time been late enough in recurving northwards to strike that colony. The track followed in the recent hurricane, or one closely resembling it, is shown as a recognised though abnormal one in some works dealing with West Indian hurricanes. The storm of Oct. 12–18, 1916, crossed the colony only slightly farther north. If the statement, made in certain newspapers, that another cyclone followed the recent one along a not far distant track is correct, then there is the curious coincidence that the visitations of 1916 and 1931 were both cases of hurricanes occurring in pairs. In 1916, the later of the two appears to have been the more destructive. It passed directly across Pensacola, Florida, giving rise to winds of 120 miles an hour, fortunately with little or no loss of life, though at an earlier stage it caused a vessel to founder with the loss of twenty lives. In the present year, reports received so far indicate that the first-comer was the more violent; it is possible, however, that the second was not less violent, but did not cross any thickly populated district.

The annual Exhibition of the Royal Photographic Society was opened on Sept. 11, and will remain open until Oct. 10. As usual, the principal part of the exhibition is pictorial, but there is also a considerable amount of material of scientific interest. The variety of subjects is very large, and it is only possible here to notice a few exhibits. The Safety in Mines Research Board shows an admirable series of photographs of flames in combustible gases moving between the plates of a condenser. With the condenser uncharged, the flames are seen to move symmetrically from the point of ignition; with the plates charged, the movement is directed towards the cathode. In the national history section, Dr. W. D. Walker has been awarded the Society's medal for a series of photographs of the life-history of the kangaroo from birth to maturity; many will be surprised to note that the kangaroo at birth is less than an inch in length. Herr Karl Stülcken shows a series of somewhat similar nature illustrating the development of the peacock butterfly through its various stages of life. Many of the exhibits this year are interesting especially in relation to medicine and surgery. Several examples of the cure of rodent ulcer are shown, but the most striking exhibit in this field is, perhaps, that of two negatives taken inside a stomach by means of a tiny stereoscopic pinhole camera. In order to take the pictures, the camera, with a small lamp attached, was swallowed by the patient.

The eighth International Congress of Photography took place at Dresden on Aug. 3–8. It is significant that at its closing session the Congress adopted for itself a new name: The International Congress of Scientific and Applied Photography. At the previous Congress, held in London in 1928, an attempt was made to include pictorial photography, but at Dresden there was no time to consider anything but science in relation to photography. Altogether, eighty-two papers were communicated. These will be printed in one volume shortly, and will form a very valuable record of many of the scientific researches carried out during the past three years all over the world. Many of the papers dealt with problems of cinematography and sound-recording on film. These applications of photography have made great demands for an increased accuracy of control in the processing of film, and have necessitated exhaustive researches into the behaviour of sensitive materials under high intensities, which previously had not been much studied.

The problems of standardised sensitometry were again brought forward before the Congress, and agreement was reached concerning a standard light source for testing negative materials. The proposals are those put forward from America in 1928, and a great deal of credit is due to Messrs. Gibson and Davis, of the Bureau of Standards in Washington, for the careful working out of a series of light filters for producing artificial daylight from various primary sources of light. There still remains much in sensitometry which needs standardisation, and the Dresden Congress will perhaps be notable by reason of the German proposals for standardised testing of commercial products. These were put forward tentatively and will be investigated by the various national committees on sensitometry before any general action is taken. The application of 'H and D' numbers to the evaluation of sensitivity has been attacked very much during recent years, and it may well be that a new basis for 'speed' evaluation will eventually be adopted. One of the evening lectures delivered to the Congress was by Dr. Goldberg, who dealt with the subject of photoelectric cells in recording. The Royal Photographic Society is fortunate in having secured Dr. Goldberg for the Traill-Taylor Memorial Lecture, which is to be given on Oct. 27, at the Society's rooms at 35 Russell Square, W.C.1, at 7 p.m. Dr. Goldberg will again deal mainly with the subject of photoelectric cells.

A new Scottish centre of economic and industrial study and research will be inaugurated at Dundee on Friday Oct. 2, when the School of Economics and Commerce is to be opened by Sir Josiah Stamp. The School owes its foundation to the liberality of a prominent leader of the jute industry, Mr. George Bonar, who desired to make available better facilities for higher education in economics and commerce. According to the deed of gift, the courses of instruction are to be of university standard, and the School will aim at preparing its students for responsible administrative and professional positions and providing opportunities for educational advancement to those already engaged in industry. To this end, three different courses of instruction are offered by the School. To graduates of approved universities it offers a one-year post-graduate course; to other qualified students it offers a two-year course; and to students already engaged in industry it provides facilities for evening study. The Principal of the School is Dr. J. A. Bowie, formerly director of the Department of Industrial Administration in the College of Technology, Manchester.

A characteristic of the malignant tumours known as sarcomata is the richness of their blood-supply; frequently even the thin lining membrane of the blood-vessels is absent, so that the sarcoma cells lie in direct contact with the blood-stream and are very liable to be swept away to distant parts of the body. They should, therefore, be susceptible to the toxic influence of therapeutic agents injected into the blood-stream. Positively-charged colloids, injected intravenously, will cause precipitation of the negatively-charged blood proteins; hence it is safe to use only negatively-charged colloids, which, moreover, might react with the basic substances of the cell nucleus and so alter the metabolism of the cell. A. C. Hendrik and E. F. Burton have, therefore, tried the therapeutic effects of a non-toxic colloidal solution of metallic arsenic, in which the particles are negatively-charged (*Canad. Med. Ass. Jour.*, vol. 24, p. 642; 1931). Four cases of bone tumour were selected for the treatment, and the progress after infection was followed radiographically; in two of them deep X-ray therapy was also given. The results in all cases were encouraging: calcification and ossification of the tumour occurred and the bone destruction was retarded or inhibited. The solution was also administered to some patients suffering from carcinoma: the young undifferentiated cells of the tumour appeared to be destroyed; in bone sarcoma this destruction is succeeded by the deposition of calcium, enabling progress to be followed radiographically.

In a series of papers contributed to the *Electrical Times* during August and September, J. C. Wigham gives an interesting account of the progress Russia is making in industrialisation by the five years plan. Before the War, Russia was largely an agricultural country exporting wheat, timber, and oil. After the revolution, owing to internal disorganisation, the country became too poor to pay for manufactured articles from outside. The Soviet Government therefore decided three years ago to erect industrial plants in Russia to manufacture the goods formerly imported, so as to make Russia economically independent. Amazing progress has been made. The first part of a huge furnace plant at Magnetogorsk, capable of turning out three million tons a year, is expected to be ready by Oct. 1. In about a year's time the Ford plant at Nijni Novgorod for building 140,000 motor cars a year will probably be completed. The outfit brought from America is beginning to be assembled and complete cars will soon be manufactured. At Stalingrad a tractor plant designed to manufacture 50,000 tractors a year is already at work. It is not quite clear how the management of these works is to get the requisite staff of skilled and unskilled workmen. Most of the workpeople employed, men and women, boys and girls, have up to a few months ago been working on the land or as skilled or unskilled labourers in industries other than engineering. The immediate provision of trained skilled workmen is almost an insuperable problem, as training for a new industry always takes time. If the production of these great factories is not carefully balanced, there will be over-production and the unwanted surplus will be sold abroad at any price it will fetch. Good progress has been made in developing electrical power plants and in some other engineering schemes, but the railways are behindhand and the coal mines are said to be poorly equipped.

The first congress of the Section of Preventive Pædiatrics of the Save the Children International Union of Geneva was held at the Hague on Sept. 7–8, under the presidency of Prof. G. Scheltema, of Groningen, and was attended by members of fourteen different countries. The subjects for discussion were: the mortality during the first ten days of life and its prevention, introduced by Prof. P. Lereboullet and Dr. Lacomme, of Paris, and Prof. A. Schlossmann, of Düsseldorf, and return cases of scarlet fever and their prevention, introduced by Prof. F. von Groer, of Lemberg, and Dr. A. Lichtenstein, of Stockholm. The British representatives who were invited to take part in the discussions were Dr. H. Chodak Gregory, who dealt with neo-natal mortality, and Dr. J. D. Rolleston and Dr. B. Schlesinger, who discussed return cases of scarlet fever. The next congress will be held at Geneva in July 1932.

The details of the programme for the symposium on the British fuel problem, to be held in the Great Hall, the University, South Kensington, at 10 a.m. on Monday, Sept. 28, in connexion with the meeting of Section B (Chemistry) of the British Association, have now been settled. The symposium will take the form of three addresses in simple and non-technical language. Sir David Milne-Watson, the governor of the Gas Light and Coke Company and the president of the Institute of Fuel, will talk on coal, Sir John Cadman, the chairman of the Anglo-Persian Oil Company, on oil, and Mr. H. T. Tizard, Rector of the Imperial College, South Kensington, on future possibilities.

We much regret to announce the following deaths: Prof. Percy Groom, M.B.E., F.R.S., formerly professor of the technology of woods and fibres at the Imperial College of Science, on Sept. 16, aged sixty-six years; Sir Howard Grubb, F.R.S., scientific adviser to the Commissioners of Irish Lights, and widely known by his construction of astronomical telescopes and other instruments, on Sept. 16, aged eighty-seven years; Prof. David Starr Jordan, emeritus chancellor of Stanford University, California, formerly president of the University, who was an authority on fishes, aged eighty years; Dr. Joan Proctor, curator of reptiles and amphibia to the Zoological Society of London, on Sept. 20, aged thirty-four years; Sir William Simpson, C.M.G., who was director of tropical hygiene at the Ross Institute, Putney, and editor of the *Journal of Tropical Medicine*, on Sept. 20, aged seventy-six years.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* Nature. *No notice is taken of anonymous communications.*]

The Angular Momentum of Light.

The work of Compton on X-ray scattering led to the general acceptance of the idea that the scattering of radiation by a material particle is a unitary process in which energy and linear momentum are conserved. A molecule is, however, a much more complicated structure than an electron, and the conservation principles by themselves would give us an erroneous idea of what we should expect in light-scattering. This follows from the fact that a molecule has in general three degrees of freedom of rotation, several degrees of freedom of vibration according to its complexity, and various possible modes of electronic excitation, and that each of these may correspond to one or other of an extended series of quantum numbers. Restricting ourselves to the cases in which the molecule takes up a part of the energy of the quantum, the conservation principles would indicate that the spectrum of the scattered light should contain an immense number of new lines.

Actually, a remarkable simplicity characterises the observed spectra of the light scattered by polyatomic molecules, a simplicity which is in striking contrast with the complexity of their absorption and emission spectra. It is clear that the Compton principles cannot be regarded as capable of *predicting* the observed phenomena of light-scattering, and that their utility lies solely in the *interpretation* of results discovered by experiment. These remarks seem necessary to correct an impression to the contrary which finds expression in some recent publications.

