Nature

A WEEKLY

JOURNAL OF SCIENCE

VOLUME CXXVIII

JULY, 1931, to DECEMBER, 1931

"*To the solid ground
Of Nature trusts the mind that builds for aye.*"—Wordsworth.

London
MACMILLAN AND CO., Limited
NEW YORK: MACMILLAN COMPANY

INDEX

NAME INDEX

TITLE INDEX

CORRESPONDENCE.

REVIEWS AND SHORT REVIEWS.

Agriculture, Forestry, and Horticulture:

Anthropology and Archæology:

Biology:

Chemistry:

Engineering:

Geography and Travel:

Geology, Mineralogy, and Mining:

Mathematical and Physical Science:

Medical Science and Physiology:

Metallurgy:

Meteorology:

Miscellaneous:

Philosophy and Psychology:

Technology:

The various Supplements should be collated and bound with the numbers with which they were issued.

Printed in Great Britain by R. & R. CLARK, LIMITED, *Edinburgh*.

NATURE

A WEEKLY JOURNAL OF SCIENCE

"To the solid ground
Of Nature trusts the mind that builds for aye."—WORDSWORTH.

SATURDAY, JULY 4, 1931.

CONTENTS.

Safety Work in Chemical Industries.

THE common impression that chemical industry is exceptionally dangerous is largely derived from such disasters as the serious explosion at the Royal Naval Cordite Factory, Holton Heath, on June 23, in which ten men were killed and three seriously injured. Like the Castleford disaster of last year, the explosion originated in the nitrating house, and indicates the devastating effects of chemical processes which are allowed to get out of control.

In spite of the poisonous and dangerous materials and the high temperatures and pressures which are frequently used, the accident rate in chemical industry compares very favourably with that of other industries, in a number of which both the frequency rate and the severity rate of accidents are considerably higher. This position is the result not only of experience but also of accurate and scientific control of the manufacturing processes. Chemical manufacturers are now well aware of the dangers connected with their industry, and take every possible step to reduce the number of accidents in chemical industry and develop adequate safety measures.

It is, indeed, significant that even in processes which to the ordinary person appear to involve the greatest risks, the accident rate, as a result of exceptionally strict control, is even lower than normal. The price of safety is unceasing vigilance, and the characteristic of chemical industry is not a high accident rate, but the appalling consequences which may attend the single slip or oversight on the part of the human element, which is responsible for 90 per cent of industrial accidents. The Castleford disaster may apparently be traced to the neglect to sample the waste acid storage tanks in the ordinary way, the Home Office inspectors observing that proper sampling might have led to detection of the presence of the nitro-compound in the acid mixer and allowed suitable precautions to be taken.

Even the strictest control may, however, at times be thwarted by some abnormal conditions, and if, as at Holton Heath, responsible officials such as the chemist in charge perish in the explosion, or, as at Chatterley, Stoke-on-Trent, on June 3, lose their lives in attempts at its control, it is difficult to detect the abnormal circumstances responsible and devise precautions to prevent its recurrence. This emphasises both the need for research into the causes of accidents and the importance of correlating, by publication, abstracting, and indexing, the information obtained by research or other means.

As noted in a recent article in Nature (May 30, p. 805), to this formidable problem scientific workers have as yet given inadequate attention. Much valuable work has already been done, especially in chemical industry, which compares very favourably with other industries. In Germany, the work of the Berufsgenossenschaft der chemische Industrie is well known, and its publication in *Die chemische Industrie* of illustrated notes on accidents, safety precautions, and devices compiled by the technical inspectors receives a wide circulation. In Great Britain, the efforts of the Association of British Chemical Manufacturers, which in the last two years has undertaken the task of abstracting, indexing, and publishing safety information pertaining to chemical industry, are by no means so well known as they should be. The Association has published quarterly, since January 1930, a classified summary of safety information, derived not only from published literature but also from the records of the Association. The latter include information supplied privately by members of the Association, and this adds very considerably to their value. The wider the membership of the Association, and the more fully its members co-operate in this work by pooling their information on safety matters, the more effective and invaluable its Safety Summary will become.

In addition to the Safety Summary, the Association of British Chemical Manufacturers has for several years published what are termed "Safety Circulars". These are single sheets dealing with accidents which either present some unusual feature or indicate some useful precaution. The circular usually describes briefly the accident and its cause, and gives the views of the Works Technical Committee of the Association as to the precautions necessary to avoid repetition of the accident. Recent circulars have dealt with the escape of sulphuric acid in transfer by air pressure from a tank waggon to a raised storage tank, fires at a tar distillation plant and benzole plant, the bursting of a drum of phenol by compressed air, and fires at cellulose spraying plants. Such circulars are obviously of an interest which is not confined to chemical industry in the narrower sense. This is recognised by the Association, which holds the view that safety information, like medical science, should receive the widest possible publication. Accordingly, not only has a system of co-operation been arranged for the pooling of information with French and German colleagues, but also the benefits of its safety service are available to non-members on payment of a suitable fee.

A further feature of the safety work of the Association of British Chemical Manufacturers is the "Model Safety Rules for Chemical Works", of which Part 1 and a first section of Part 2 have already been issued to its members. These rules, as indicated by Mr. J. Davidson Pratt in his recent address on "The Cleaning and Repair of Plant and Vessels containing Dangerous Materials" at the Chemical Session in the National Safety First Week at Leeds, in some respects go beyond the Chemical Works Regulations issued by the Home Office. The addition to which Mr. Pratt particularly referred was intended to prevent misunderstanding where the full implications of the regulations regarding the thorough removal of dangerous material might conceivably be overlooked.

In his paper, Mr. Pratt outlines the main types of risk attached to the cleaning of containers and the chief precautions to be taken. While the details to be followed may vary widely with different materials and classes of vessel, certain general principles can be enunciated. For these the widest publicity is desirable, especially since volatile and dangerous solvents are now widely used in industries where the scientific knowledge and control is by no means so prominent as in chemical industry. In such industries the design of plant to facilitate safe cleaning may be completely overlooked and the question of responsibility assumes great importance.

Even in chemical industry the term 'responsible person' does not always receive an interpretation consistent with its use in the Chemical Works Regulations. Many serious accidents have occurred because the testing of stills or containers prior to repair work or entry by workmen has been entrusted to persons without adequate scientific knowledge. Under modern conditions, industrial safety requires the employment in industry generally of larger numbers of chemists and other responsible scientific workers. Under-staffing on the scientific side definitely increases the risks of operatives, and while it is probable that some delegation of responsibility is unavoidable under industrial conditions, the scientific and technical staff should be adequate to ensure thorough training of, and personal contact with, those to whom such responsibility is at any time delegated. It was a public-spirited policy which led the organisers of the British Association of Chemists to include in its programme the endeavour to secure legislation providing that certain prescribed operations should be under the direct control and supervision of a qualified chemist. While in practice such operations can frequently be carried out by well-trained assistants, their efficiency, especially from the safety point of view, depends upon uninterrupted personal contact with a responsible chemist upon whose experience and knowledge they can draw at once in emergency.

Radioactivity and the Atomic Nucleus.

Radiations from Radioactive Substances. By Sir Ernest Rutherford, Dr. James Chadwick, and Dr. C. D. Ellis. Pp. xii + 588. (Cambridge: At the University Press, 1930.) 25*s.* net.

THE appearance of a new book on radioactivity by Lord Rutherford and his associates is a noteworthy event in the world of physics. Rather than prepare a new edition of his standard treatise on "Radioactive Substances and their Radiations", the senior author has chosen to devote his present discussion primarily to the significant developments in radioactivity which have occurred since that treatise appeared. These developments deal primarily with the characteristics of the radiations from radioactive materials and the effects which they produce. In view of the present state of physics, and the fundamental questions associated with the outer part of the atom apparently well understood, and the atomic nucleus offering perhaps the most vital problem with which physics is now faced, we are fortunate to be presented with this clear and comprehensive account of the information regarding the nucleus which is afforded by studies in radioactivity. Nothing could be more timely.

One is impressed by the extent of the important information that has come from recent studies in radioactivity. Thus, among other things, discussions are found of the disintegration of atoms by alpha ray bombardment; the studies of nuclear charge and nuclear size by the scattering of alpha rays; the discovery of rare alpha, beta, and gamma particles of extraordinarily large energy, revealing hitherto unsuspected types of disintegration; the quantum mechanics theory which describes how radioactive disintegration is possible; magnetic beta ray spectra, and their associated gamma ray spectra, revealing nuclear energy levels and evidence that electrons as discrete entities may not exist within the nucleus; crystal measurements of gamma ray wave-lengths, and the precise confirmation of Einstein's photoelectric equation at very high frequencies; recent quantum theories of gamma ray scattering; experiments with cosmic rays and their significance regarding the origin of the rays. Many of these developments have resulted from the labours of the authors themselves, and none could be found better qualified to describe them.

Gradually our knowledge regarding the atomic nucleus becomes more precise. Experiments with scattered alpha rays have shown its minute size and its relative large mass. They have enabled us to measure its charge, and even to estimate the field of electric force in its neighbourhood. Further information on the latter point is given by the speed with which the alpha particles are ejected from the radioactive nucleus. Combining the evidence from these alpha ray experiments, it becomes evident that surrounding the nucleus there is a 'potential wall', which prevents alpha particles that are outside from entering the nucleus and those on the inside from escaping. We are thus afforded a basis for developing a quantum theory of radioactive disintegration according to which the probability of an alpha particle jumping this wall is greater if it has large energy, and a qualitative explanation of one of the fundamental laws of radioactivity is obtained. Studies of the sharpness of gamma ray lines suggest a nucleus in which planetary alpha particles correspond to the electrons of the outer atom; though how these particles are held together remains unknown. Similarly, the condition of the electrons in the nucleus remains unsolved. There is no gamma radiation that can be traced to these electrons, and when they appear as beta particles their energies are distributed over broad bands. Though much new light is shed by these studies in radioactivity, the nucleus of the atom, with its hoard of energy, thus continues to present us with a fascinating mystery.

It is inevitable that in an undertaking of this magnitude not all parts of the treatment can be kept strictly up to date. Thus, for example, in discussing the spectra of gamma rays from crystals, though the important work of Thibaud (1925) and Frilley (1928) is mentioned, that of Steadman (1929), which reveals gamma rays of frequency much higher even than those observed with the magnetic spectrometer, is not referred to. The impression is, nevertheless, that the authors have covered the field with great thoroughness, and have made careful selection of the material that is included.

For those who are familiar with Rutherford's style from his earlier writings, it is superfluous to mention the clarity and succinctness of his portion of the present book. Dr. Chadwick and Dr. Ellis are, however, to be congratulated in having caught something of the senior author's lucidity of expression. The result is a well-balanced discussion which the novitiate will find readable, and those working in the same field will find a mine of suggestive ideas and authoritative information.

ARTHUR H. COMPTON.

Man's Remote Ancestry.

The Origin of the Human Skeleton : an Introduction to Human Osteology. By Dr. Robert Broom. Pp. 164. (London : H. F. and G. Witherby, 1930.) 10*s*. 6*d*. net.