We may extend Compton s principle and add angular momentum to the quantities which we should expect to find conserved in the collision between a light-quantum and a molecule. The fact that, in liquids and solids, the mutual influence of the material particles is very considerable, attaches some uncertainty to the interpretation of the results obtained with them. The recent success of Bhagavantam at Calcutta in measuring the polarisation and intensity of light scattered by gases, however, opens up new possibilities for the development of the subject.

As a working hypothesis, we may follow Dirac and assume that the angular momentum of a photon is *plus* or *minus* $h/2\pi$, intermediate values being inadmissible. This supposition enables us to interpret very simply the known selection rule $\Delta m = 0$ or ± 2 for the change of rotational quantum number of a diatomic molecule in light-scattering, which follows as a natural consequence of it. Further, it follows [1] that a change in rotational quantum number of the molecule should be accompanied by a reversal in the sign of circular polarisation of the photon, when the latter is scattered in the forward direction. This reversal has been actually observed by Bär and by Bhagavantam with the rotational wings accompanying the original mercury lines scattered in liquids, and the data obtained by Bhagavantam with hydrogen gas may also be interpreted as a confirmation of the same result.

It is remarkable that the latter result is also predicted by the classical electromagnetic theory of light for the case of a rotating anisotropic particle scattering circularly polarised radiation. Nevertheless, it is clear that the observed phenomena may be regarded as an experimental proof that radiation has angular momentum associated with it, and that it has the values $\pm h/2\pi$ for each quantum.

C. V. Raman.

210 Bowbazar Street, Calcutta,
Aug. 15.

[1] Nature, **128**, 114, July 18, 1931.

The Penetration of Light through Successive Layers of Tissue Paper.

In a letter to Nature,[1] J. R. Ashworth mentioned the use of a stepped wedge of fine quality tissue paper in describing a method of measuring ultra-violet light from the sky, photographically. In a later issue,[2] P. W. Cunliffe pointed out that "a step wedge constructed of a diffusing medium, such as thin tissue paper, does not obey the logarithmic 'law', which is valid only for transparent media". It so happens that I obtained data last spring which bear on this subject.

Mr. G. M. Spooner, working on phototropism, was desirous of reducing illumination by steps, and used sheets of tissue paper for the purpose. The alteration in the intensity of diffuse daylight was measured, using a vacuum sodium photoelectric cell, covered with a double surface flashed opalised-glass plate. The combination has a maximum sensitivity in the violet or near ultra-violet. The results are shown in the table.

No. of sheets.	Series A.	Series B.	Transmission per cent.	B (calc.).
1	67·0	69·5	..	..
2	48·7	52·5	75·5	55·0
3	..	40·1	76·4	43·5
4	29·1	30·8	76·8	34·4
5	..	25·3	82·1	27·2
6	..	19·7	77·9	21·5
7	..	16·2	82·3	17·0
8	..	12·8	79·0	13·5
9	..	10·4	81·3	10·7
10	..	8·4	80·8	8·4
			Mean 79·1	

The calculated values in the last column were obtained by using the mean percentage transmission, 79·1 per cent, and multiplying the Series B value for one thickness, namely, 69·5 per cent, by it, to obtain the amount transmitted by two thicknesses, and so on to the tenth.

It may be seen that the calculated and observed values agree well, when allowance has been made for the extra loss by reflection and scattering at the first surface. This amounts to 9·6 per cent. The transmission coefficient appears to increase somewhat with increasing numbers of sheets, at the start. This is probably due to heavy absorption of the shortest wavelengths, which are thus eliminated.

W. R. G. Atkins.

Marine Biological Laboratory,
Plymouth, Aug. 25.

[1] Nature, **127**, 893; 1931.
[2] Nature, **128**, 35; 1931.

Analysis of Complicated Band Spectra with the Aid of Magnetic Rotation Spectra.

The absorption spectra of polyatomic molecules are usually so complicated that an analysis of their rotational fine structure seems impossible. We have therefore tried if the magnetic rotation spectra which are obtained by putting the absorbing gas in a magnetic field between crossed nicols [1] will not simplify those spectra sufficiently so that an analysis becomes possible. It was found that with NO_2 a remarkable simplification occurred. But in this case also the simplified magnetic rotation spectrum is very complicated and we have not yet succeeded in analysing it, further experimental work under higher dispersion being required before an analysis can be attempted.

With NO_2 in a bulb of 3 cm. in diameter at rather low pressure (only slight trace of yellow by transmitted light), a rotation spectrum appeared with a field strength about equal to that of an ordinary permanent magnet. As the field increased, some of these lines disappeared and new lines were developed. The disappearance seems to be a real phenomenon, and not due to a 90° rotation, as observations with the double quartz wedge of *R*- and *L*-quartz indicated that the rotations involved were of only a few degrees.

In order to clarify the situation and illustrate better the theoretical significance of the magnetic rotation spectra, we studied some diatomic gases, in which case two different conditions are possible : (*a*) at least one of the states involved in the transitions has a magnetic momentum, or (*b*) neither initial nor final state have a magnetic momentum (for example, $^1\Sigma \rightarrow {}^1\Sigma$ transitions).

The amount of the magnetic rotation of an absorption line is determined by its Zeeman effect. If there is a magnetic momentum, it is, except for abnormal cases, along the internuclear axis. In this case there is an appreciable Zeeman effect only for the lower values of the rotational quantum number, as the rotation disturbs the orientation of the magnetic moment in the external field. Accordingly, we should expect in the magnetic rotation spectrum excited by low fields with appreciable intensity only lines which arise from such levels. In higher fields new lines with higher values of the rotational quantum number will appear. An example of such a case is furnished by Na_2, the magnetic rotation spectrum of which has been used already by Loomis [2] for the vibrational analysis of the absorption spectrum. We photographed it with varying field strengths. It behaves exactly in the way indicated above.

If neither the initial nor the final state of the non-rotating molecule have a magnetic momentum, there would be no Zeeman effect, and accordingly no magnetic rotation, if the molecule could be considered as being entirely rigid. (A possible influence of the nuclear momenta is evidently too small.) But by its rotation the molecule is deformed, and this deformation can usually most easily be described as a decoupling of the orbital nomentum from the internuclear axis. A magnetic momentum in the direction of the *rotational* axis is thus produced, which may cause a magnetic rotation of the lines in question. But contrary to case (*a*), the lines with *higher* rotational quantum numbers will be chiefly affected.

We have such a case in the absorption bands of Br_2 and I_2, which are both $^1\Sigma \rightarrow {}^1\Sigma$ transitions. The magnetic rotation spectrum of these gases shows indeed a striking difference from the magnetic rotation spectrum of Na_2. Instead of showing only a few lines, it yields a large number of closely spaced lines, the relative intensities of which do not change perceptibly with the strength of the magnetic field. On account of the insufficient dispersion, we have not yet been able to analyse these spectra in detail, but it is apparent that they are quite different from the absorption spectrum, and it seems that they behave in every respect as is to be expected for case (*b*).

The experiments are to be continued with higher dispersion, and a more detailed account will be given elsewhere.

R. W. WOOD.
G. H. DIEKE.

Dept. of Physics,
Johns Hopkins University.

[1] See R. W. Wood, *Phil. Mag.*, 1903–1910, also " Physical Optics ".
[2] *Phys. Rev.*; 1927.

Structure of the Raman Band of Water.

DURING some investigations, I have remarked that, with the increase of concentration of hydrochloric acid, the complex triplet structure of the Raman bands of water becomes more and more blurred. This result is in contradiction with a remark of Rao,[1] that the above-mentioned bands become sharper with the increase of the concentration of the electrolyte. In order to throw more light on that question I undertook some experiments, a detailed account of which will appear in the *Bull. de l'Acad. Polonaise*, now in the press.

A quartz bulb of the type described by Wood, which contained the liquid investigated, was covered, except for a narrow ring, with a black, opaque coating. It was put inside a low pressure mercury lamp in the form of a ring. The light scattered from the walls of the bulb could be eliminated by placing the bulb in a suitable position. The micro-photometer curves of the Raman spectrum, which I have obtained in this manner, show distinctly the triplet structure of the Raman bands of water, and the influence of the variation of concentration of hydrochloric and nitric acids on the distribution of intensities in the band.

The results obtained in the case of nitric acid are in accordance with Rao's observations, who simply described what could be seen on the plates with the naked eye. The water bands become sharper with the increase of the concentration, the central component splits in two parts, and the intensity of the short wave-length component increases rapidly. It seems strange that on Rao's microphotometer records only the splitting of the central band could be seen, while the structure of the remaining bands was not visible.

A new band appears on the curve (*c.* 4675 A.), which corresponds to concentrated nitric acid. Gerlach had observed it already on his plates and has ascribed it to the HNO_3 molecules. However, on his microphotometer curves that band could not be seen.

In the case of hydrochloric acid, this phenomenon has a different character. The intensity of both outer components decreases with the increase of the concentration, and the inner component apparently enlarges. Working with a solution of hydrochloric acid in water, I have remarked that the enlargement of the lines scattered by HCl, without change of the wave-length, has an asymmetrical character. The farther end of the enlarged line dissolves into a band, which ends abruptly on the long wave-length side by a sharp edge, the distance of which from the line is about 150 cm.$^{-1}$.

STANISLAW RAFAŁOWSKI.

Physical Laboratory,
Society of Sciences and Letters,
Warsaw, July 20.

[1] Rao, *Proc. Roy. Soc.*, A, **130**, 489 ; 1931.

I HAVE photographed the Raman band of water excited by the mercury line 2536 at a temperature of 17° C. with a Hilger *EI* spectrograph and exposures of about 125 hours. In the place of the two or three components which, according to the observations of other workers on the water bands corresponding to the same frequency difference and excited by the mercury lines 3650 or 4358, are found, I observed at least nine weak and diffuse components, which could not be reproduced but could be clearly seen with the naked eye under suitable conditions of illumination.