WHEN, nearly forty years ago, Dr. Broom went to Australia to study the most primitive mammals now surviving, very little that was more than conjecture was known of the origin of mammals. As the result of his researches on the comparative anatomy of the Australian monotremes and marsupials and the examination of the rich harvest of fossils that has rewarded his thirty-four years of searching in South Africa, he has recovered so many links between the most primitive reptiles and mammals as to be justified in claiming, as he does in this book, that the essential problem of the origin of mammals is now definitely solved. Incidentally also, the question of the origin of lizards and crocodiles has been answered, and new light has been thrown upon the ancestry of dinosaurs and birds.

It is not surprising that the man who has contributed so largely to these great achievements, and himself recovered in the field most of the material which made them possible, should be able to write with freshness and originality, with a disregard for traditional views and pedantry, on the subject of his lifework. In this small book, Dr. Broom gives a concise and wonderfully simple and convincing account of the information afforded by the comparative anatomy of the skeleton in vertebrates to demonstrate the line of evolution leading to reptiles, the derivation of mammals from one of the reptilian groups (Ictidosauria) at the close of the Triassic, and the origin of the Primates from a primitive Menotyphlous mammal before the end of the Cretaceous.

In the process of building up his argument, Dr. Broom examines in turn the comparative anatomy of the skull, the vertebræ and sternum, and the limbs, and thus incidentally has written in bold outline a most fascinating story of " the origin of the human skeleton ", which is the descriptive label he has given his book. His wise selection, no less than his boldness and courage, eliminates most of the puzzling complexities of a difficult subject, and has enabled him to write with full mastery and lucidity a surprisingly easy and stimulating narrative. Whether or not this drastic re-interpretation of our knowledge will stand the test of critical analysis is, at the moment, of less importance than the consideration that a mass of new information is skilfully woven into the fabric of an easily comprehended hypothesis, which will provide the student with a clear-cut scheme wherewith to test the evidence, as well as the scheme itself, the brilliant hypothesis which Dr. Broom has constructed in tentative interpretation of the facts. This masterly synthesis is a conspicuous contribution to the study of the origin of mammals and of the evolution of man, which every student of human and comparative anatomy should assimilate.

G. ELLIOT SMITH.

Gold Resources of the World.

The Gold Resources of the World : an Inquiry made upon the Initiation of the Organising Committee of the XV International Geological Congress, South Africa, 1929. With a Summary by A. C. Sutherland. Pp. xiv + 457 + 38 plates. (Pretoria : Wallach's, Ltd., 1930.) 25*s*.

IN 1929 the fifteenth International Geological Congress met in South Africa—synchronising as to time with the meeting of the British Association. The organising committee of the Congress had decided beforehand to initiate an inquiry into the gold resources of the world, as it was felt that such a subject was singularly appropriate. Previous congresses had dealt with the world's resources of iron ore, coal, and pyrites, and these reports are still looked upon as standard works of reference. The Prime Minister of the Union, General Hertzog—who was honorary president of the Congress—issued a circular letter on Oct. 31, 1927, asking for the assistance and co-operation of those countries which have ever been known producers, and the reports are set out in this volume. There are also innumerable maps and useful statistical tables.

Let it be said that, on the whole, these reports are extraordinarily well done, and the names of their respective authors are a guarantee of accuracy, so far as this is possible. An introduction by Dr. A. L. Hall, a member of the staff of the Geological Survey of the Union, who acted as general secretary of the Congress, explains the scope of the work, and a most informative summary of the reports by Mr. A. C. Sutherland, formerly mine surveyor on the staff of the Union Government Mining Engineer, gives all the information which the casual reader would wish to have. So far as one can see, no country has been omitted, and although the same degree of accuracy, or rather approximation to accuracy, cannot be claimed for the gold resources report as for the previous three which have already been mentioned, it can be said that it is the best which can be done.

Gold has always been the premier precious metal. Mythology, the classics, and the Bible all teem with references to it, but never has it been talked about so much as to-day. True, the economists differ as to its utility, and one hears criticisms concerning its distribution, but all are agreed that it is the basis of the monetary system of most of the important countries of the world. It is also the yard-stick whereby wealth is measured and consequently the basis of credit. Yet, contrary to popular opinion, it is merely a commodity, subject like all others to ordinary economic laws, and when it costs a mine twenty-one shillings to recover gold from one ton of ore which contains only twenty shillingsworth of gold, the mine which has that ore must assuredly go out of business. Moreover, with all the searching during the centuries—and the search still continues—no other metal or commodity seems capable of taking its place.

No wonder, therefore, that there have been gold rushes in California, Australia, the Klondike, and in South Africa; and these will continue. True, we do not hear of them so much to-day, because our old world has been fairly well prospected during the past fifty years. But one would not expect to hear of a gold rush in Ireland, yet it is well known that there is plenty of alluvial gold in County Wicklow, and there was a veritable rush there in 1795, when 800 oz. were recovered by peasants in six weeks. The summary already referred to shows that the British Empire is responsible for more than 70 per cent of the world's production, the Transvaal itself accounting for more than 50 per cent. Gold was first discovered in Bechuanaland by Carl Mauch in 1866; and since returns were made, the recorded value of the Transvaal output alone is now more than one thousand million pounds. The United States, which has long been out of the race for the premier position, is only a little way behind South Africa, and Australia comes next, with a total value of about six hundred millions.

Dr. Pirow, Government Mining Engineer to the Union of South Africa, on page 337 makes the following remarkable statement: " Since the year 1884, prior to which date no reliable figures are available, the Union of South Africa has produced a total of 229,051,118 fine ounces of gold, equivalent to 22·4 per cent of the total estimated world production to date, or 34 per cent of the production since the Union first entered the list of gold producers ".

Though gold is widely distributed, the countries which have contributed substantially to the world's store in the past are comparatively few in number and some of them have ceased production altogether. Australia has fallen from its high position, but that is due entirely to political causes. When these are removed, it is possible that this great country may again become one of the principal producers.

The economist of the orthodox school will naturally be more interested in reserves rather than production, and this is possibly the weakest part of the reports. It has to be recognised, however, that these depend on economic considerations, and the zero line of payability is, therefore, never constant. It appears, however, that it is to the British Empire, and more particularly to South Africa, Canada, and to a lesser extent to Australia, that the world must look for its future supplies. In the Transvaal alone it is quite possible that gold to the value of one thousand million pounds may still be won—a stupendous total. There is no report from Panama, but that country's prospects as a producer appear to be good.

It remains to be said that the printers are the well-known South African firm of Wallach's, of Pretoria, which is the administrative capital of South Africa. But Pretoria is not a large city, and as the reports are printed in English, German, and French—the three official languages—and one in Italian, the production is indeed a remarkable tribute to their ability.

Wm. Cullen.

Short Reviews.

Bergey's Manual of Determinative Bacteriology: a Key for the Identification of Organisms of the Class Schizomycetes. By David H. Bergey, assisted by a Committee of the Society of American Bacteriologists, Francis C. Harrison, Robert S. Breed, Bernard W. Hammer, Frank M. Huntoon, with an Index by Robert S. Breed. Third edition. Pp. xviii + 589. (London: Baillière, Tindall and Cox, 1930.) 27*s.* net.

THIS publication, which has now reached its third edition, is an extension and elaboration of the admirable and painstaking work of the Committee on Characterisation and Classification of the Society of American Bacteriologists (1917, 1920). When one considers the labour involved in a compilation of this nature, it would be agreeable if one could be persuaded that the value of the results obtained is commensurate with the effort expended. But even the most cursory examination of the pages of this manual suggest that too much is taken for granted in the published descriptions of various micro-organisms.

When, for example, one finds organisms of almost precisely the same morphological, cultural, and biochemical characters and of serological identity classified, not only under separate species but even under separate genera (*Pseudomonas fluorescens* and *Phytomonas* spp.; *Pseudomonas aeruginosa* and *Phytomonas aptata*; *Corynebacterium pseudotuberculosis* and *Shigella pfaffi*), one wonders where the authors' taxonomic conceptions may eventually lead us. The closely related species, *B. whitmori* and *B. mallei*, are, moreover, included in separate genera (*Flavobacterium* and *Pfeifferella* respectively), and the genus *Shigella*, in addition to *S. pfaffi* mentioned above, is made to include a rough variant of *Salmonella gallinarum* (*Shigella jeffersonii*). Turning to the genus *Salmonella* itself, one finds that practically no attention has been paid to the mass of brilliant and elaborate research made in recent years that has thrown so much light upon the complex serological relations of this extremely natural and self-contained group of bacteria.

A comprehensive and critical revision of the text would appear to be necessary when the next edition of this work is contemplated.

R. ST. J.-B.

Textbook of Logic. By Prof. A. Wolf. Pp. 407. (London: George Allen and Unwin, Ltd., 1930.) 10*s.* net.

THE best text-book on a special subject is not always written by the scholar with the greatest reputation in that subject. It is gratifying, therefore, that a logician of Prof. Wolf's measure should have written a text-book which can unhesitatingly be put in the first rank.

Logic in the past has too often erred on the side of mechanical formalism and remained to the student out of all relation to common sense and practical needs. In the author's own words, it has become "the recruiting place for the sadly depleted philosophy classes". Prof. Wolf, whose very position at the London School of Economics keeps him in touch with most of the sociological and humanistic developments of the day, is emphatically alive to the practical needs of the student and scholar alike. His close contact with social science makes his treatment of logic fruitful in the application to modern types of argument, while the style is lucid and pleasant, and the treatment, in spite of its full dose of symbolism and technical instruction, distinctly attractive.

The exercises, given at the end of the book and therefore not impeding the continuity of the argument, will enable the student to apply the sound principle of the author that logic, no more than algebra or geometry, can be mastered by reading alone.

Pioneers of Public Health: the Story of some Benefactors of the Human Race. By M. E. M. Walker. Pp. xv + 270 + 23 plates. (Edinburgh and London: Oliver and Boyd, 1930.) 12*s.* 6*d.* net.

THE pioneers whom Mrs. Walker has chosen to commemorate are the twenty-one eminent men whose names adorn the walls of the new building of the London School of Hygiene and Tropical Medicine, a drawing of which forms the frontispiece. As Sir Humphry Rolleston points out in the foreword, twelve of the pioneers are British, four are from the United States, three from Central Europe, and two from France. Among the various departments of public health, epidemiology and State medicine are represented by Thomas Sydenham, Lemuel Shattuck, Sir Edwin Chadwick, William Farr, Sir John Simon, and Hermann Biggs; naval and military hygiene by James Lind, Sir John Pringle, and Edmund Alexander Parkes; preventive medicine by Johann Peter Frank, Edward Jenner, Max von Pettenkofer, Major Walter Reed, and General William Crawford Gorgas; bacteriology by Pasteur, Lister, and Koch; and protozoology by Surgeon-Major Timothy Richards, Lewis Alphonse Laveran, Sir Patrick Manson, and Sir William Leishman. A concise but sympathetic account of each pioneer is accompanied by his portrait and followed by a brief list of references.

L'Esprit et ses maladies. Par Marcel Nathan. (Bibliothèque générale illustrée, 15.) Pp. 80 + 60 planches. (Paris: Les Éditions Rieder, 1930.) 20 francs.

DR. NATHAN provides us with an excellent summary of the prevailing French attitude towards the mind and its diseases. He divides his small book up into three sections: the brain and the mind, the so-called organic psychoses, and the so-called functional psychoses. To include mania and melancholia as functional or non-organic conditions in the present state of our knowledge is scarcely justifiable. They are probably of metabolic origin. The best part of the book is the illustrations, some of which are actual photographs of patients, while others are reproductions of well-known pictures, by various Continental artists.

The Beginnings of Science.*

By Dr. Charles Singer.

When did science begin ? Can any question be more fundamental for the history of rational thought ? An adequate answer would doubtless demand the formulation of an exact and generally acceptable definition of science. No one, perhaps, has yet succeeded in accomplishing this seemingly simple task. But without insisting on a precise delimitation of the term ' science ', we may get some way, at least, by taking its current if inexact sense. Thus we may treat science as simply the systematic *process* of recording natural happenings with the object of discerning some relation between them.

I would emphasise the word *process*. Science is often discussed as though it could be presented as a body of knowledge or doctrine, but reflection will soon reveal that this point of view cannot be maintained. For is it not the case that science that has ceased to develop soon ceases to be science at all ? The science of one age is often the nonsense of the next. Think, for example, of judicial astrology, or of the doctrine of lucky and unlucky numbers. Who, if he did not know their history, would recognise these as the debris of finely conceived and far-reaching scientific hypotheses, which once attracted clear-thinking minds seeking for rational explanations of the world in which they lived ? We may smile, if we will, at such an explanation of the face of the earth as the doctrine of successive disasters followed by successive creations. The view that fossils are the early and clumsier attempts of an omnipotent Creator may even move us to theological wrath. Yet such conceptions were but stages in the development of geological ideas, just as the scientific views of our own time are but a stage in a great secular process which will continue when we are no more.

It therefore behoves the historian of science to be very charitable, very forbearing, in all his judgments and presentations. He must not ask too much of previous ages, nor must he judge them by the standards of his own. He needs constantly to recall that he is dealing with work of erring and imperfect human beings, each of whom had, like himself, only a very partial view of truth. There is an unquenchable and irresistible tendency innate in the human mind to erect general laws or rules in explanation of the happenings of the world. That tendency is no less present in the historian of science than in the great minds whose work he records, and if he is to be judged at all by posterity, he can but echo the epitaph :

> Reader, thou that passest by,
> As thou art so once was I ;
> As I am, so shalt thou be,
> Wherefore, reader, pray for me.

Time, still, like an ever-rolling stream, bears all its sons away. It is the stream itself and the spirit that dwells therein that the historian of science has to study.

Science, then, is a process that can be followed through the ages ; it is not a mere passive body of knowledge. The sheer validity and success of the scientific process, as applied in our own time in western Europe and America, has given rise to popular misunderstanding as to the nature of science, and some misapplication of such terms as ' science ' and ' scientific '. We hear of the *science* of some prize-fighter, and a book has been published on the " Science of the Sacraments ". There is nothing in the laws of this or any other country which forbids its citizens from giving the words of their language such significance as they may choose, but the word *science* as employed in these connotations has no clear link with the great progressive method of acquiring knowledge with which the historian of science has to deal. The very form of the adjective from science might itself give pause to those who would force the word to cover such topics as the skill of the prize-fighter or a knowledge of the theory and practice of religious rites. The word *scientific* means, derivationally, *knowledge making*, and no body of doctrine which is not being progressively *made* can for long retain scientific attributes.

During the last two generations the evolutionary conception of Nature has become so general that it now pervades our thoughts on every aspect of living activity, nor can we understand an organic product until we know how it came to be what it is. Now, the efforts of the human mind are essentially such products. It has thus become generally recognised that to comprehend, for example, the constitution of a State or the teaching of a religion it is absolutely necessary to know its past. This is the true reaction of evolutionary doctrine on the study of history.

On the study of science itself, however, this reaction of evolutionary doctrine has been less generally recognised. Why this should be is perhaps not altogether clear. One reason may be that the triumphant and absorbing successes of the application of the scientific method have deflected attention from the process itself. Another reason, which is perhaps but a restatement of the former, is that the very rapid growth of the products of the scientific process in quite modern times has turned men's thoughts away from its more ancient achievements. Yet it is clear that if we would understand the process itself, we must examine its application in the past and watch its action under conditions different from those in which we ourselves live. Only thus can we hope to attain any real insight into the nature of the process and of the effect it has had on man's estate throughout the ages.

Among the criticisms that can be made of any attempt to trace the history of science, there is one

* Inaugural address delivered to the Second International Congress of the History of Science and Technology, by the president, on June 29, at the Royal Geographical Society.

that should be met at the outset. It has been said that the history of scientific activity presents a field so vast that it cannot be compassed at first hand by any single mind. The criticism is without validity. If pressed, it would not only prevent the writing of the history of science, but would also prevent the writing both of history and of science. Who, of his own knowledge, can compass the history of even a single country ? Who, of his own knowledge, can deal with the animal kingdom, with the science of geometry, or with the structure of the earth ? Yet this has not prevented, and should not prevent, the writing of histories of England and of Europe, of works on zoology, of treatises on mathematics, or of text-books of geology. The scope of such books in reference to the first-hand knowledge of their writers must be effectively infinite. The difficulty in writing them—as in reading them—is the difficulty in getting a philosophical grasp of the principles involved. In obtaining such grasp, first-hand knowledge is of primary importance. Yet this knowledge, applied in such a field, is but a means to an end, and the writer must be judged by his grasp of the principles he sets forth, rather than by the actual number of experiments he has made or experiences that he has undergone.

But to return to our question as to when science began. The question can as little be answered as the question, When does a man begin to grow old? "Before that I to be begun, I did begin to be undone." Anthropologists have detected germs of the scientific process in the lowest and rudest races of mankind. As soon as a child begins to observe, he begins to make generalisations. The savage sees the action of a living thing in the wind and the flow of the water. He generalises from his imperfect observation that movement means life. The baby calls every male " daddy " ; his, too, is an elementary generalisation based on imperfect experience. Both ascriptions are imperfect attempts at deducing laws.

Here, however, we encounter a real gap in the historical narrative. We can see the scientific element in the baby's generalisation or in the savage's belief. Yet we cannot, with any confidence, trace them forward in a continuous stream to anything that we should call science in the current use of that term. How far, then, can we trace the matter the other way, ascending the stream of time ? In this attempt the last decade has been particularly fruitful, and I shall venture to devote the remainder of my remarks to the special nature of this recent historical achievement. As is too often the case on the scientific front, the pioneers are more concerned with their own progress than with the relation of their advances to those of others. The onlooker truly sees most of the game, and perhaps it is not going too far to say that the game cannot be clearly seen except by the onlooker. This is the justification of the professed historian of science. Without him research in one department would rapidly lose touch with research in other departments. This is so with recent scientific history. Let us seek in the same spirit among the records of a far earlier scientific history.

As we trace the records of science back into the mists that shroud the dawn of history, we see its varied disciplines dwindling to two, namely, to medicine and mathematics. So far as complete works are concerned, the earliest of all scientific treatises that have come down to us are in the medical class. They are contained in the miscellaneous group of tracts known as the " Hippocratic Collection ".

The " Hippocratic Collection " takes its name from the alleged ' father of medicine '. In a less critical age this mass of writings was all ascribed to Hippocrates, and there are some who still find it difficult to abandon the old paths. Nevertheless, there is no evidence, worthy of the name, that any part of any of these works was written by Hippocrates, nor indeed is there any real evidence that Hippocrates wrote anything. It is, however, certain that some works in the " Hippocratic Collection " were composed in the fifth century B.C., at which period their eponymous author was born. Sections of some of them may well date back to the sixth, and portions of them even to the seventh century. Moreover, it has long been recognised that these medical writings were an integral part of a far wider and more deeply based contemporary rational movement in philosophy.[1]

It has indeed been argued that the relations between the medical and historical writings of ancient Greece are closely paralleled by the relations between the evolutionary and historical writings of a generation or two ago. We might put it that Hippocrates was to Thucydides as Darwin was to Buckle or Lecky. A good case for the comparison has been made recently by Prof. Cochrane of Toronto.[2]

However this may be, it is evident that behind these earliest surviving scientific monuments of the fifth, sixth, and seventh pre-Christian centuries there must be a scientific tradition that was already ancient when the Greek world was still young. Of this more ancient rational tradition the mathematical fragments have been more successfully pieced together than the medical.[3] Thus we have details of the achievements of the followers of Pythagoras, and perhaps of Pythagoras himself, whose life occupied the greater part of the sixth century. Moreover, Thales, the sage of Miletus, of whose scientific achievements there can be no doubt, takes us yet further back and into the seventh century. He takes us, too, beyond Greece, for his mother was a Phœnician. He himself had travelled in Egypt. Phœnicia suggests contact with Mesopotamia and the ancient Sumerian civilisation. Recent discoveries in that region, notably those that deal with the treatment of metals, suggest a command of natural forces which demanded theoretical scientific knowledge. Yet it is to Egypt that the Greeks commonly ascribed the origin of their medical and mathematical knowledge.

Among the Greeks before Thales and the seventh century, our view of the rational spirit grows very dim. In the " Works and Days " of Hesiod, written in the eighth century B.C., we get some astronomical lore. Such knowledge, however, must have been common property in the Near East, and indeed in every early agricultural community. In the absence of an adequate calendar, some astronomical knowledge is necessary for the elementary operations in the field. Hesiod, it is true, has something rather beyond farmers' astronomy, but in him we have the independent scientific element at a well-nigh irreducible minimum.

Can we, then, trace the rational tradition among the Greeks behind Hesiod and the eighth century? I think we can. In the Iliad of Homer we obtain glimpses, distant, it is true, of an independent rational medical system. The Iliad tells of a great deal of fighting, in the course of which no less than 147 wounds are well described, and in many cases their treatment detailed. Now this treatment is always on entirely rational grounds, and magical elements are conspicuous by their absence. This and many other hints in the Iliad imply the practice of scientific medicine by recognised practitioners, without relation to folk-medicine. Thus, with the aid of the Iliad, we may trace the scientific tradition among the Greeks as far back as the ninth or tenth century. It is noteworthy that in the Odyssey the origin of medicines is ascribed to Egypt.

In view of the consensus among the Greeks as to their debt to Egypt, all traces of the scientific spirit revealed in the Egyptian papyri are of peculiar interest. Yet the finds have been, till recently, extraordinarily disappointing, and the contrast between Greek science and Egyptian science is greatly to the disadvantage of Egypt. For the inferiority of the Egyptian position as against the Greek, due weight has not always been given to differences in the records of the two civilisations.

First, we have to remember that the picture that we form of Greek thought is derived from the literary remains of the Greek people. That there have been irreparable losses to that literature is true, but the surviving part has come down to our time because it was read by the generations that came between the Greeks and ourselves, and it was read because, by each succeeding age, it was thought to be worth reading. Greek literature, as we have it, is thus, in essence, a selection. It is far otherwise with the Egyptian records. We have here merely what time has spared, and that old reaper has no more discretion with books than he has with the lives of men. He spares what he will and as he will. What kind of literature should we hope to recover from the wreck of our own civilisation? Daily journalism and trade advertisements occupy many times more bulk, and therefore would have a better chance of survival, than the works of the philosophers and men of science.