The accompanying reproduction (Fig. 1) is from one of the untouched photomicrographs taken with a large model of Moll's microphotometer, which has been modified in this Institute so as to lessen the irregularities of the registered curve caused by the largeness of the reduced grains of the plate in comparison with their scanty numerical density. The

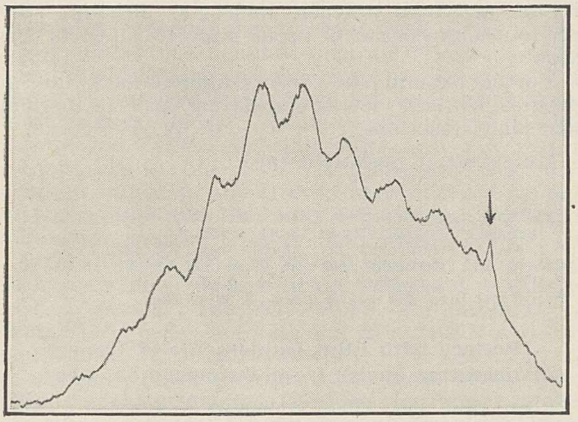

FIG. 1.

arrow indicates the mercury line 2759, which probably hides a tenth band. The other nine are clear.

The wave-lengths of each single component and the corresponding Raman frequency (average of the measurements carried out on photomicrographs of different plates) are given in the following table:

	λ.	$\nu_{\text{vac.}}$	$\Delta\nu$.
Exciting line . .	2536·5	39412·6	
1st component . .	2765	36155	3257·6
2nd ,, . .	2769	36104	3308·6
3rd ,, . .	2773	36052	3360·6
4th ,, . .	2777	35999	3413·6
5th ,, . .	2780·5	35954	3458·6
6th ,, . .	2784	35909	3503·6
7th ,, . .	2788	35857	3555·6
8th ,, . .	2792	35806	3606·6
9th ,, . .	2796	35755	3657·6

The average distance between two components is 50 cm.$^{-1}$.

The structural analogy between the present band and the band of water vapour at $2{\cdot}7\,\mu$ examined by Neunhoeffer should be noted.[1]

A more detailed description will be published elsewhere shortly.

G. BOLLA.

University of Milan, July 25.

[1] Neunhoeffer, *Annalen der Physik*, **2**, 334; 1929.

Photoelectrons and Negative Ions.

A SUMMARY of the results of an experimental research concerning the formation of negative ions from electrons may prove of interest. The electrons were generated by means of light emitted from a quartz mercury vapour lamp ('Home Sun' D.C. type) and incident upon a gold-plated electrode distant 2 cm. from a similar electrode. Between these two electrodes an alternating potential difference of 'square' wave form was established. During a fraction (f) of the time of a complete cycle the electric carriers advance to the receiving electrode; in the remainder of the cycle their motion is reversed, and they are withdrawn from the gas. The gas contained in the measuring vessel was air at various pressures; no purification of the air was attempted other than careful drying.

The experimental procedure consisted in determining for a given gas pressure (p) the curve representing the direct current (i_0) plotted against the applied potential difference (V), and also the curves which exhibited similarly the currents (i_1 and i_2) when the numbers of complete cycles per second were n_1 and n_2 respectively ($n_1 = 30$ and $n_2 = 600$ approx.). The ratios i_1/i_0 and i_2/i_0 were then plotted against $1/V$. The curves obtained were of the type given in the accompanying diagram (Fig. 1). In the curve B, which relates to the higher frequency, one observes a flat portion corresponding to the larger values of V and an apparent point of inflection. It was significant that this point of inflection always corresponded to the voltage which was known to be required in order that the negative ions might traverse the full distance between the electrodes.

In order to explain these curves, a mathematical expression for i/i_0 in its relation to V was developed, the assumption being made that the electric carriers are formed as electrons and that a fraction of these become attached to molecules during their passage through the gas, thus giving rise to negative ions. Mathematically, if N electrons traverse in the free state a distance x from the electrode where they originate, then, after traversing a further distance dx, the number of free electrons will be decreased by $\lambda N dx$, where λ depends on the nature of the gas and is, in addition, a function of V and p. It was found that the theoretical curves thus obtained exhibited the general characteristics of the experimental curves; however, the values of λ which were required to bring the experimental curves into agreement with the theoretical relations were completely different for the two curves A and B. As it is not conceivable that λ can depend on the frequency of commutation, the conclusion is inevitable that the assumption stated above, which has been made the basis of numerous experiments in recent years, is quite erroneous.

The mathematical expression for i/i_0 was next modified, the assumption being made that, of the

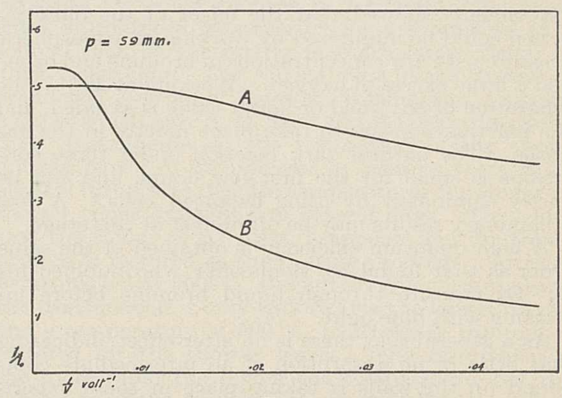

FIG. 1.

electric carriers formed at the electrode, a fraction θ consists of electrons and the remainder of negative ions. The assumption previously made was also retained, namely, that the electrons are liable to further attachment during their progress through the gas, the coefficent of attachment λ being defined as above. A close comparison between theory and experiment disclosed the result that the experimental curves could only be satisfied by values of λ extremely close to zero. On putting λ equal to zero the mathematical expressions for i/i_0 take the simple form:

$$i/i_0 = f - (1 - \theta)vx \qquad (x < f/v)$$
$$i/i_0 = \theta f \qquad (x > f/v)$$

where x is $1/V$, and v denotes nd^2/k, k being the mobility of the negative ion, and d the distance between the electrodes. The velocity of the electron is assumed to be large in comparison with that of the ion. The fraction of electrons (θ) is a function of the impressed voltage and of the gas pressure.

The agreement of experiment with the above theory was established over a range of pressures from 7 mm. to 1 atmosphere. The physical interpretation of the theory is that the great majority of negative ions are formed in the vicinity of the electrode at which the electrons originate; those electrons which do not give rise to negative ions near this electrode traverse in general the whole interval between the electrodes in the free state. Only an inconsiderable fraction of the ions, if any, can be formed by attachment in the body of the gas.

The values of θ in relation to the pressure and to the applied field have been obtained and will be given when the account of the experimental work is published in full. E. M. WELLISH.

University, Sydney, June 26.

Photosensitised Decomposition of Ozone by Bromine.

As a result of work on the photochemical chlorine-ozone reaction carried out at King's College, London,[1] experiments have been in progress on the bromine-ozone reaction in the hope of explaining the differences between the two reactions noted by Bonhoeffer [2] and commented on by various authors since that time. It was found that chains of considerable length were produced in certain circumstances, and to account for this and other facts, the formation of an oxide of chlorine as an intermediate product was postulated.

It is suggested that the formation of a similar unstable oxide will account for the high quantum efficiency in the bromine-ozone reaction, and this receives support from work on the thermal process.[3, 4]

Lewis and Schumacher [3] concluded that it would be useless to attempt the $Br_2 - O_3$ photo-reaction because of the many complicating factors, but preliminary experiments showed that the effect of the dark reaction could be minimised by working at atmospheric pressure with low concentrations of bromine and ozone and a large excess of oxygen. Working at 20° C., the separation of any solid or liquid oxide is avoided, and the reaction appears to take place mainly in the gas phase. The natural dark reaction under these conditions is small for the first few hours, and can be partly eliminated by using balanced cells.[2] A few preliminary results may be of interest at this stage.

A high quantum efficiency is obtained of the same order as that found by Bonhoeffer, who bubbled his $O_2 - O_3$ mixture through liquid bromine before insolating with blue light.

As a general rule, there is no after-effect, indicating that little or no absorption of an intermediate compound on the walls is taking place in these experiments and this is also indicated by the fact that no appreciable change in transmission of $365\mu\mu$ or $546\mu\mu$ takes place on insolation. However, it is probable that this depends on the nature of the surface. The $Br_2 - O_3$ photochemical action differs from the $Cl_2 - O_3$ reaction in that there is no increase in rate of decomposition while the last few millimetres of ozone are being decomposed.[5, 1]

A further difference is that the quantum efficiency at $546\mu\mu$ is practically equal to that for $365\mu\mu$, although the wave-lengths correspond to absorption in the band and continuous regions respectively. (Compare Jost and Jung in the $H_2 - Br_2$ photo-reaction.)[6]

Experiments indicate a direct proportionality of rate to intensity in the region covered, and approximately the same quantum efficiency is obtained for mixtures containing 0·3 to 3·3 per cent bromine and 0·5 to 4 per cent ozone.

In view of the above, it is considered that an oxide of bromine is the 'carrier' in both the thermal and photo reactions. Lewis [4] indeed mentions this possibility, but inclines rather to the view that the carrier is an activated oxygen molecule, although the photo-decomposition of ozone scarcely supports this view.

Further experiments varying different factors are in progress with the view of elucidating both the thermal and photo-reactions. J. W. T. SPINKS.

University of Saskatchewan,
Aug. 18.

[1] Allmand and Spinks, *Jour. Chem. Soc.*, 1652; 1931.
[2] Bonhoeffer, *Zeit. für Physik*, **13**, 94; 1923.
[3] Lewis and Schumacher, *Zeit. physik. Chem.*, **6B**, 423; 1930.
[4] Lewis and Feitknecht, *Jour. Am. Chem. Soc.*, **53**, 2910; 1931.
[5] Weigert, *Zeit. Elektrochem.*, **14**, 591; 1908.
[6] Jost and Jung, *Zeit. physik. Chem.*, **3**, 83; 1929.

Pottery with Flint Implements of Upper Palæolithic Facies from Swanscombe, Kent.

SOME time ago,[1] there appeared in NATURE a short account of a series of flint implements of Upper Palæolithic facies which I had found in a deposit, presumably of glacial origin, on Flamborough Head, Yorks. The cultural horizon of these implements was situated some six feet below ground-level and rested upon a layer of gravel which, in its turn, capped the Upper Purple Boulder Clay.

Some months later,[2] I announced my discovery of similar flint implements in the Brown Boulder Clay at Kirmington, Lincs, a deposit universally admitted as of glacial origin.

This year I located a similar series of flint implements, but associated with undecorated fragments of rough pottery, at Greenhithe, Kent. The site, which occupies a lateral valley, shows the following section:

G.	Surface soil with ground-level at 50 ft. above O.D.	2 ft.	0 in.
F.	Stony loam containing chalk fragments and an occasional 'raft' of Coombe rock	6 ft.	0 in.
E.	Brickearth with implements and pottery fragments	3 ft.	6 in.
D.	Sand with occupation-level at base .		6 in.
C.	Gravel	1 ft.	6 in.
B.	Coombe rock.	5 ft.	0 in.
A.	Chalk		Plus.