Secondly, the remnants that have come down to us from ancient Egypt have mostly been recovered from tombs. They were the kind of things that the men of their day thought suitable to bury with their dead. The commonest of all are, in fact, rolls of the "Book of the Dead". If we had to compare them with something in our own civilisation, they would perhaps correspond to the inscriptions on tombstones, to hymn-books, and to prayers for special occasions. It is true that we have an admixture of other documents, but the proportional distribution of surviving Egyptian writings bears no relation to the proportional distribution of Egyptian interests.

Thirdly, it must be remembered that much surviving Greek literature is from the most vital period of Greek history. On the other hand, the overwhelming mass of Egyptian papyri are from the New or Middle Kingdom, whereas the Old Kingdom was the day of Egyptian power. The later scribes were content with copying earlier material. These later scribes were, moreover, commonly careless and not uncommonly incompetent, and, as it falls out, this was especially the case for the papyri that bear on scientific topics.

Bearing in mind these contrasts in the circumstances of Egyptian and Greek documents, let us turn to the surviving papyri of scientific content. These, like the earliest Greek scientific material, divide naturally into the medical and the mathematical. A number of documents fall into each of the two categories, but most of them are so debased or so trivial that we miss little if we take only the principal specimens. Of these there are two in each class that are of primary importance. In the medical class there is the long known Ebers Papyrus and the recently described Edwin Smith Papyrus. In the mathematical class there is the Rhind Papyrus and the very recently described Moscow Papyrus. These four contain practically all that is known of Egyptian medicine—other than that of a purely magical character—and most that is known of Egyptian mathematics.

The Papyrus Ebers, known for seventy years, is still not completely intelligible. It presents many linguistic difficulties, chief among them being the names of drugs. It is of the New Kingdom, and is generally dated as of the sixteenth century B.C. It is in the main a collection of remedies for various named conditions which are sometimes briefly described. Its general intellectual level is about comparable to an English family receipt book of the seventeenth century, of which several have been published. There is no definite physiological, pathological, or pharmaceutical theory, but there is also little that one can call superstition. The book is taken up with a list of traditional treatments of a more or less disgusting character. That sections are taken from a much older work is evident from a few isolated paragraphs in it that are devoted to anatomy. These are so confused as to be unintelligible, but it is obvious that the scribe is trying to abstract an older and more scientific document.

During the last few months Prof. Breasted, of Chicago, has presented us with his edition of an Egyptian medical document of a somewhat different order.[4] The Edwin Smith Papyrus has had a romantic history, having been originally discovered about the same time, and perhaps in the same tomb, as the Ebers. A series of remarkable circumstances left it in private libraries and unknown to scholars until a few years ago.

In general form the Edwin Smith Papyrus is not unlike the Ebers, in date somewhat similar or a little earlier, and its scribe no less careless and incompetent. He was, however, engaged in copying a document of greater scientific value, and probably of greater antiquity than that which was occupying the scribe of the Ebers Papyrus, for there can be little doubt that the original source of the Edwin Smith Papyrus was of the Old Empire. Moreover, the Edwin Smith Papyrus deals with surgical conditions, and especially injuries, while the Ebers is occupied with diseases. Injuries and their treatment lend themselves to clearer descriptions than do the diseases. We thus have in the Edwin Smith Papyrus a document of high value for comparison with certain works of the "Hippocratic Collection" of about twelve centuries later. Without discussion of details it may be said that through the mist of scribal ignorance and misunderstanding we can see in the Edwin Smith Papyrus an author who not only recorded actual case histories, but was seized at times of the spirit of science; that is to say, he records in order to learn something of the workings of the body as distinct from any attempt to treat his patient. Some of his observations, such as that injuries to the brain on one side result in paralysis of the other side of the body, are repeated in the "Hippocratic Collection", and do, in fact, throw light on the nature of physiological mechanism. The Edwin Smith Papyrus—or at least that part of it which survives—is devoted to injuries about the head. It gives us a glimpse—alas! that it should be so dim—of a lost and more ancient scientific literature to which such magnificent treatises as the "Wounds of the Head" and "Fractures and Dislocations" of the "Hippocratic Collection" may well have been related.

For Egyptian mathematics the most important document is the Rhind Papyrus, which was finely edited a few years ago by Prof. T. E. Peet, of Liverpool.[5] Its age is about that of the Edwin Smith Papyrus, though it is copied from an original of the nineteenth century B.C. It professes to be a 'guide for calculation'. Apart from simple rules for giving the areas of figures enclosed by right lines, we have the measure of a circle from which an estimate of π as 3·16 can be deduced, and a calculation with reference to the proportions of pyramids. In this last a certain relation which, as the Papyrus says, "makes the nature of the figure", is deduced from the side of the square base and vertical height or *per-em-us* as the Papyrus calls it. The word *per-em-us* is doubtless the source of the Greek word *pyramis* and our *pyramid*. The problem clearly links up with the mathematical triumph of Thales in deducing the height of a pyramid from its shadow.

The last scientific document of Egyptian origin to be considered is the Moscow Papyrus, which was only published in full by Prof. Struve a few months ago.[6] It is of the Middle Kingdom and thus older than the others. It contains the determination of the volume of a truncated pyramid and the area of a hemisphere.[7] Both are correct, the latter on the basis of the Egyptian value for π as 3·16. It yet remains to be seen whether these determinations are based on general formulæ—as is believed to be the case by Prof. Struve—or whether they are empirically obtained. If the former, it will be necessary to rewrite the history of ancient science and with it much of ancient philosophy.

The rationalisation of the Greek intellect within a very few centuries has always appeared something of a miracle—an epiphany. On the other hand, an ancient and slowly disintegrating scientific tradition in Egypt or in the Near East would fit in well with what we know of the early history of Greek science. Whether such traditions existed is a question of fact which can only be solved by the Egyptologists or Assyriologists. In the meantime, the Rhind, the Edwin Smith, and the Moscow Papyri have made such a view less fantastic than would have appeared to be the case ten years ago.

[1] The more important works of the "Hippocratic Collection" are being edited by Mr. W. H. S. Jones and Dr. E. T. Withington for the Loeb Library. For a complete critical version we still depend on Emil Littré's "Œuvres complètes d'Hippocrate" in 10 volumes (Paris, 1839–61).

[2] C. N. Cochrane, "Thucydides and the Science of History" (Oxford University Press, 1929).

[3] An excellent summary of Greek mathematics has recently been prepared by Sir T. L. Heath, "A Manual of Greek Mathematics" (Oxford: The Clarendon Press, 1931).

[4] J. H. Breasted, "The Edwin Smith Surgical Papyrus", 2 vols. (University of Chicago Press, 1931).

[5] T. E. Peet, "The Rhind Mathematical Papyrus" (Liverpool, 1923). Another edition was produced for the Mathematical Association of America, 1927–29, by A. B. Chace, L. S. Bull, and H. P. Manning, with a bibliography of Egyptian and Babylonian Mathematics by R. C. Archibald.

[6] W. W. Struve, "Mathematischer Papyrus des Staatlichen Museums der schönen Künsten in Moskau" (Quellen und Studien zur Geschichte der Mathematik; Abt. A, Quellenband 1), Berlin, 1930.

[7] The Moscow Papyrus is discussed by Battiscombe Gunn and T. Eric Peet, "Four Geometrical Problems from the Moscow Mathematical Papyrus", *Journal of Egyptian Archæology*, **15**, p. 167, Nov. 1929; and Kurt Vogel, "The Truncated Pyramid in Egyptian Mathematics", *Journal of Egyptian Archæology*, **16**, p. 242, Nov. 1930. The work of Struve is critically reviewed by T. E. Peet in the *Journal of Egyptian Archæology*, **17**, p. 154, May 1931.

Population Problems.

THE second general assembly of the International Union for the Scientific Investigation of Population Problems met in the rooms of the Royal Society of Arts on Monday, June 15, the chair being taken by the president, Prof. Raymond Pearl. Delegates of ten nationalities were present.

During the opening session the president reviewed the work of the Union during the three years of its existence, and claimed, with reason, that the progress made could be regarded as gratifying. Fourteen countries already have National Committees, which function with varying degrees of intensity, whilst in still other countries (Czechoslovakia, Greece, Poland) National Committees are in process of organisation. There are three International Research Commissions receiving funds from the Union and dealing respectively with population and food supply, differential fertility, and the vital statistics of primitive races. In addition, grants have been made to many individuals for investigations which fall outside the scope of these Commissions. Sixty-four per cent of all moneys expended is allocated to research. Nine numbers of the official bulletin have been published.

Election of officers took place, and Sir Charles Close succeeds Prof. Raymond Pearl as president of the Union.

During the morning sessions of the following three days, various modifications of the statutes and regulations shown to be desirable by the experience gained during the past three years were made. The afternoon sessions were devoted to the reading of scientific papers.

Prof. J. D. Black, chairman of the commission dealing with population and food supply, outlined a scheme which had been prepared to serve as a basis for the making of an inventory of the work already done on this particular subject and as a guide in the planning of future research. Prof. Jens Warming, of Copenhagen, discussed the trends in agricultural production in Denmark. In his country the increase of the harvest is greater than the growth of population, and if there should be a shortage of one kind or source of food (for example, grain, as was the case during the War) it is a relatively simple matter to adjust this by curtailing the amounts used for animal fodder.

Prof. P. K. Whelpton, of the Scripps Foundation, said that population increase was declining rapidly in the United States, being 9 per cent in 1930 as against 18 per cent in 1920. Consequently, the age composition had changed considerably in the last decade. The number of children under five has actually declined, while the number of persons over fifty has increased about 25 per cent. This slower growth and trend toward a nation of elders should have marked effects on economic, social, and political life, checking expansion and making for greater conservatism.

Prof. A. L. Bowley, of the London School of Economics, dealt with some economic aspects of the tendency of population in Great Britain. He showed that during the past twenty years wages have increased, especially so in the case of town labourers ; so much so that in 1929 such a man in regular work had a wage sufficient to provide the bare necessities for a family of four children under fourteen years of age. Poverty in urban districts is due, not to low wages, but to illness, age, unemployment, incapability, death, or absence of the natural bread-winner. During the same period there has been a progressive change in the constitution of the family. The falling birth-rate since 1914 has resulted in a decrease in the number of child-bearing women, a fall in the number of children, and an increase in the number of old people. With the rise of the real wage and the reduction in the number of children per family, future generations will live in an environment progressively more and more favourable for satisfactory development. Smaller families mean better housing conditions and less competition for employment.

Dr. Karl Edin, of Stockholm, reported further on his study of differential fertility among the social classes. His figures show that in this city fertility tends to rise and not to fall with increase in income. Furthermore, sterility is greater amongst the poor couples. Prof. Eugen Fischer, of the Kaiser Wilhelm Institut für Anthropologie, reported on Dr. Muckermann's studies on differential fertility of the agricultural workers and university teachers in Germany. The conclusion to be derived from this study is that a social group, selected on the basis of intellectual achievement, is incapable of maintaining its numbers. Dr. L. I. Dublin, of the Metropolitan Life Insurance Company of New York, read a paper on the outlook for the American birth-rate. He concludes that the decline of the birth-rate is universal, and results primarily from voluntary control of conception and not from reduced fertility. He assumes that the population of the United States will become stationary in the course of the next generation or two with a birth-rate of 14·28 per thousand, and that, having reached this stationary stage, it will then proceed to decline at a rate that will reduce it to one-half in 300 years, in 161 years, in 108 years, or in 80 years, according to whether or not certain variables operate.

Prof. C. B. Fawcett dealt with some factors of population density. He estimates that the total habitable land area of the world is about 50,000,000 square miles and the approximate population of the world about 2000 million. The mean density of population over all the inhabited land of the world is therefore about forty persons per square mile. The actual distribution of population over the land varies from 680 per square mile in Belgium to 2·2 in Australia. It is difficult, perhaps impossible, to enumerate all the factors causing this wide variation in local densities, but amongst the most important are the following—natural resources of the land, mineral wealth and power, geographical location. Developments in modern transport have led to a readjustment of the balance between local fertility and density of population. Products gained locally are, in the great majority of cases, not used locally, but serve to maintain the population of distant regions ; and therefore the age-old tendency for density of population to increase in proportion to fertility of the land has lost much of its strength. In some countries we even find that increase in food production locally is accompanied by a decrease in the agricultural and rural population. There is no indication that the fertile regions of the New World are likely to become the home of densely crowded peasant populations comparable to those of China. Prof. Fawcett argued that in Britain the Poor Laws during the last century and the Unemployment Insurance to-day both have had the unforeseen and undesirable result of restricting freedom in the matter of internal migration. The growth of the town-planning movement and of the consciousness of the need of a well-considered country-planning in many lands indicates the likelihood of a far greater governmental interference in the future.

Prof. J. W. Gregory spoke on some effects of current migration restrictions. During recent years there has been an almost complete suppression of immigration on the part of those countries which formerly received the bulk of European emigrants. One effect of such restriction in the United States is labour shortage, resulting in an increased internal migration of negroes and Mexicans. Higher wages and improved hygienic and social conditions tend to increase the duration of life and reduce the infantile mortality of the negro, and this, with the absence of European immigration, must raise the proportion of negroes in the population. This view was not accepted by several of the American delegates, one of whom instanced the fact that birth control clinics were now being opened and considerably used by the negro population of the Harlem district of New York.

Dr. G. W. Kosmak dealt with the position of the obstetrician in relation to certain aspects of the population problem. He expressed the opinion that certain developments in the practice of obstetrics at the present time may have a not inconsiderable effect in reducing the birth-rate; for example, the increase in operative deliveries, which result in a higher mortality, and at the same time undoubtedly produce increased sterility through infection. He pointed out that the dread of maternal mortality played its part in the encouragement of women to have recourse to birth control.

In a paper on the future of the Belgian population, Prof. Baudhuin, of the University of Louvain, concludes that the population is now approaching its maximum, which it will attain about 1940, when it will number 8,110,000; and that after this there will be a gradual decline, so that in the year 2000 it will be only 5,760,000.

Further interesting papers on this subject were presented by Mr. Lotka, Dr. Wicksell, and others, and, in the concluding sessions, papers dealing with the broader biological aspects of the population problem were presented by Mr. Elton, who dealt with the cyclical variation in the numbers of lemming, Arctic fox, and field mouse population, and by Mr. J. A. Fraser Roberts, who discussed the significance of the results of mass selection in the improvement of the breeds of domesticated animals.

The function of the Union is to discuss such matters as the above dispassionately and scientifically, and it is doing its best to carry out this duty, though somewhat hampered by want of funds. Much of the money which has hitherto been spent on the work of the Union has been presented by generous individuals and institutions in America; it is the turn of other countries to follow such a good example, especially as an excellent opportunity now offers itself. The chairman of the American National Committee, Dr. Louis I. Dublin, informed the general assembly that certain sources in the United States would be prepared to pay to the Union the sum of 5000 dollars a year, for three years, on the condition that a similar total sum was presented to the Union by individuals, or institutions, in other countries. This offer was gratefully accepted by the general assembly. Will not those who are interested help by their subscriptions to make this generous offer available? Subscriptions may be sent to the General Secretary, International Population Union, 46 Catherine Street, Westminster.

Prof. Eugen Fischer extended an invitation, which was unanimously accepted, to the Union to hold its third general assembly in Germany in 1934.

Obituary.

Mr. W. F. Denning.

As announced in Nature for June 20, the veteran astronomer, Mr. William Frederic Denning, died at Bristol, mainly as the effect of the weakness of age, on June 9 last.

Mr. Denning was world-famous, having a reputation based on careful and assiduous use of the telescope, but known more especially for his naked-eye observation of the flight of meteors and his deduction from them of radiant points that form a large part of contemporary knowledge of this byway of science.

Denning was born on Nov. 25, 1848, at Redpost, near Radstock, in Somerset. When quite a boy the aspect of the night sky had an attraction for him, and at the age of seventeen he became possessed of a $4\frac{1}{4}$-inch refracting telescope, which was followed in 1871 by a 10-inch reflector, with which his more important observations were made. At the period when Denning began his astronomical career, the medium for publications relating to the science was the *Astronomical Register*, a monthly periodical started in 1863, in which astronomers made public their views and observations; and to this Denning began to contribute in 1868, his earliest communications being on the surface of Jupiter and the appearance of its satellites, and others on the visibility of Mercury with the naked eye, which was a subject to which he gave much attention throughout his life. A letter in the issue of December 1868 on his observation of the Leonid meteors of that year is interesting as foreshadowing the main work of his life. In 1869 an organisation known as the Observing Astronomical Society was formed under the auspices of the *Register*, which numbered more than forty active members in its second year, and of this Denning was secretary and treasurer. The pages of the periodical show how well he fulfilled the duties of his office during the few years of the existence of the Society. He was president of the Liverpool Astronomical Society in 1887-88.

Denning did not become a fellow of the Royal Astronomical Society until June 1877, but he contributed several short papers to the *Monthly Notices* before that date, with Mr. Proctor, Mr. Main, or some other as sponsor—among these being notes on the visibility of Mercury as a naked-eye object in the twilight, and of the possibility of seeing Jupiter and Venus in sunshine, which he said he was frequently able to do. The majority of them, however, were records of his observation of luminous meteors, and one communicated in April 1876 is specially to be noted, for it was a determination of twenty-seven radiant points that he had determined from his own observations, and was the first of a series of such papers that he contributed during his career. Reference is made in it to similar lists of radiant points by Greg, Tupman, Herschel (Alexander), and to a committee of the British Association on luminous meteors that had published full reports for several years past—for there were many workers in this field at the time, and Schiaparelli had already put forward his views on the relation between meteor-streams and cometary orbits. It is clear that at the beginning of the nineteenth century shooting stars were considered to be of electrical origin, though aerolites found on the earth were recognised as having come from without. It was not until about 1834 that the significance of meteor radiation was recognised as indicating direction in space, and hence later came the further conclusion that meteors move in orbits around the sun.

Denning evidently determined to associate himself with the band of workers in this new branch of science, and to take his full share in the arduous duty of observing. He has described his plan of working in his paper of May 1890, this being a catalogue of 918 radiant points of shooting stars observed at Bristol:

"All the observations were made in the open air and from the garden adjoining the house. Attention was almost invariably given to the eastern sky. In mild weather I sat in a chair with the back inclined at a suitable angle; but on cold frosty nights I found it convenient to maintain a standing posture, and sometimes to pace to and fro, always however keeping the eyes directed towards the firmament in quest of meteors."

Denning's papers on meteors were many, and touch the subject at many points. Bare mention can only be made here of stationary radiants, a difficult subject depending largely on his observations as data. Almost the last of these papers was one in November 1923, which is a catalogue of 314 radiants from observations made at Bristol between the years 1912 and 1922, and, with those in three previous lists of which this is a continuation, brings the total of radiant points determined by him to nearly 1500. The number of meteors observed by him in the years specified was 6220, and of these the flights of 4008 were recorded. This paper contains some notes embodying items from his experience or his views on various meteoric subjects that make it valuable. A General Catalogue of more than 4000 radiant points determined by himself and others, compiled by him, is to be found in vol. 53 of the Memoirs of the Royal Astronomical Society.

Besides the large amount of naked-eye observing here indicated, Denning found time to use his telescope, and in this respect his success was noteworthy. The search for comets is a task requiring assiduity and patience, and he was rewarded for efforts of this kind by the discovery of five. His first was on October 4, 1881, and the comet then discovered, after being further observed by himself and others, was believed to be periodic, but was, however, not seen afterwards. Comets discovered by him in 1890, 1891, and 1892 were not periodic, whereas for the fifth, discovered in 1894, a period of 7·3 years was computed. Many nebulæ not previously known were found by him in the course of his search for comets, and the Nova in Cygnus of August 1920 is credited to him as its first observer.

It is difficult to summarise or comment on Denning's observations of Jupiter and the other planets, but they comprise many determinations of rotation period of the giant planet from observation of various spots. He gave to the world his knowledge so gained in a book, "Telescopic Work for Starlight Evenings", published in 1890; and a brochure on the planets Mercury and Venus, a reprint of chapters contributed to the *Observatory* magazine, is a valuable summary of experience. In 1895 the Valz prize of the Paris Academy was awarded to him for his meteoric work, and in 1898 Denning was the recipient of the gold medal of the Royal Astronomical Society, the grounds for the award being his meteoric observations, his cometary discoveries, and other astronomical work. He received the degree of M.Sc. from the University of Bristol in 1927 *honoris causa*. In the year 1904 he was granted a Civil List pension of £150 a year for his services to science, for he followed no profession. In his youth he had worked with his father, who was Borough Accountant of Bristol, and it is somewhat unexpected to learn that at that time he was a cricketer of skill and reputation, and that he might have been included in the eleven representing his famous county. But he preferred a secluded life that he could devote to astronomy. Though not inclined to make friends personally, he had a large list of correspondents, whom he was always ready to help with advice, and one passes from among us who lived solely for the acquisition of abstract knowledge, for which he endured much self-sacrifice and sought no personal reward.

H. P. H.

We regret to announce the following deaths:

Prof. Solon Irving Bailey, emeritus professor of astronomy in Harvard University, on June 5, aged seventy-six years.

Prof. Friedrich Becke, formerly general secretary of the Vienna Academy of Sciences, on June 18, aged seventy-six years.

Sir Hugh Bell, Bart., chairman of the council of Armstrong College, Newcastle-on-Tyne, and past-president of the Iron and Steel Institute, who occupied a prominent place in the industrial life of the north of England, on June 29, aged eighty-seven years.

Mr. E. W. Blair, senior scientific officer of the Royal Naval Cordite Factory, Holton Heath, who was killed in the explosion at the factory on June 23.

Dr. T. F. Chipp, assistant director of the Royal Botanic Gardens, Kew, on June 28.

News and Views.

In our Supplement of this week will be found the main part of Sir Richard Glazebrook's Guthrie lecture to the Physical Society of London. The lecture was founded to perpetuate the name of Frederick Guthrie, the physicist through whose action in 1873 the Society was formed. Born in Bayswater in 1833, Guthrie studied chemistry under Graham and Williamson at University College, London, and also under Bunsen at Heidelberg and Kolbe at Marburg. Returning to England, he held posts at Owens College, Manchester, and the University of Edinburgh, and from 1861 until 1867 was professor of chemistry and physics in the Royal College, Mauritius, where he had as a colleague Walter Besant, the novelist. In 1869 he became a lecturer in physics at the Royal School of Mines and the Normal School of Science, South Kensington, and this post he held until his death on Oct. 21, 1886. John Hall Gladstone (1827–1902) became the first president of the new society, and Guthrie occupied that position in 1884. Unlike Guthrie, who was a chemist first and a physicist afterwards, Sir Richard Glazebrook has devoted all his life to physics. Born in 1854, after graduating at Cambridge he became one of the first demonstrators under Maxwell in the Cavendish Laboratory, and held other posts in the University. His main work has been done in the National Physical Laboratory, of which he became the first director in 1899. During his period of office, which lasted twenty years, he saw the staff increase from three persons to more than five hundred, and under him the Laboratory came to fulfil its object, " to make the forces of science available to the nation ".