Deposit E (the Brickearth) has been examined by Dr. R. H. Rastall, of Cambridge, who states that it is definitely not loess, but that it presents all the appearance of having been deposited by water action. The overlying stratum F (with its erratics, chalk fragments, and 'rafts' of Coombe rock) would seem to confirm the glacial origin of the implementiferous deposit of Flamborough Head previously described.

As a result of the generous assistance rendered by Mr. A. C. Davis, managing director of the Associated Portland Cement Manufacturers Co., Ltd., and the trustees of the Percy Sladen Memorial Fund, a series of excavations has been planned, reports on which will be published from time to time. The first excavation is well advanced, and a fine group of implements and pottery fragments has been recovered.

J. P. T. BURCHELL.

30 Southwick Street, W.2,
Aug. 11.

[1] NATURE, Feb. 15, 1930.
[2] NATURE, Nov. 15, 1930.

Research Items.

Bird Song and Weather.—Changes in weather, and especially sharp frost or snow, influence the amount of bird song, but the influence is different upon different species. H. G. Alexander has made careful observations of the effect of decided spells of hard weather upon birds in Birmingham (*British Birds*, Sept., p. 97). Frost reduces the amount of song, and effects especially the ground-feeding species, such as skylarks and thrushes, but cold winds have the same effect upon more arboreal feeders. Some species respond vocally to sunshine, like the coal-tit, and some are encouraged by rain, like the blackbird. It is suggested that sunshine or rain may affect favourably the food supply of these birds and thus may induce song, but rain stimulates blackbirds more than either thrushes or robins, although the food is very similar. There may be curious idiosyncrasies in the behaviour of closely related species. The song-thrush, the author says, sings in the early morning, and from late November onwards in favourable weather; the blackbird is rarely heard until February, and most of its early song is in the afternoon. Perhaps the 'song' means something different for the two species—more of a normal outlet for surplus energy for the song-thrush, more of a love song for the blackbird.

Nitrogen Content of Apples in Storage.—Pilling and Pearsall point out (Annual Report of the Agricultural and Horticultural Research Station, Long Ashton, 1930) that until now very little attention appears to have been paid to the changes in protein content in apples during storage. In view of the fact that such proteins, an essential protoplasmic constituent, form no less than 2 per cent of the dry matter of the apple, any considerable changes are likely to affect very seriously the continued life of the apples. Their preliminary observations, carried out in connexion with the fruit storage experiments at Long Ashton, seem to open a fruitful line of attack. During storage protein decomposition ensues, and the products—presumably after passing through amino nitrogen and ammonia nitrogen stages—accumulate as 'rest N' compounds of unknown origin and composition. An interesting result of this preliminary work is the fact that break-down in every case investigated seems to occur when the 'rest N' reaches a proportion of more than 17 milligrams per 100 grams of fresh weight.

Properties of the Earth's Crust.—The Geophysical Supplement to the *Monthly Notices* of the Royal Astronomical Society, vol. 2, No. 8, June 1931, contains four seismological papers, and one on forced tides in rotating rectangular basins of uniform depth (S. F. Grace). H. Jeffreys gives new determinations of the times of transmission of *P* and *S* waves at short epicentral distances, and E. Tillotson discusses the data for a 1923 earthquake originating in Yugoslavia, and finds that the travel times for *P* agree best with Jeffreys' tables; he also makes estimates of the thickness of the various layers near the surface, and of the energy of the earthquake (10^{21} ergs). R. Stoneley also discusses the thickness of the continental layers of Europe, from seismic data. H. Jeffreys in a theoretical paper examines the cause of the oscillatory movement in seismograms; in a homogeneous elastic solid an impulsive disturbance is not drawn out into a train of waves. The paper shows that the continuous variation of the earth's elastic properties with depth would not draw out the disturbance into an oscillation, nor can the mutual gravitation of the oscillating medium, nor friction and scattering, have this effect. The only suggestion that survives is that the oscillations are due to reflections of the original pulse within the surface layers, with partial reflection into the lower layers at each arrival at the interfaces.

The Guayra Falls of the Parana.—The Guayra Falls, a few miles above that town on the upper Parana river, have been known since the sixteenth century but have been seldom visited. In the September number of *Discovery*, Mr. E. C. Rashleigh gives an illustrated account of these falls, which, he claims, have the greatest flow of any falls in the world. There is a total drop of 373 feet in about thirty miles, and while no single fall exceeds 130 feet and no sheer leap is more than 65 feet, the volume and speed of the water make up for lack of height. Above the falls the river is 2½ miles wide, but the gorge below the falls is only eighty yards in width. The flow of water above the falls has been measured and averages 500,000 cubic feet per second, while in flood time it may be 1,000,000 cubic feet. This compares with 212,000 cubic feet at Niagara and 100,000 cubic feet at Paulo Affonso on the Rio São Francisco, which would appear to be the largest two of other falls. A Brazilian commission estimated the horse-power of the Guayra falls at 6,000,000, but Mr. Rashleigh points out that if it were possible to divert and canalise the whole river so as to utilise the total drop of 373 feet, the horse-power in flood season would amount to 174,000,000.

Ultra-Violet Window Glass.—Many of the glasses which have been produced capable of transmitting ultra-violet light of wave-lengths between 320 and 280 micro-millimetres, which are the most active therapeutically, deteriorate in their transmission on exposure for a few months to sunlight. The same effect is produced by exposure for a short time to a source, such as the quartz mercury lamp, richer in ultra-violet light. The August issue of the Bureau of Standards *Journal of Research*, Washington, contains a paper by Messrs. A. Q. Tool and R. Stair describing their experiments on the restoration of the transmitting power of such glasses by heating them in an electric furnace to definite temperatures for longer or shorter times extending to several days. They find that the colour of the glass disappears and the transmission is restored as the heating proceeds. At temperatures below 300° C., though the colour disappears, the transmission is only restored for the longer waves, and a temperature of 500° C. is necessary before it is restored for the shorter waves. The restoration is the more rapid the higher the temperature, but deformation of the glass begins about 600° C.

A New Electron-Inertia Effect.—In Maxwell's "Treatise on Electricity and Magnetism", he described three inertia effects which should exist in conductors, such as metals are now imagined to be. Two of these have been verified experimentally, in particular by Barnett and by Tolman, and in the *Philosophical Magazine* for August (p. 349) Prof. Barnett describes the observation of the third. It consists essentially in the angular acceleration of a coil of wire when the current through it is altered; the free conducting electrons are accelerated in one direction, and the coil itself accelerated in an opposite sense. The apparatus needed is naturally very sensitive, but was already set up in almost the requisite form for an investigation of the Einstein-de Haas effect of rotation by magnetisation. The minute twist imparted to the coil could be measured either by balancing it against another couple applied by the action of a second coil on permanent magnets attached rigidly to the main coil, or by the direct observation of the deflection, the former method proving the more accurate. The results show that the carriers of electricity have a negative charge—from the sense of the deflections—and that the ratio of charge to mass for the conducting particles is close to that found for electrons by other means, the best value obtained for the ratio being $1\cdot74 \times 10^7$ e.m.u., and the standard value $1\cdot77 \times 10^7$ e.m.u.

Accuracy obtainable with Gas-filled Photoelectric Cells.—In the *Scientific Proceedings* of the Royal Dublin Society for May, Dr. W. R. G. Atkins publishes a useful and interesting paper describing experiments on the accuracy obtainable with gas-filled photoelectric cells. The question arose in connexion with experiments made to determine by means of photometers the light penetration into sea water. Two cells, a gas-filled cæsium hydride cell and a gas-filled potassium hydride cell, were tested. The former was tested for constancy of emission after the glow discharge had been passed momentarily. It was found that when the anode potential was maintained at 143 volts, a variation of about 33 per cent occurred. Immediately after the glow discharge the sensitivity decreases about 2 per cent per minute, but after a time it begins to rise. The potassium cell was tested for constancy of emission in a similar way, and the variation was found to be within two per cent with a current of about five microamperes, the anode potential being 59 volts. At 166 volts the constancy appears to be somewhat less. The rate of decrease of sensitivity after the glow amounts to about 2 per cent at 166 volts and more than 3 per cent at 59 volts. It is therefore advisable to make measurements immediately after the discharge, which should be of momentary duration only. The potassium cell gives results which can be relied upon to within 2 per cent for post-glow readings for currents at least as great as five microamperes. The results refer to measurements made within a short period of time, and offer no evidence as to the constancy or inconstancy of the cell over long periods.

Astronomical Topics.

The Total Eclipse of the Moon on Sept. 26.—The second total lunar eclipse of the year is visible in England in circumstances closely similar to those of the eclipse of April 2. In each case the first contact of the shadow is about the time of moonrise, but as the moon is five degrees farther north on this occasion, the conditions at the end are slightly more favourable. Totality begins at $19^h\ 5^m$ U.T. ($8^h\ 5^m$ P.M. Summer Time), and lasts $1^h\ 25^m$. The moon leaves the umbra at $21^h\ 42^m$ U.T.; the shading of the penumbra remains fairly obvious for some minutes longer.

Total eclipses afford opportunity for observing the occultation of faint stars, which cannot be seen near the moon at other times. In fact, the best determinations of the moon's diameter are those derived from occultations during eclipses.

The study of the colours on the eclipsed moon is full of interest; they vary in different eclipses, and even in different parts of the disc. It is chiefly the lower layers of the terrestrial atmosphere that are effective in bending the sunlight that falls on the eclipsed moon; these layers vary greatly in transparency according to meteorological conditions. Hence, study of the moon reveals the integrated effect of the weather in the regions of earth that have the sun and moon on their horizon at the time. For most of totality the western part of this region will lie in the Atlantic Ocean.

Occasionally lunar eclipses are used for observing faint comets that cannot be seen in a moonlit sky; but it does not at present appear that this eclipse will be of use in this way.

It is of some interest to note that the small solar eclipse of Sept. 12, visible in Bering Straits, was the last eclipse of a series in the Saros cycle; one member of that series was the eclipse of May 3, 1715, when the sun was totally eclipsed at the Royal Observatory, Greenwich, for $3^m\ 12^s$. Flamsteed noted that the "weather was perfectly clear for the whole eclipse".

The Recent Opposition of Eros.—*Astr. Nach.*, No. 5815, contains notes by Prof. J. Hartmann and M. Dartayet on the observations of Eros made at La Plata early in the present year. The times of the exposures of the photographs were electrically recorded to one-tenth of a second. No screening of the planet was necessary, as its light did not differ much from that of the comparison stars. A series of photographs were taken at zenith distance 75°, to check the refrangibility of the planet's light; those for obtaining the parallax were at Z.D. 65° to 60°. 359 plates were taken near the meridian, which will be useful for deducing the mass of the moon. The planet and neighbouring stars were observed with the transit circle on eleven nights.