To Sir Richard Glazebrook the subject of standards has been a lifelong study, and his Guthrie lecture is a valuable and authoritative review of the ancient standards, the connexion between ancient and modern standards, and the scientific methods by which the latter are examined, compared, and reproduced. As in so many other matters, the first application of science to the question of the weights and measures of Great Britain was due to the Royal Society, while the replacement of the old French measures by the metric system was due to members of the Paris Academy of Sciences. Graham, Bird, Troughton, Kater, Baily, Sheepshanks, and Miller were among those who introduced accuracy into British standards, while the history of the metric system is connected with such famous names as those of Lagrange, Laplace, Borda, and Condorcet. Not the least interesting part of Sir Richard's lecture is that dealing with the modern methods of basing standards on the length of the seconds pendulum, the quadrant of the earth, or the wave-length of light.

The annual inspection of the National Physical Laboratory by the general board, on June 23, was made this year the occasion for the official opening of the new physics building by the president of the Royal Society, Sir Gowland Hopkins. Sir Richard Glazebrook, the first director of the Laboratory, and Sir J. J. Thomson, Master of Trinity College, Cambridge, and chairman of the research committee of the Laboratory, also took part in the ceremony. In the course of a brief sketch of the history of the laboratory since its formal opening in Bushy House in 1902 by the then Prince of Wales, Sir Richard Glazebrook referred to the early difficulties of the Royal Society in finding a suitable site for the laboratory. Sir Richard traced the development of the laboratory during the time that he was director and later, when he was succeeded by Sir Joseph Petavel; and he contrasted the space allotted to physics in the early days with that now necessary to meet the requirements of the physics department. A warm tribute was paid to the interest and insight of the many eminent men of science and engineers who have made possible the continued development of the laboratory.

Sir J. J. Thomson in a brief speech pointed out that the choice of the Bushy Park site has been more than justified, on account of the tremendous expansion which has taken place since the laboratory was first formed. Sir Joseph referred to the place of the laboratory in the general development of pure and applied science, and to its relation to university and industrial laboratories. At the conclusion of the addresses, the new building was formally declared open by Sir Gowland Hopkins, and those present were afforded an opportunity of inspecting it. The design for the new building was prepared by Mr. F. A. Llewellyn, of H.M. Office of Works. The proposed building has a frontage of 295 feet with wings of 135 feet in length, forming three sides of a rectangle. The central portion only, with a frontage of 180 feet, has been erected at present, and will be used to accommodate the heat and general physics section of the physics department, with part of the radiology and sound divisions.

On June 24, H.M. the Queen opened the Tuke Building at Bedford College for Women (University of London). The new building, the foundation-stone of which was laid by H.R.H. Princess Mary, completes a quadrangle and is dignified and stately, if rather severe in outline. The total cost of the building will probably exceed £110,000, of which a little more than three-quarters has been raised by grants and donations. Among its features are a fine lecture hall capable of seating the entire student body of the College, new laboratories for physical and inorganic chemistry, experimental psychology, and physics, besides accommodation for other departments, including philosophy and mathematics. Perhaps the most attractive feature of the new extension, for those interested in science, is the astronomical observatory, containing a seven-inch refracting equatorial by Grubb, generously presented by the Woolwich Arsenal Institution. The Department of Psychology occupies the first floor of one wing and comprises a lecture room and laboratories. The latter are well equipped with modern recording apparatus and material for studying the special senses. A pendulum tachistoscope is built into one of the walls. There is also a kodascope for the projection of films in the study of evidence and report. Special features of the new chemical laboratories are the replacement of gas heating by electrical devices—we hope that the bunsen burner, that symbol of the nineteenth century laboratory, has not vanished completely—and the arrangements for lighting and ventilation. The name of the new building commemorates the long principalship (1907–29) of Miss Margaret Tuke, who contributed so much to the success and present position of the College.

The Repton School Science Society was founded in 1866 and has had an almost unbroken existence since that date. Among the original members of the Society are numbered Prof. F. O. Bower and Sir Martin Conway, M.P., and the records of the earliest meetings are interesting in that they show that the subjects discussed have now become part of the routine science teaching in the school. The Society held a conversazione at Speech Day, June 26 and 27, which consisted of short lectures, demonstrations, and exhibits in physics, chemistry, and biology. The physics section included, among other things, a lecture on X-rays, in which members of the audience were ‘ screened ’ to show the heart beating and the bones of the arm ; there was also a lecture on the electrical gramophone, illustrated by records kindly lent by the Bell Telephone Laboratories, New York. The demonstrations included the principle of the Radiovisor burglary alarm, and a model to show the effect of coal dust on explosions in mines. There were lectures on dyes and liquid air in the chemistry section, and among the demonstrations were a set of experiments to illustrate bleaching and a group of experiments on electroplating. A notable feature of this section was a model of a petroleum refinery, lent by the British Petroleum Company. The biology section contained numerous dissections and exhibits, a micro-film of simple unicellular organisms actually taken by members of the Society, and a demonstration of blood circulating in the tail of an anæsthetised tadpole. Living chick embryos in various stages of development were also shown.

Ninety-five heads and skulls of Asiatic and American ungulates and carnivores have been selected for the British Museum (Natural History) from the collection of the late C. St. George Littledale, and form the most important addition to the collection of Asiatic ungulates since the Hume bequest came to the Museum in 1912. The Zoological Department of the Museum has purchased a specimen of the pigmy hippopotamus from the French Ivory Coast. This animal is confined to a comparatively small area of West Africa, and does not seem to extend into the great forest zone of the Congo. The New York Zoological Society has presented to the Museum a skeleton of the extinct giant tortoise of Charles Island, Galapagos. In 1832 the island was colonised, and within a short time the animals were exterminated. There was considerable doubt as to the exact species until a large number of complete skeletons, of which the present specimen is one, was discovered in a cave by Dr. C. H. Townsend in 1928. The collections brought home by Mr. Bertram Thomas from the Rub'al Khali, Arabia, are now being worked out, and a selection has been placed on exhibition in the Central Hall of the Museum. The mammals include two foxes of interest, an Arabian race of the common fox, and a fennec fox. The reptiles of the desert region are chiefly Asiatic in their relationships, whereas the affinities of those of the Qara Mountain region are with the reptiles of East and North-East Africa. The insects demonstrate very clearly the strong affinity existing between the fauna of southern Arabia and Africa. Many species have not been observed hitherto outside Africa ; there is also a marked Mediterranean element. Recent acquisitions in the Mineral Department include two small diamonds, the first found in Sierra Leone ; a piece of an unusual type of stony meteorite which was seen to fall on Nov. 25, 1930, at Karoonda, South Australia (see Nature, Mar. 14 and April 25) ; and a mass of meteoric iron weighing 125 lb., found in 1922 at Piedade do Bagre, Minas Geraes, Brazil, which is a single crystal individual.

In an interesting letter to the *Times* for June 16, the Rev. J. P. Rowland, *S.J.*, has estimated the position of the epicentre of the North Sea earthquake of June 7. From the times of the first and second phases on the Kew and Stonyhurst records, he finds the time at the origin to be 0 h. 25 m. 12 s. G.M.T. From this and the time of arrival at six British observatories, the distances of the origin from the various observatories were calculated and arcs of circles were drawn on the map with the stations and distances as centres and radii. The point in which the arcs for Kew and Stonyhurst intersect is adopted as the epicentre, namely, 53° 43·8′ N., 0° 53·2′ E. The arcs from the other stations, with the exception of Oxford, form a small triangle at distances of not more than two miles from this point. According to the *Daily Science News Bulletin* (June 8), issued by Science Service, Washington, D.C., the earthquake had but little effect on the seismographs in the United States. It was recorded at Washington and rather indefinitely at Georgetown University.

Continuous daily records of the hours of bright sunshine have been made by many of the meteorological stations in all parts of the world for many years, and these records have proved useful in various lines of scientific research. In one of the usual methods, a record is burned on a card by the solar rays concentrated by a glass sphere. Provided the instructions given with the instrument are carefully followed, this method gives fair results. Difficulties arise in interpreting the results on a day when the sun has been intermittently obscured by numerous small but dense cumulus clouds. The burned spots have to be considered collectively, and the estimate made of the total hours is only a rough approximation. In the *Canadian Journal of Research* for March 1931, Wallace A. Thomson describes a method of recording the bright sunshine by means of a photoelectric cell and an electric clock. When light of a definite intensity falls upon the photoelectric cell, the electric clock is automatically started by the action of a relay. This relay also stops the clock just as promptly when the sun disappears behind a cloud or below the horizon. It is thus only necessary to read the time on the clock at the end of each day, when the number of hours it has been running since it was last observed gives the number of hours of sunshine during that period of time. Comparative records are given of the hours of bright sunshine observed during a week at Manitoba Agricultural College by the author's cell and clock, by two types of sunshine recorder, and by personal observations by the author. It was found that the photo-cell and clock method never omitted any portion of the daily record that would not be considered questionable. On several days, the clock continued to operate until only half the sun was visible above the horizon. The other methods sometimes omitted about two hours of the record.

STRIKING progress continues to be made by the recently formed industry for canning English-grown fruits and vegetables. During the last two years, the number of firms in operation has risen from five to nearly forty, and the output has increased fourfold since 1928. The application of the National Mark Scheme in 1930 considerably stimulated the demand for English canned products, and although during this first season the scheme was applied to some half-dozen fruits and vegetables only, yet more than fifty per cent of the total output (which equalled the total imports of canned fruits other than pineapples from the rest of the Empire) was packed under the mark. Further, the high standard of quality required was well maintained. Encouraged by this success, the Ministry of Agriculture states in a recent weekly news-sheet that it is now extending the scheme to a much larger number of fruits and vegetables. Careful attention is also being paid to standardisation, particularly as regards sizes of cans, weight of fruit, and strength of syrup. Four sizes of cans will be put on the market, and two different strengths of syrup will be available. Lacquered cans, although already widely employed, will be required for red and blue fruits and for peas and beans sold under the National Mark Scheme. A large market for English canned produce is available in the Empire, particularly in South and East Africa and in India, several consignments having already been dispatched, but careful co-operation between the fruit and vegetable growers and the canner is necessary, if full advantage is to be taken of this rapidly expanding market.

THE most striking feature of the National electricity scheme in Great Britain is the grid, the common distribution mains of all the selected power stations. This makes necessary the standardisation of all systems of supply, and to effect this many difficulties have to be overcome. The principal difficulty is the standardisation of the frequency of the alternating current supplied by the various companies. The cost of this work was not over-estimated when it was put at eighteen million pounds, but it is defrayed by the Central Electricity Board in the first instance and will afterwards be recovered by a levy on the whole of the electricity supply undertakings in the country. There are three main areas affected. In central Scotland the Glasgow Corporation and the Clyde Valley Co. are changing over from 25 cycles to 50 cycles. A similar change is being made in Birmingham. The operation has to be done gradually, as provision must be made for the continued use of consumers' machinery during the change. The most difficult problem of all is the conversion of the north-east England scheme, where the greater part of an area of over five thousand square miles is supplied at a frequency of 40·8 cycles per second. A change of frequency affects every piece of rotating apparatus, from the power house to the smallest domestic motor. All electromagnetic devices are more or less affected. In making new installations it is necessary to erect machines which can work at dual frequency or, at least, which can readily be converted from one to the other. As the Electricity Board points out, this change gives an opportunity to many important industrial works of economically modernising and re-equipping their electrical machinery. Many ways of doing this are described in the *English Electric Journal* for June.

THE keen competition that is taking place for overseas traffic makes it necessary for marine engineers to keep abreast of the latest engineering developments. The expenditure of several millions on a new liner is only justified if it remain an efficient unit for at least twenty years. Too slavish an adherence to the policy of 'safety first' may lead to it being outclassed by a competing vessel. In the *Electrical Times* for June 4, A. D. Constable discusses fairly fully the case for the use of electric propulsion in a large high-speed liner. A detailed scheme is worked out, and he advocates notable innovations in marine engineering practice. At first sight a direct mechanical drive between the turbines and the propeller shaft seems more desirable than to install electric generators and motors between them, especially as the transmission losses in the case of large liners are about six per cent less for the mechanical drive. The cost of the electrical machinery is also the greater. On the other hand, the great flexibility of the electric drive, the possibility of using five propeller shafts and twin rudders, the economical working at all speeds, and the great convenience of having all the auxiliary services on board ship worked electrically, in many cases indicate that the all-electric ship is the more economical. Provided that every electrical machine and device is of the best materials and design and in accordance with the most modern specifications, the ship should run in all weathers with freedom from trouble and anxiety, and with an economy hitherto not reached in marine work. If in addition higher steam pressures were used in the boilers, a very appreciable reduction might be made in the excessive amount of space now occupied by the boilers.

THE annual report of the Director of the Imperial Institute, Lieut.-Gen. Sir William Furse, shows

(*Continued on p.* 29.)

Supplement to NATURE

No. 3218 JULY 4, 1931

Standards of Measurement: Their History and Development.*

By Sir RICHARD GLAZEBROOK, K.C.B., F.R.S.

ANCIENT STANDARDS OF LENGTH.

WHEN man became a measuring animal, he naturally took as his standards the parts of his own body. The cubit, the length of the fore-arm from the elbow joint to the tip of the middle finger, was his unit of measurement; the Egyptian hieroglyph for a cubit is a figure of the arm, and this unit was divided into spans, palms, digits, etc. There were various cubits, differing somewhat in length, and our knowledge of them has come to us in the main from Egyptian monuments. It appears probable, however, that the Egyptians obtained their cubit originally from Chaldæa, and one of the oldest standards we know of is to be found in the Louvre, where there is a bust of Gudea, a Sumerian king of about 2300 B.C. On it there is engraved a scale showing sixteen digits of the Sumerian cubit, which was divided into thirty digits.

The cubit from which it appears probable that our foot and inch have descended is generally known as the Olympic cubit, because it passed from Egypt into Greece. It was, as we shall see shortly, about 18·24 in. long and was divided into two spans, the stretch from the thumb to the little finger, of about 9 in. A span was equal to three palms, the breadth of four fingers, each being about 3 in. in length, and the palm was divided into four digits, each $\frac{3}{4}$ in., or more accurately 0·76 in. There was also the fathom of 4 cubits, 72·96 in. or 6·08 ft., the outstretch of the two arms.

At a somewhat later date another unit, the foot, equal to two-thirds of a cubit, was introduced, and this was divided into twelve thumb-nail breadths—Gk. ὄνυξ—whence came the terms uncia, ounce, inch, used for the twelfth part of the troy pound and of the foot.

I have not heard of an existing specimen of an Olympic cubit, but we can determine its length in the following manner. Herodotus tells us that "the Egyptian cubit is equal to that of Samos", that is, the cubit used in Greece, and we can obtain the length of this from the measurement of various Greek temples. The Hecatompedon of the Parthenon is a square of 100 ft. in side. This was measured in 1846 by F. C. Penrose, who gave as the length of the Greek foot 12·1610 in.; whence the cubit, being 3/2 feet, is 18·2415 in.; this was corrected later to 18·2405 in., or (say) 18·24 in.

There is another link to be obtained thus. The side of the Great Pyramid is stated to be 500 cubits in length. This has been frequently measured. Sir Henry Lyons informs me that the result obtained a few years since by Mr. J. H. Cole, of the Egyptian Survey, was 230·364 metres or 755·76 ft. Earlier measures give much the same result. Sir Flinders Petrie found the average length to be 9068·8 inches or 755·7 ft., giving for the length of the cubit, if we accept the statement that a side of the base of the Pyramid measured 500 cubits, the value of 18·14 in. This is nearly the same as the 18·24 inches found from the Greek temple, and we may perhaps accept this value as close to the truth. This foot with its division into twelve thumb-breadths (ὄνυξ) became the Greek foot.

In due course, the foot passed to Rome, becoming somewhat altered in value; the Roman mile of 5000 Roman feet is generally said to be equal to 8 Greek stadia, each of 600 ft. or 400 cubits, so that the Roman foot was equal to 24/25 of the Greek foot, or 11·67 English inches. This makes the Roman foot equal to 0·973 English feet. Direct measurement by Martin Folkes and others give as

* From the Guthrie Lecture for 1931, delivered before the Physical Society of London on May 15. I wish to express my indebtedness to many friends, and first and foremost to Sir Henry Lyons, for most of the historical apparatus shown during the lecture, to the Deputy Warden of the Standards for apparatus in his charge, then to the Director of the National Physical Laboratory and Messrs. Sears and Dye for their valued help, and to Mr. Chrislelow for his care in preparing the slides. For the part relating to ancient standards, thanks are due to Col. N. Belaiew, C.B., to Mr. Sidney Smith, of the British Museum, and to the library staff of the Royal Society, who helped in looking up the references; while I am indebted to Mr. Hope Jones, of the Synchronome Co., and to Mr. Shreeve, representing the Bell Telephone Co., for information as to time measurements.

the value 0·967 English feet, or putting it the other way round, 1 English foot = 1·03 Roman feet.

In time, Roman measures were established in Britain, but as to when and how the change from the Roman to the British foot took place we have no evidence. Various surmises are possible. It is known that the Gothic nations in the fourth and fifth centuries, established in the neighbourhood of the Crimea, used a large cubit. This became the basis of the Russian measures prior to the reign of Peter the Great, and may have travelled westward with the Goths and been brought to England by the Anglo-Saxons. But more likely it was a chance alteration. Maybe King Henry I. did fix the yard by the outstretch of his arm, and this happened to give a foot some three per cent in excess of the Roman foot.

King David of Scotland (*c.* 1150) ordained that the Scotch inch should be the mean measure of the thumbs of three men, the thumbs being measured at the root of the nail. There was a standard foot fixed in Old St. Paul's and all measures were referred to the standard, "qui insculpitur super basem columpnae in Ecclesia Sancti Pauli".

In the time of Queen Elizabeth, steps were taken to fix definite standards of measurement, but before telling of these it is desirable to refer to the history of weights.

Ancient Standards of Weight.

The standard of weight in Sumerian times was the mina, the history of which has been very fully examined by Col. Belaiew. From the mina in course of time came the talent, and the Alexandrian talent formed the basis of the Greek, Roman, and western European weights until the advent of the metric system.

The Alexandrian talent was divided by the Romans into 125 libræ, each containing 12 unciæ, so that there were 1500 ounces to the talent. The weight of the talent has been found to be 93·65 lb. avoirdupois or 655,550 grains. Thus the weight of the Roman ounce was 437 grains while the pound contained 5244 grains. This weight became current in Britain, but the pound, instead of remaining at 12 oz. was raised to 16 oz., each of 437 grains, and possibly became the basis of our avoirdupois weight, a pound of 6992 grains. Another suggestion is that the pound avoirdupois came from the Attic mina of 6945 grains.

The Saxon kings, however, had brought to England as a standard weight the marc of Cologne. Two marcs weighed 7216 grains and were divided into 16 oz. each of 451 grains. Twelve of these ounces, reckoned as weighing 450 grains each, constituted the Tower or Mint pound[1] by which the coinage was weighed. In the time of Edward III., a Tower pound of silver was coined into 240 silver pennies each weighing 22·5 grains, giving 5400 grains for the pound and 450 for the ounce.

There was another pound in ordinary use, the Troy pound. Its origin is uncertain. In France we find a Marc de Troyes of 472 grains to the ounce and it may have come from that. Another suggestion is that the word troy has no reference to the French town but rather to Troy Novant, a monkish name of London founded on the legend of Brutus. Troy weight was mentioned in the reign of Henry IV., and in the time of Henry V. goldsmiths were ordered to use "la libre de Troy" and coin 360 pennies from a pound of 5400 grains. Thus a penny weighed 22·5 grains, and an ounce 450 grains.

The troy pound became the standard for the coinage in 1527, when Henry VIII. enacted that "the pounde Towre shall be no more used, but all manner of golde and sylver shall be wayed by the pounde Troye which maketh XII. oz Troye and which excedith the pounde Towre by III. quarters of the ounce". This would make the pound troy weigh 5737·5 grains. It was afterwards defined as 5760 grains, and the ounce troy (1/12 part) as 480 grains.

Throughout this time avoirdupois weights, though not defined by statute until 1485, had been used, and from quite early days a Libra Mercatoria one-fourth greater than the Tower pound and containing therefore 6750 grains was employed.

In the time of Edward III. (1352) we read of weighings "cum ponderibus de haberdepase", and weights of this denomination existed in the time of Elizabeth. "Haberty poie" pound is mentioned in the time of Henry VII. Henry VIII. (1532) ordered that meat shall be sold by weight called Haver-du-pois.[2] The Avoirdupois pound contained 16 Roman ounces of 437 grains each—6992 to the pound.

Elizabeth by her action in 1574 introduced what has become our modern system of weights and measures. She ordered a jury to examine the standard weights and measures in use, to report on them, and to construct standards "as well of troy

[1] In 1842 a Tower pound from the Pyx Chamber was found to weigh 5404 grains.

[2] According to the "New English Dictionary", quoted by Nicolson, to whose book, "Men and Measures", I am indebted for much of this account of English weights, Averdepois is the best spelling of the name. *Aver* is an old-established English word for 'goods'.

weight as of avoirdupois ". The existing standards were found to be very erroneous, and a second jury was appointed in 1584. The result of their work was the production of 57 sets of weights, both troy and avoirdupois, which were distributed to the Exchequer and various local authorities. Some of these weights are still extant, and do not differ by more than a grain from the Imperial standard.

Either at this period or previously the weight of the avoirdupois pound was raised by 8 grains, bringing it from 6992 to 7000 grains, at which it has remained ever since. Thus the avoirdupois ounce is 437·5 grains.