Plates for the investigation of the light-variation were taken on March 10, 21, and 25. The plates on the first night cover almost the whole of the light-period of 5¼ hours, in which there is a double maximum and minimum. The light range on the first two days was about three-tenths of a magnitude; on March 25 it did not exceed two-tenths. The times of maximum and minimum conformed well with the formula given by Rolf Müller in *Astr. Nach.*, No. 5768.

Perseid Meteors Observed in America.—The United States have a very active body of meteor observers, under the direction of Dr. Charles P. Olivier, director of the Flower Observatory, and author of a well-known text-book on meteoric astronomy. A bulletin from Science Service, Washington, D.C., dated Aug. 17, reports that the weather was unfavourable in the eastern States, but that successful observations were made at 47 stations in the United States and Canada. These are enough to prove that the maximum was quite a good one: "the rate after midnight rose to two per minute, which is well over the average. . . . Many brilliant meteors accompanied the shower."

As there is likely to be a good display of Leonid meteors about Nov. 17, it is desirable that as many observers as possible should co-operate. Those to whom such work is new should make themselves acquainted with the methods of observing them.

The Preservation of Food.*

THE Report of the Food Investigation Board for 1930 is notable, as in previous years, for the great variety of the researches which have been carried out under the Board's auspices. They are concerned with the changes taking place in meat and fish, fruit and vegetables on storage, especially at low temperatures, with the commercial application of the results obtained, and with the engineering problems involved in the construction and running of large stores. The report notes that the work of the Board has already been effective, in that two commercial gas stores for the storage of apples are now in operation : in one, over a period of five months, the losses during storage of 'Bramley's Seedling' apples did not exceed 0·5 per cent. Close touch is kept with investigators in other parts of the Empire : co-operation will be facilitated by the appointment of assessors, representing the Dominions and Colonies, to the Board during the past year.

The model store chamber at the Ditton laboratory, designed to hold 120 tons of fruit, is now in operation. The problem is to secure uniformity of temperature, humidity, and gas content, at desired values, inside a stack of material which generates heat, evaporates water, consumes oxygen, and evolves carbon dioxide. Large scale storage involves special questions, since the heat, water vapour, and gases produced in the body of the stack have finally to be removed from its surfaces : the greater the ratio of volume to surface, the greater is the difficulty of effective removal without the establishment of gradients. The investigations must therefore be carried out in special chambers arranged for the continuous scientific control of the environment and the measurement of the changes occurring in it : all measurements can be made from outside—for example, temperatures by a 200-point resistance-thermometer outfit.

Some of the scientific problems to be met by the biological engineers have also been investigated : one of the most important is the rate of evaporation from stored materials. Investigations have been carried out by A. J. M. Smith, during the year, on eggs and cheese. In the case of the former, there is no close correlation between rate of evaporation and area of surface, nor does the rate of air-movement (at constant humidity) have any effect on the rate of evaporation. In fact, evaporation appears to depend chiefly on the shell, which acts as the limiting factor : the rate falls off with time, but this is apparently not due to the eggs containing less water but to an increase in the resistance to diffusion of one of the membranes. During the first ten days or so of the life of the eggs the loss of weight is also due in part to output of carbon dioxide. The initial movement of water from the white is not only outwards but also inwards to the yolk, since the osmotic pressure of the latter is the higher : later the yolk loses not only the additional water but also some of that originally present. Examination of the water content of cheese at different levels from the surface showed that the gradient of water content was very steep, the bulk of the evaporated water coming from the outer 2 cm.

Investigations on the canning of fruit and vegetables have been carried out by T. N. Morris and J. M. Bryan. Using a tin-iron couple, it was found that oxygen increases slightly the corrosion of the tin by acid, but depresses that of the iron : in the absence of oxygen the corrosion of tin is negligible. The detinning of tinplate is most severe at low hydrogen ion concentrations (*p*H 4–5) within the range encountered in canned fruits : thus, corrosion is greater with cherries than with gooseberries. On the other hand, at low acidity, oxygen accelerates instead of depressing the corrosion of iron. It was also found that a rough surface accelerates both corrosion and the formation of hydrogen ; that at high acidities exposed portions of the metal are attacked, at low, the pits and seams, and that traces of tin in solution inhibit the corrosion of iron. Traces of sulphur dioxide accelerate the corrosion of iron at high acidity, but retard it at low ; gelatin and other inhibitors of acid corrosion may exert a powerful influence at high acidity but little or none at low. It may be necessary to store the fruit or vegetables before they are canned : strawberries and cherries can be stored frozen in sugar syrup ; peas require blanching by boiling water before being frozen. On subsequent thawing and canning, the latter have the appearance and flavour of fresh canned peas, provided the liquid drained off on thawing is used as a covering in the tin : the thawed peas themselves resemble fresh peas if cooked at once.

During the year a survey of the freezing, storage, and transport of New Zealand lamb was carried out by E. Griffiths, J. R. Vickery, and N. E. Holmes : it was concerned chiefly with the measurement of the temperature, relative humidity, and movement of air surrounding the carcasses, as well as with the temperatures of the latter themselves, in the various stages of storage and transport. It was noticed that the 'bloom' or general appearance of the carcasses depended on breed, age, and nutrition of the sheep as well as on the treatment accorded after death. The value of beef is greater when it is imported chilled and not frozen, since it is ready for immediate sale, is well conditioned and tender, and little different in appearance from home-killed beef. The drawbacks of chilled, instead of frozen carriage, are microbial growth and rancidity. T. Moran, R. B. Haines, and C. H. Lea have shown that air movement delays the growth of moulds and the development of rancidity when meat is stored at 0° C.

Rancidity cannot be measured by chemical tests, as the products responsible for the taste and odour vary in different cases : it can be prevented by storage below $-10°$ C., when the meat is, of course, frozen : at $-5°$ C. the growth of moulds and yeasts is not completely inhibited. Light favours the development of rancidity, by hastening oxidation in the superficial layers of the fat : the process is autocatalytic and continues after subsequent removal to the dark. On the other hand, an unpleasant flavour develops in the dark, which is not due to atmospheric oxidation of the fat. It has also been found that an *Actinomyces* is responsible for the development of a musty odour in meat : it finds its way into the store with straw.

Work has also been carried out on the theoretical aspects of the subject of chilling and freezing : thus, muscle is irreversibly damaged when frozen below about $-2°$ C. : it can still form lactic acid, which can be removed by oxidation ; but the resynthesis of the acid to glycogen can no longer take place. J. Brooks has shown that the discoloration of meat is due to the formation of methæmoglobin from hæmoglobin in the superficial layers : this process is inhibited by continuous storage at below $-10°$ C.

In the case of pig products, E. H. Callow has shown that carcasses of pork can be frozen, transported, and then made into bacon, provided that the fat is hard, otherwise rancidity develops : the nature of the fat

* Department of Scientific and Industrial Research. Report of the Food Investigation Board for the year 1930. (London : H.M. Stationery Office, 1931.) 3*s*. net.

depends on the diet of the pig. More lately it has been found that mild-cured or tank-cured bacon, frozen at − 35° C. and stored at − 10° C. or − 15° C., after slow thawing, and smoking in the case of the latter, tasted for the greater part like ordinary bacon after cooking, but in each case slight rancidity had developed in small areas of the fat. Work has also been carried out on the swelling of gelatin and pork muscle in solutions of sodium chloride.

The Torry Fish Research Station acquired the steam-drifter *City of Edinburgh* during the year. C. A. Reay has carried out further experiments on the freezing and cold storage of haddock. Under certain conditions an irreversible change in the muscle occurs which may not be very obvious on thawing but is evident after curing, since the glossy pellicle of the surface is absent and the tissue is friable, inelastic, and opaque instead of elastic and translucent. The rate of change is slowest at 29°–25° F. and − 9° to − 13° F., and quicker at the intermediate temperatures; at the higher, bacterial growth occurs, the lower involves greater expense in refrigeration.

Research work on fruit and vegetables has been continued. J. Barker has found that cyanide at first accelerates the respiration of the potato instead of inhibiting it as in the case of many animal tissues. The effect appears to be due to an activation of the starch-hydrolysing mechanism, so that more respirable material is available: later inactivation occurs. A. S. Horne has found that East Malling apples, which have a reputation for good keeping qualities, owe their freedom from wastage to absence of infection in the orchard: when infected they are less resistant than fruit from other areas. Resistance to fungal attack depends in part on the acid content of the apples, which decreases with age.

The Idu (Japan) Earthquake of Nov. 26, 1930.

SINCE the great disaster of 1923, Japan has been visited by three destructive earthquakes, in the Tazima province on May 23, 1925, when 428 lives were lost; in the adjoining Tango province on March 7, 1927, when 3017 persons were killed, and in the Idu peninsula on Nov. 26, 1930. Prof. A. Imamura

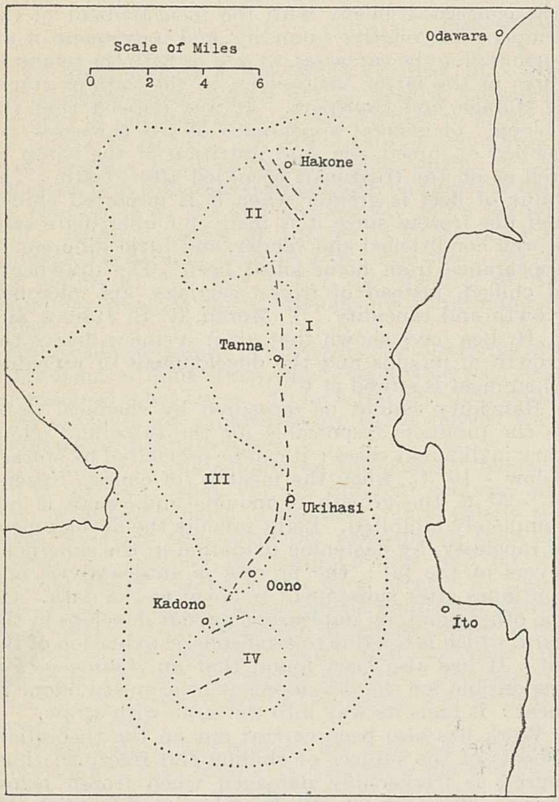

FIG. 1.

has written two interesting papers on the last-named earthquake while a valuable memoir has recently been contributed by Mr. S. I. Kunitomi of the Central Meteorological Observatory.*

According to Mr. Kunitomi, the earthquake was felt over a land-area of 133,000 sq. miles, including the greater part of Japan. The series of Ito earthquakes, more than 4000 in number, closed at the end of May (NATURE, vol. 126, pp. 326, 971). Then followed a pause of about five months until Nov. 7, when a slight earthquake occurred with its epicentre near the Tanna basin. Every day after this, the fore-shocks of the Idu earthquake increased in number until, on Nov. 25, 734 shocks were recorded at the Misima Observatory near the north end of the peninsula. Up to 4 A.M. on Nov. 26, the total number of fore-shocks was 2165, of which 184 were felt at the observatory. Mr. Kunitomi's map representing the distribution of the fore-shock and after-shock epicentres shows that the former were as a rule clustered along the Tanna fault, while the latter were widely scattered over the epicentral region and especially at the bases of Mounts Huzi, Asitake, and Hakone, and off Cape Ooze.

One of the most useful sections of Mr. Kunitomi's paper is that which deals with the origin of the Ito and Idu earthquakes. He has studied the distribution of the directions of initial motion in the Idu earthquake and the stronger Ito earthquakes, especially that of March 22. In all of these earthquakes the distribution is the same, and implies in each a horizontal movement of the crust-blocks along a N.N.W. and S.S.E. line, or nearly along the course of the Tanna fault, the eastern block moving to the north and the western to the south.

The Idu peninsula lies on the west side of Sagami Bay, the bed of which and the surrounding shores formed the epicentral area of the Kwanto earthquake of Sept. 1, 1923. Prof. Imamura points out that there have been three epochs of seismic activity in this region, in 818, 1703 and 1923, and that the first and third were followed, after 23 and 7 years respectively, by destructive earthquakes in the Idu peninsula. The recent Idu earthquake may thus, he suggests, be regarded as an after-shock of the earthquake of 1923.

The earthquake occurred on Nov. 26, at 4 h. 3 m. A.M. (Nov. 25, 7 h. 3 m. P.M., G.M.T.). In a sketch-map, the essential features of which are here reproduced (Fig. 1), the broken lines represent the faults along which dislocations occurred during the earthquake, the outer dotted line bounds the area in which at least 1 per cent of the houses collapsed, the inner dotted lines I-IV, the areas in which the percentage was not less than 25. It was in the areas II-IV that the greatest losses of life and property occurred, 259 persons being killed and 2142 houses destroyed.

Of the faults that appeared during the earthquake, four are especially noteworthy. (i) The Tanna fault

* *Tokyo Imp. Acad. Proc.*, vol. 6, pp. 419-422; 1930, and *Japan. Jour. Astr. Geoph.*, vol. 8, pp. 51-65; 1931. *Tokyo Geoph. Mag.*, vol. 4, pp. 73-102; 1931.

crosses the Tanna tunnel at right angles, about 500 feet below the surface. In the tunnel itself, the crust on the west side was shifted 7 ft. 10 in. to the south and 2 ft. 0 in. downwards relatively to that on the east side ; though, at the surface, the dislocation was much less marked. (ii) The northern or Hakone fault, trending north-west, may be a segment of the Tanna fault. (iii) The Oona fault begins near Ukihasi and runs S. 30° W., with a relative southward shift of the west side amounting in one place to 3 ft. 3 in. (iv) The southern segment of the latter fault, or Kadono fault, trending S. 70° W., with relative shift of the west side of 4 ft. 3 in. to the south and 1 ft. 8 in. upwards.

From a study of the seismograms obtained at Tokyo, Prof. Imamura distinguishes four series of waves coming from as many different origins, that are probably represented by the areas I-IV in the accompanying map. The movement of the whole block-system started north of Ukihasi (in lat. 35° 2′ N., long. 139° 0′ E.), passed northwards with comparative quietness along the Tanna fault, and southwards, with sharp destructive shocks caused by the displacements of the three blocks II, III, and IV. The crust on the west side of the fault-system was shifted relatively southwards, the whole movement coming to an end after the lapse of about 10 seconds. The stress causing this block-movement probably acted in the same way as that in the great Kwanto earthquake of 1923 ; in other words, the recent Idu earthquake was an after-shock of the Kwanto earthquake.

C. DAVISON.

The National Radio Exhibition.

THE National Radio Exhibition, which was opened at Olympia on Sept. 18, occupies a floor space three times as large as last year and is now the largest radio exhibition in the world. The exhibition is organised by the British Radio Manufacturers' Association, and is arranged in such a well-planned manner that it cannot fail to be of interest to all broadcast listeners, whether technically minded or not. This exhibition definitely supports the idea which was becoming evident last year, that the radio manufacturing industry has passed through its somewhat uncertain experimental stage to that of steady development along trustworthy and well-established lines. The modern commercial radio receiver compared with its prototype of a year or two ago, which resembled an ill-assorted collection of components wired together in a box, is built somewhat on the lines of a car chassis.

Apart from the progress made in the design of receivers based on well-established principles, two recent developments are indicated in the exhibition. The first is an attempt to improve the selectivity obtainable in reception without any appreciable sacrifice of the quality of reproduction. More than one method of reaching this objective is being investigated, and it is possible that the results obtained may to some extent alleviate the interference difficulties which sometimes arise when transmitting stations are in too close proximity to one another, both in a geographical sense and from the point of view of their operating frequencies. The second and perhaps more recent novelty in Great Britain is the introduction of the 'variable-mu' valve, that is, of a valve in which the action of the grid in controlling the anode current varies along the axis of the electrode system, usually as a result of a variation in pitch of the turns of the grid. Such a valve, having a variable amplification factor according to the actual conditions under which it is operating, provides a means of avoiding certain distortion effects encountered in the normal type of screen-grid valve. A means of overcoming the effects of variation of the incoming signal due to fading and other causes is also provided by the new valve, which may be operated under conditions securing automatic volume control in the radio-frequency portion of the set.

A prominent exhibit is that of the British Broadcasting Corporation, which includes a large map of the British Isles showing the density of population in relation to the broadcasting stations. A study of the map reveals that the B.B.C. stations are placed in the most advantageous positions to secure that the great majority of the population are within the service area of one or more stations. Apparatus is also installed on the B.B.C. stand to supply programmes to all loud-speakers operating in the exhibition.

For the rest, the exhibition shows the great range of modern receiving sets which are now available to suit all tastes and length of purse. The great modern tendency is to make the receiver a self-contained unit, including the loud-speaker, and ready for connexion to the electric supply mains. The larger and more expensive models contain also an electrically operated gramophone, and in some cases these now embody automatic record-changing mechanism by means of which half an hour's continuous gramophone music can be obtained without any attention. The more successful of the portable receivers remain in a somewhat improved form, while battery-operated models are still produced for those to whom an electric supply is not available. Altogether it may be said that the receivers show a marked improvement in design and performance over those exhibited last year, while the selling prices are in most cases appreciably lower.

Birthdays and Research Centres.

Sept. 28, 1873.—Prof. J. L. COOLIDGE, professor of mathematics in Harvard University.

I am at present engaged on a history of geometrical methods. This is a long work that will cover many years.

A problem to which attention might usefully be given is the situation of the singular points of a rational plane algebraic curve.

Sept. 28, 1889.—Prof. H. MUNRO FOX, professor of zoology in the University of Birmingham.

Protoplasm contains a considerable number of elements, some of them present only in traces. Of these, some may be of considerable functional importance. During the last two years, in collaboration with Mr. H. Ramage, I have been making a quantitative spectrographic study of the presence of traces of elements in the tissues of a wide variety of animals.

Some years ago I carried out a physico-chemical investigation of chlorocruorin, a green blood pigment present in certain polychæte worms. Chlorocruorin turned out to be the only known substance having a chemical structure closely similar to hæmoglobin. By its resemblances and differences it throws light on the nature of hæmoglobin. At the same time chlorocruorin has a number of peculiarities. I am at present studying the blood circulation, metabolism, and mode of life of the animals possessing chlorocruorin, with the view of elucidating the functional rôle of this respiratory pigment.

Oct. 2, 1875.—Prof. A. W. CONWAY, F.R.S., professor of mathematical physics, University College, Dublin.

In conjunction with Prof. M'Connell, of Trinity College, Dublin, vol. 2 of Hamilton's "Mathematical

Works " is being prepared. This entails the examination of the immense amount of unpublished MSS. which Hamilton left behind. Hamilton left unpublished many dynamical ideas which are attributed to later writers.

As time permits, I am investigating the connexion between wave mechanics and relativity.

Oct. 2, 1876.—THOMAS SHEPPARD, director of the Hull Municipal Museums, and editor of the *Naturalist*.

Realising the importance of the work of my old friend Dr. C. Davies Sherborn, I began early the thankless task of compiling bibliographies relating to British geology, prehistoric archæology, zoology, and botany. These have been published by the Yorkshire Geological Society, British Association, East Riding Antiquarian Society, and in the *Naturalist*. The north of England bibliographies formerly compiled by Dr. A. Harker have been prepared by me since 1893, and in 1915 was published the bibliography of Yorkshire geology, 1534–1914 (666 pages).

In editing the natural history, geological, antiquarian, and museum publications during the past forty years, I have endeavoured to popularise various aspects of science. Towards this end I have written papers and books on numerous subjects, and am gratified by being told that there are more entries under my name in the Geological Society's card catalogue than under that of any other British geologist, living or dead.

Always interested in forgeries, I have caused trouble in high places by exposing fakes.

More than thirty years ago I was appointed to take over the Museum of the old Hull Literary and Philosophical Society, then typical of its kind, and this educational work has been so much appreciated by my fellow-citizens that we now have separate museums specialising in prehistoric archæology, natural history, commerce and transport, fisheries and shipping, applied art (ancient and modern), a memorial to William Wilberforce, and folk-lore. Three others are in preparation.

Societies and Academies.

LONDON.

Institute of Metals, Sept. 15 (Annual Autumn Meeting, Zurich).—A. J. Murphy: The constitution of the alloys of silver and mercury; with an appendix by G. D. Preston on the X-ray examination of the system silver-mercury. Progressive additions of mercury to silver cause a continual reduction in the temperature of the initial freezing point down to $-38 \cdot 8°$ C., the freezing point of mercury. No alloy in the series has a freezing point lower than that of pure mercury. Silver can retain in solid solution 55 per cent by weight of mercury at 276° C., the amount probably increasing somewhat at lower temperatures.—A. von Zeerleder: Influence of variations in heat-treatment and ageing on duralumin. Quenching in hot water or in oil causes less deformation, and if the temperature of the quenching medium, as well as the ageing temperature, be 50° C., there is no disadvantageous influence on the physical properties. Measurements of the electrochemical potential, electrical conductivity, tensile and corrosion properties showed that a temperature of 145° C. (293° F.) had a decidedly disadvantageous influence.—W. E. Alkins and W. Cartwright: Experiments in wire-drawing. (1) Behaviour of a composite rod. Composite round rods of annealed copper, built up by drawing a number of tubular layers of equal thickness over a central solid core, have been drawn in drafts of varying severity through straight-sided dies of three different angles of taper. Butt ends when drawn through the dies become concave without showing any steps between the layers; the concavity increases with the angle of taper of the die and also with the amount of reduction at the draft. All the layers undergo a proportionate reduction in thickness and therefore the same relative reduction in area of cross-section.—E. L. Francis and F. C. Thompson: The drawing of non-ferrous wires. The power required to draw wire is directly proportional to the maximum stress of the original material. With tungsten carbide dies, the pull required is practically independent of the speed of drawing over a wide range. A comparison is made between the efficiency of steel, carbide, and diamond dies.—H. W. Brownsdon and E. H. S. van Someren: Application of the spectrograph to the analysis of non-ferrous metals and alloys. The possibilities and limitations of spectrographic methods are reviewed. Methods for the routine spectrographic examination of brass and some lead alloys are outlined, and tables are given indicating the relationship between impurity or minor constituent concentration and relative line intensities.—D. M. Smith: The spectrographic assay of some alloys of lead. The method is based on standards of known composition either synthetically prepared or determined by accurate chemical analysis. One of its great practical advantages is that it is very much more rapid than ordinary chemical assay of these metals. Spark spectra are preferred, as giving more consistent results than arc spectra. By simple direct comparison of spectra the constituents can be determined within the range $0 \cdot 1$-1 per cent, with an accuracy of 10 per cent.—John L. Haughton and Ronald J. M. Payne: Transformations in the gold-copper alloys, with an appendix on X-ray examination of gold-copper alloys, by G. D. Preston. By recording autographically the variation of resistance with changing temperature of alloys of composition ranging between 20 per cent and 70 per cent atomic of gold, and by measurements of the specific resistance of alloys slowly cooled to room temperature, the transformations in alloys with compositions in the neighbourhood of those corresponding with the compounds AuCu and $AuCu_3$ have been confirmed, and the presence of another transformation in alloys approximating to the concentration of compound Au_2Cu_3 has been established.—N. S. Kurnakow and N. W. Ageew: Physico-chemical study of the gold-copper solid solutions. Both annealed and quenched alloys were studied. The existence of the compounds AuCu and $AuCu_3$ has been confirmed by constructing isothermal diagrams of the electrical resistance, and the limits of the solid solutions have been indicated.—M. Cook and E. C. Larke: Physical testing of copper and copper-rich alloys in the form of thin strip. Consistent results for tensile strength and elongation are obtainable on all the materials down to and including $0 \cdot 02$ in. thickness. One of the most satisfying methods of measuring hardness is the diamond pyramid static indentation method. Cupping machines, although they may measure some kind of ductility and, if properly correlated, may afford a good sound indication of the behaviour of a material for cupping and drawing operations, are limited in respect of specification.

(To be continued.)

PARIS.

Academy of Sciences, August 3.—A. Lacroix: The tectites of the Philippines. These correspond closely in appearance and chemical composition with the tectites from Indo-China, Malay, and Borneo, and have probably the same origin as the latter.—**Aimé Cotton**: Polarising prisms with normal field based on internal crystalline reflection.—**Charles Achard, Augustin Boutaric, and Maurice Doladilhe**: The physical properties of the blood serum and of the proteins separated from this serum by the acetone method in man and in some animals in the normal state. The experiments detailed show that colloidal suspensions made up from the proteins separated from a serum and a volume of water equal to the original volume of a serum possess a viscosity and an optical density practically identical with those given by the original serum. Hence the properties of the proteins separated by the acetone method appear to remain unaltered.—**Gabriel Bertrand and P. de Berredo Carneiro**: The active principle of guarana. The presence of a new alkaloid in guarana (Schar, Thoms, Nierenstein), not caffeine, is definitely negatived by the author's work. He found 4·8 per cent of caffeine, and careful examination of this failed to show the presence of any other alkaloid.—**André Blondel**: Some new forms of the method of recording and observing the angular deviations of internal combustion engines. A neon lamp is substituted for the spark or arc lamp used in earlier methods.—**A. Bigot and J. Dubois**: The presence of the Ordovician in the Moroccan Anti-Atlas. This is proved by the discovery of an *Acidaspis Buchi* in an exceptional state of preservation near the base of the schists and quartzites of Djebel Tachilla.—**G. Pfeiffer**: The reciprocal relation between two systems of linear equations in involution.—**Jean Placinteanu**: The true vibration of ionised gases.—**J. Cabannes and E. Canals**: The Raman effect in a crystal of sodium nitrate.—**René Audubert and Jean Roulleau**: The rôle of the phenomena of photoconductance in the photovoltaic effect. The results of experiments described show that the phenomenon of photoconductance cannot be considered as the essential factor of the photoelectric effects: if it intervenes, it should be considered as a secondary phenomenon.—**G. Darzens and André Lévy**: The direct bromination of metacresol. The exact conditions for the direct bromination of metacresol to monobromocresol are given: the compound was proved to contain the bromine atom in the para position to the hydroxy group.—**P. Vayssière**: Some observations on the migratory acridians.—**Louis Bounoure**: The Golgian nature of a characteristic cytoplasmic element of the germ in the first stages of the development of the frog.—**A. Paillot**: Parasitism and symbiosis in the aphides.—**E. Landauer**: Study of a medium for cultivating the spirochæte of fowls.—**G. Delamare and C. Gatti**: Some characters of *T. rigidum*.

WASHINGTON, D.C.

National Academy of Sciences (*Proc.*, Vol. 17, No. 6, June 15).—**E. M. East**: Immunity to sugar cane mosaic acquired by the host. Sugar cane infected with mosaic can throw off all pathological symptoms and remain apparently healthy for a time. It is not known whether reappearance of mosaic is due to re-infection or whether the mosaic virus is merely reduced in virulence. Strains subject to mosaic, though apparently healthy, give the same precipitin test as those definitely infected with mosaic, whereas strains never known to have mosaic react differently.—**D. C. Cooper and R. A. Brink**: Cytological evidence for segmental interchange between non-homologous chromosomes in maize.—**Andrew Watson Sellards**: The behaviour of the virus of yellow fever in monkeys and mice. Yellow fever virus maintained by passage from brain to brain of mice loses its virulence for monkeys by ordinary routes of injection. Intraperitoneal injection of such virus immunises monkeys against typical yellow fever virus; similar inoculation of man may sometimes be justifiable.—**Frederick D. Rossini**: The heat of combustion of methyl alcohol. A stream of air was saturated with the vapour and burnt at constant pressure in an oxygen atmosphere. An electrical method was used to determine the thermal effect (NATURE, 127, 506, March 28, 1931). The heat of reaction found was $173·63 \pm 0·05$ kgm.-cal. per mole at 15°.—**Eric G. Ball and W. Mansfield Clark**: A potentiometric study of epinephrine.—**William Hovgaard**: The distribution of stresses in welded and riveted connexions. Theoretical investigations suggest that when a girder of limited length is attached to a major structure subject to tension or compression parallel to the girder, there is marked concentration of shearing stresses at the ends of the girder, and their intensity is much greater than ordinarily supposed. Experimental evidence of the effect is given. This has important consequences in ship design and may account for fracture of deck plating at corners of deckhouses, hatches, etc.—**Harry Grundfest**: The relative effectiveness of spectral radiation for the vision of the sun-fish, *Lepomis*. The fish is placed in a cylindrical glass tank surrounded by a cylindrical screen of equal and alternate vertical bars and spaces. The tank is placed on a glass-topped table and illuminated from below. Light is reflected through the screen round the tank from the inside of a hollow truncate 45° cone. Rotation of the screen causes movement of the fish, which is usually motionless. The least amount of illumination (spectral energy) causing movement is determined for various regions of the spectrum; the wave-length of maximum efficiency is 535–545mμ, corresponding well with the maximum of the visual purple absorption (540mμ). This indicates that visual purple is the photosensitive agent for dim vision. Substituting a fine wire mesh for the screen, measurements were made at bright illuminations. The maximum efficiency is then at 640mμ. This suggests that in fishes, as in man, there are two visual mechanisms, for dim and bright illuminations respectively.—**J. F. Ritt**: Systems of algebraic differential equations.—**Gordon Pall**: The number of representations function for positive binary quadratic forms.—**Edward Kasner**: Dynamical trajectories and the ∞^3 plane sections of a surface.—**Einar Hille and J. D. Tamarkin**: On the summability of Fourier series (4).—**W. T. MacCreadie**: On the stability of the motion of a viscous fluid.—**A. Adrian Albert**: Normal division algebras of order 2^{2m}.—**Edwin H. Hall**: Electric conductivity and optical absorption in metals, once more. A discussion of the results obtained by Meier and by Hagen and Rubens on the basis of the dual theory of conduction.—**W. W. Coblentz, R. Stair, and J. M. Hogue**: The spectral erythemic reaction of the human skin to ultra-violet radiation. Isolated spectral lines from a large quartz monochromator were used, and the time of exposure to produce a minimum perceptible erythema on the authors was determined. The wave-length range of the erythemogenic rays begins about 315mμ; the response wave rises abruptly to a maximum at 297mμ, descends less abruptly to a minimum at about 280mμ, and rises to a less intense maximum at about 250mμ. The erythema produced by the shorter wave-lengths is very transitory. The response curve is practically the same for different persons.

Official Publications Received.

BRITISH.

Transactions of the Royal Society of Edinburgh. Vol. 57, Part 1, No. 2: A Contribution to the Molluscan Flora of the Laki and Basal Khirthar Groups of the Indian Eocene. By L. R. Cox. Pp. 25-92+4 plates. (Edinburgh: Robert Grant and Son; London: Williams and Norgate, Ltd.) 10s.

Jamaica. Annual Report of the Department of Agriculture for the Year ended 31st December 1930. Pp. 35 + 3 plates. (Kingston: Government Printing Office.)

India: Meteorological Department. Scientific Notes, Vol. 3, No. 22: The Structure and Movement of a Storm in the Bay of Bengal during the period 13th to 19th November 1928. By Dr. K. R. Ramanathan. Pp. ii+29-33+9 plates. 2·4 rupees; 4s. 3d. Scientific Notes, Vol. 3, No. 23: Historical Note on the Catch of Raingauges. By H. R. Puri. Pp. ii+37-59+6 plates. 1 rupee; 1s. 9d. (Calcutta: Government of India Central Publication Branch.)

Board of Education. Educational Pamphlets No. 85 (Industry Series No. 10): Report by H.M. Inspectors on the Provision of Instruction in Applied Chemistry in Technical Schools and Colleges in England and Wales. Pp. 55. (London: H.M. Stationery Office.) 1s. net.

Rothamsted Experimental Station: Lawes Agricultural Trust. Report for 1930. Pp. 172. (Harpenden.) 2s. 6d.

Imperial Agricultural Research Conference, 1927. Abstracts of Papers on Agricultural Research in the United Kingdom, published during the Year October 1929 to September 1930. Pp. 166. (London: H.M. Stationery Office.) 1s.

Union of South Africa: Department of Public Health. Report on Investigation into Malaria in the Union of South Africa, 1930-31. By Prof. N. H. Swellengrebel. Pp. 45. (Pretoria: Government Printer.)

Proceedings of the Royal Irish Academy. Vol. 40, Section B, No. 4: A Tentative Reconstruction of the Successive Margins of the Quaternary Ice-Sheets in the Region of the North Sea. By Prof. J. Kaye Charlesworth. Pp. 67-83. (Dublin: Hodges, Figgis and Co.; London: Williams and Norgate, Ltd.) 6d.

The National Physical Laboratory. Report on the Physics Department for the Year 1930. Pp. 62-99. (London: H.M. Stationery Office.) 2s. net.

The Cordwainers Technical College (Incorporated). Prospectus of Classes in Boot and Shoe Manufacture and Making, and Leather Goods Manufacture. Day and Evening Classes, Session 1931-32. Pp. 43. (London.)

Air Ministry: Aeronautical Research Committee: Reports and Memoranda. No. 1379 (Ae. 504—T. 3010): Biplane Fins on a Model of R.101. By Dr. R. Jones and A. H. Bell. Pp. 13+3 plates. 9d. net. No. 1391 (Ae. 512—S. 73): Measurements of Lift and Drag of Southampton Seaplane. By A. S. Crouch. Pp. 3+3 plates. 6d. net. (London: H.M. Stationery Office.)

Department of Scientific and Industrial Research. Building Science Abstracts. Vol. 4 (New Series), No. 7, July. Abstracts Nos. 1141-1338. Pp. 223-258. (London: H.M. Stationery Office.) 9d. net.

Apia Observatory, Apia, Western Samoa. Report for 1928 and 1929. Pp. 176. (Wellington, N.Z.: W. A. G. Skinner.)

FOREIGN.

Bureau of Entomology. Report of the Entomologist. Pp. 34. (Washington, D.C.: Government Printing Office.)

World Social Economic Congress, under the Auspices of the International Industrial Relations Association. Principles and Practicability of Economic Planning. Section 1: Principles and Practice of Scientific Management. By Dr. H. S. Person. Pp. 64. Section 2: Europäische Aspekte der Rationalisierungsbewegung-Bedeutung des Scientific Management für die Sozialökonomische Planung. Von Hugo von Haan. Pp. 37. Section 3: The Problem of Economic Planning. By Dr. Lewis L. Lorwin. Pp. 43. (The Hague: International Industrial Relations Association.)

Cornell University Agricultural Experiment Station. Bulletin 519: Studies of the Genus Delphinium. By Earle I. Wilde. Pp. 107. Bulletin 520: Fertilizer Tests of several Soil Types. By T. L. Lyon. Pp. 19. Bulletin 521: Cultivation Experiments with certain Vegetable Crops on Long Island. By H. C. Thompson, P. H. Wessels and H. S. Mills. Pp. 14. Bulletin 523: The Sociology of a Village and the Surrounding Territory. By Bruce L. Melvin. Pp. 138. Bulletin 525: A Survey of some Public Produce Markets in Up-State New York. By F. P. Weaver. Pp. 149. (Ithaca, N.Y.)

Bernice P. Bishop Museum. Bulletin 76: Social Organization of Manua. By Margaret Mead. Pp. iv+218. Bulletin 79: History and Culture in the Society Islands. By E. S. Craighill Handy. Pp. iii+110+6 plates. Bulletin 80: Archaeolgy of Kauii. By Wendell Clark Bennett. Pp. iv+156+15 plates. Bulletin 81: Vascular Plants of the Leeward Islands, Hawaii. By Erling Christophersen and Edward L. Caum. (Tanager Expedition, Publication No. 7.) Pp. 41+16 plates. Bulletin 82: Report of the Director for 1930. By Herbert E. Gregory. Pp. 36. Occasional Papers, Vol. 9, No. 12: Notes on Joinvillea. By Erling Christophersen. Pp. 7. Occasional Papers, Vol. 9, No. 13: Vascular Plants of Johnston and Wake Islands. By Erling Christophersen. (Tanager Expedition, Publication No. 6.) Pp. 20. (Honolulu.)

State of Connecticut: State Geological and Natural History Survey. Bulletin No. 50: Fourteenth Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1929-1930. Pp. 26. 10 cents. Bulletin No. 49: Public and Semi-Public Lands of Connecticut. By Philip Laurance Buttrick. Pp. 151. 1 dollar. (Hartford, Conn.)

Division of Fish and Game of California: Bureau of Commercial Fisheries. Fish Bulletin No. 28: Handbook of Common Commercial and Game Fishes of California. By Lionel A. Walford. Pp. iii+183. Fish Bulletin No. 29: The Striped Bass of California (*Roccus lineatus*). By Eugene C. Scofield. Pp. 84. Fish Bulletin No. 30: The Commercial Fish Catch of California for the Year 1929. By the Staff of the Bureau of Commercial Fisheries. Pp. 135. Fish Bulletin No. 31: Studies of the Length Frequencies of the California Sardine (*Sardina caerulea*). By the California State Fisheries Laboratory. Pp. 55. (Sacramento: Calif. State Printing Office.)

Proceedings of the American Philosophical Society. Vol. 70, No. 3. Pp. 215-316. (Philadelphia.)

The Science Reports of the Tohoku Imperial University, Sendai, Japan. Second Series (Geology), Vol. 14, No. 2A. Pp. 97-133+plates 29-39. (Tokyo and Sendai: Maruzen Co., Ltd.)

CATALOGUES.

'Caprokol' Brand of Hexylresorcinol, the Urinary Antiseptic for Oral Administration. Pp. 8. Acriflavine "B.D." Pp. 8. (London: The British Drug Houses, Ltd.)

Books on all Technical and Applied Science. Pp. 104. (London: W. and G. Foyle, Ltd.)

Diary of Societies.

FRIDAY, SEPTEMBER 25.

INSTITUTE OF BREWING (at Queen's Hotel, Birmingham).—Dr. F. Windisch: New Results Concerning the Metabolism of Yeasts in their Relation to the Fermentation of Wort and Beer.

THURSDAY, OCTOBER 1.

INSTITUTION OF AUTOMOBILE ENGINEERS (at Royal Society of Arts), at 8.—W. A. Tookey: The Internal Combustion Engine and its Performances (Presidential Address).

FRIDAY, OCTOBER 2.

INSTITUTION OF CHEMICAL ENGINEERS (at Chemical Society), at 6.—N. E. Rambush and F. F. Rixon: The Gas Generator as a Direct Producer of Metallurgical Products.

SATURDAY, OCTOBER 3.

GILBERT WHITE FELLOWSHIP (at 6 Queen Square, W.C.1), at 3.—Dr. P. Flemming: Harley Street, Historical and Topographical Notes (Lecture).

CENTENARY.

OCTOBER 1 AND 2.

JAMES CLERK MAXWELL CENTENARY CELEBRATION (at Cambridge).

Thursday, Oct. 1.—Sir J. J. Thomson: Memorial Lecture.

Friday, Oct. 2 (*morning*).—Addresses by Prof. Max Planck, Sir Joseph Larmor, and Prof. Niels Bohr.

(*Afternoon*).—Addresses by Dr. William Garnett, Sir Ambrose Fleming, and Sir Oliver Lodge.

CONGRESSES.

SEPTEMBER 20 TO 27.

INSTITUT INTERNATIONAL D'ANTHROPOLOGIE (at Paris).

SEPTEMBER 23 TO 25.

INSTITUTION OF MINING ENGINEERS (at Manchester).

SEPTEMBER 23 TO 30.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (Centenary Meeting). (For Programme see NATURE, Sept. 19.)

SEPTEMBER 24 TO 27.

SWISS SOCIETY OF NATURAL SCIENCES (at La Chaux-de-Fonds and Le Locle).

SEPTEMBER 29 TO OCTOBER 2.

IRON AND STEEL INSTITUTE (at Royal Metal Exchange, Swansea).

Tuesday, Sept. 29.—Prof. C. A. Edwards and A. Preece: The Constitution of the Iron-Tin Alloys.

C. O. Bannister and W. D. Jones: The Diffusion of Tin into Iron with special reference to the Formation of Columnar Crystals.

G. Burns: The Effect of Molybdenum on Medium-Carbon Steels containing 1 to 2·5 per cent of Manganese.

R. Harrison: The Influence of Silicon on Nickel Steel.

Wednesday, Sept. 30.—J. C. Jones: Mottled Tinplates.

The Equilibrium of Certain Non-Metallic Systems. Part I. By J. H. Andrew, W. R. Maddocks, and D. Howat. Part II. By J. H. Andrew, W. R. Maddocks, and E. A. Fowler.

F. Adcock: Alloys of Iron Research. Part X. The Chromium-Iron Constitutional Diagram.

G. A. Hankins and M. L. Becker: The Effect of Surface Conditions Produced by Heat Treatment on the Fatigue Resistance of Spring Steels.

B. Matuschka: The Solidification and Crystallisation of Steel Ingots: The Influence of the Casting Temperature and the Undercooling Capacity of the Steel.

Thursday, Oct. 1.—O. Cromberg: Production Economy in Iron and Steel Works. Part II. Costs of Production.

W. H. Cunningham and J. S. Ashbury: The Surface Hardening by Nitrogen of Special Aluminium-Chromium-Molybdenum Steels on a Production Basis.

N. T. Belaiew: The Structure of Nodular Troostite.

Prof. F. C. Thompson and R. Willows: A Critical Study of the Origin of the Banded Structure of a Hot-Worked Hypo-Eutectoid Steel.

OCTOBER 5 TO 10.

CONGRESS ON TUBERCULOSIS (at Davos).—*Principal Subjects for Discussion:*—Development and Course of Tuberculosis of the Lungs; Extra-Pulmonary Tuberculosis; Collapse Therapy.