The Proclamation for Weights of Dec. 16, 1587, established avoirdupois weight, and ordered that no " person shall use any Troy weight but only for weighing of bread, gold, silver, and electuaries and for no other thing ".[3] In addition, standards of length and capacity were constructed ; the standard yard of Elizabeth is continually referred to later and was an important factor in determining the length of our present standard. The work was well done, and supplied in a satisfactory manner the needs of the country for more than a hundred and fifty years.

The Pyramids and the Cubits—Egyptian Standards.

Before continuing the history of these standards, it is of interest to go back to Egyptian times and to the Pyramids, and to learn more about those standards from which ours have undoubtedly come. I have based our foot on the common or Olympic cubit of 18·24 inches, but there were many other cubits. One in particular, the Royal cubit of Egypt, is closely connected with the building of the Great Pyramid.

John Greaves, Savilian professor of astronomy at Oxford in 1643–49, became professor of geometry in Gresham College, London, in 1631, and after some visits to the Continent started on a journey to the East in 1637. After visiting Rome and Constantinople, he arrived at Alexandria in 1638, and thence " he went twice to Grand Cairo to measure the Pyramids, carrying with him a Radius of ten feet, most accurately divided into 10,000 parts, besides some other instruments for the fuller discovery of the truth ".[4]

In his " Dissertation on Cubits ", Newton sets down the dimensions given by Greaves for various parts of the Pyramid. He then argues, following Greaves, that the builder probably used a definite unit in the design of his work, and by comparing the figures endeavours to fix on that unit ; the result is shown in the following table, in which are included the dimensions of two of the principal passages and of the great central chamber, as well as the length of one side of the great Pyramid.

Table of Greaves' Measurements of the Pyramids.

Part Measured.	Dimensions in Feet.	Value of Cubit deduced.
Breadth of entrance gallery .	3·463	2 × 1·732
Breadth of main gallery .	6·870	4 × 1·718
Height of side benches in main gallery . . .	1·717	1·717
Breadth of side benches in main gallery . . .	1·717	1·717
Length of central chamber .	34·380	20 × 1·719
Breadth of central chamber.	17·190	10 × 1·719
Length of north side of base .	693	400 × 1·732

The mean value for the cubit, excluding the first and last, Newton takes as 1·719 ft. The last line of the table, as will appear shortly, is clearly erroneous ; as to the difference between the first line and the others, Newton remarks that it comes to about 1/7 in., which is " an error of no importance if we consider the much greater irregularities observed by Mr. Greaves in the best buildings of the Romans ".

As to the base measurement there is clearly some error ; the true base was covered by debris until recently and could not have been measured by Greaves.

If we take Newton's value 1·719 ft. as the outcome of Greaves' measurements in 1638–39, we obtain as the length of the Royal cubit used in the interior of the Great Pyramid, 20·628 inches. There is ample evidence that a cubit of about this size was in general use. There is one in the British Museum, another in the Liverpool Museum, and a third in Paris. Mr. Nicolson mentions others.

The cubit is found also on the outside of the Great Pyramid ; at each corner were vertical walls, used by the builder to set out the slope of the faces. Two of these are extant and are marked in cubits of this size. From this it would appear that the Royal cubit was used throughout the building. Moreover, there still exist a number of Nilometers, used in ancient times to measure the height of the Nile flood along the valley. These are marked in cubits. Several of them were measured by Sir

[3] Nicolson, " Men and Measures," p. 102.
[4] The life of Mr. John Greaves, by Thos. Birch, Sec. R.S., prefixed to the miscellaneous works of Mr. John Greaves, Professor of Astronomy in the University of Oxford. Published by Thos. Birch, F.R.S., 1737.

Henry Lyons and Dr. Borchardt when in Egypt, with the following results :

Nilometer.	No. of Cubit Lengths.	Average Cubit in Metres.
Philae I.	12	0·520
Philae II.	12	0·532
Philae III.	16	0·535
Elephantine	12	0·523
Edfu	6	0·528
Esna	9	0·532
Luxor	6	0·529

The mean of these is 0·528 metre or 20·8 inches. Other measurements have given a rather less result.

The mean value found by Mr. Cole for the length of the side of the base was 755·8 feet. If this is to contain an even number of cubits of about the length found otherwise for the Royal cubit, that number will be 440. Assuming this as the number of cubits in a side, the length of the cubit is 1·718 ft. or 20·62 in.

The following give the lengths of the four sides of the base as measured by Sir Flinders Petrie and Mr. J. H. Cole :

	Sir Flinders Petrie.	Mr. J. H. Cole.
North	755 ft. 9 in.	755 ft. 5 in.
East	755 ft. 8 in.	756 ft. 1 in.
South	755 ft. 9 in.	755 ft. 11 in.
West	755 ft. 9 in.	755 ft. 10 in.
Mean	755 ft. 8·7 in.	755 ft. 10 in.

The agreement is practically complete.

Thus we have found good cause to suppose that there were two cubits in general use—there were others besides—one 18·24 inches in length, the other 20·62 inches. It is, perhaps, natural to inquire what was the reason for this, and Col. Belaiew pointed out to me a fact of interest in this connexion.

We know if we call l and L the lengths of the two, we have

$$\frac{l}{L}=\frac{18\cdot24}{20\cdot62}=0\cdot885=\tfrac{1}{2}\sqrt{\pi} \text{ approximately.}$$

Thus $l^2=\tfrac{1}{4}\pi L^2$.

Hence the area of a square having the small cubit for a side is equal to that of a circle with the large cubit for its diameter. This may, of course, be chance or it may be that some ancient Egyptian, wishing to construct a circle of the same area as the square, found the large cubit. We know that the value 256/81 was used for π, so that $\sqrt{\pi}=16/9$.

There are other curious facts connected with the dimensions of the Great Pyramid. Its perimeter, following Mr. Cole, is $4\times755\cdot8$ or 3023·2 ft. Earlier measurements made the base 760 ft. in length and the perimeter 3040 ft. Now the mean length of a nautical—meridian—mile, the sixtieth part of a degree, is 6080 ft. Thus the perimeter of the Pyramid is very approximately half a meridian mile. Did the wise men of old know this, and were they aware that the earth is spherical and about 8000 miles in diameter ? If the perimeter of the Pyramid was 2000 Olympic cubits, then the Olympic cubit is 1/4000 of a meridian mile and the Olympic fathom—the Greek *orgia* of 4 cubits—is one sixty-thousandth of a degree.

It is all very curious ; but can we credit such knowledge to the men who designed the Pyramids ? They placed them very accurately with regard to the meridian ; the faces of the Great Pyramid are only 3′ 43″ out, while the entrance gallery was directed towards α Draconis, the Pole Star some 5000 years ago. Thales of Miletus, born 640 B.C., taught that the earth was spherical and placed it at the centre of the universe. Pythagoras, born 580 B.C., said that the sun was the centre of the planetary world and the earth one of the planets.

The Alexandrian Talent.

In connexion with the weights, equally interesting questions arise when one begins to ask, How did men in ancient days settle on their system of weighing ? Their standards of length represented, without doubt, the lengths of parts of their own bodies; their weights may well have been chosen to represent a definite quantity of some commodity in daily use —wheat or barley, the weight and length of the grain of which has been in all countries intimately connected with standards of weight and length. The kilogramme was intended to be the weight of a unit of volume of water. How far back does this idea go ? We have seen that the Alexandrian talent weighed 93·65 lb. A simple calculation shows that the weight of a Royal cubic foot of water is 2594/27·71 lb. or 93·61 lb. Is it a coincidence that the weight of the talent of Alexandria is so closely that of a Royal cubic foot of water, or is the suggestion made by Mr. Nicolson that the agreement was designed, correct ?

The Foot and the Ounce.

Here it is perhaps relevant to refer to another suggestion made by Mr. Nicolson in an endeavour to account for the difference between the Olympic and the British foot. It is that the foot was chosen so as to make a cubic foot of water weigh 1000 ounces of (at the time) 437 grains each. This will be found to be very closely the case. But I am digressing into curiosities of metrology. The weight of a cubic foot of water was investigated by the Oxford Philosophical Society in 1685. When Wren and the founders of the Royal Society moved to London, those of the members left behind at Oxford continued their meetings,[5] and at one of these, two members, Messrs. Caswell and Walker, described how they had made a hollow cube of very hard dry oak, each edge of which was very exactly one foot, with which they proposed to determine the weight of a cubic foot of water. At a later meeting they communicated their result to the Society, finding it to be 1000 oz., and their result, along with the weights found for the same volume of a number of other substances, was sent to the Royal Society and is printed in the *Philosophical Transactions*[6] along with their table of specific gravities.

This has brought us very close to what I may perhaps call the more scientific period of our subject, and we may leave the speculations, interesting though they are, that centre round the Pyramids and their architects.

The Royal Society and Weights and Measures.

We come now to more modern times, some two hundred years ago, and from that date onwards we can trace with more certainty the history of our weights and measures.

In 1742, George II. was on the throne; the Royal Society had been founded for nearly eighty years and its fellows were actively engaged in the pursuit of natural knowledge; the importance of exact measurement was becoming more fully recognised. Vol. 42 of the *Transactions* for 1742–43 contains the account of various comparisons of weights and measures. In it is also described the laying down of 3 ft. on a brass bar belonging to the Royal Society from a scale at the Tower.

Owing mainly to the action of Graham, sundry comparisons with French and other measures were made, and with this object he had two yard measures and two pound weights carefully made and examined. One of each of these was sent to Paris by the Society and, at the request of the French men of science, were compared with the French standards by M. du Fay and the Abbé Nollet. This seems to have led to the suggestion that a formal comparison of the existing standards of length and weight was desirable, and a committee, under the chairmanship of Lord Macclesfield, undertook the task and reported on June 16, 1743.

[5] Their Minute Book is now at the Royal Society, and from it these notes are taken.
[6] *Phil. Trans.*, No. 169, p. 926, Mar. 23, 1685.

Among the standards compared were those included in the following table:

Comparisons of Yards with the Exchequer Standard of Elizabeth.

Royal Society yard	+ 0·0075 in.
Henry VII. yard	− 0·0071 in.
Guildhall yard	+ 0·0434 to 0·0396 in.
Clockworkers' yard	− 0·021 in.
Tower yard	+ 0·011 in.

The committee also examined a series of weights from the Exchequer and elsewhere.

From the time of Edward I., the troy pound is defined as containing 12 troy ounces each of twenty pennyweight; but no standard troy pound was found; 12 ounces taken from a box containing 256 ounce weights were therefore selected as representing the pound troy.

There was, however, a series of avoirdupois weights, from 1 lb. to 14 lb., marked Elizabeth Regina 1582, and a 7 lb. wt. VI. Ed. 1588. Various comparisons led to the following results for the lb. and oz. avoirdupois in grains:

Pound . . .	6998	7000·7	7000·2
Ounce . . .	437·4	437·54	437·51

Of the weights in the possession of the Royal Society, the avoirdupois pound was lighter than the standard by one grain, and the troy pound lighter by half a grain. This constitutes the earliest systematic comparison of our weights and measures that I have found.

It was realised that the length of the standards varied with temperature, but it was held that since all were of much the same material the differences would not be affected.

Two standard bars were made by Bird in 1758 and 1760 respectively for a committee appointed by the House of Commons under the chairmanship of Lord Carysfort. These were to be copies of the Royal Society standard as laid down by Graham, 1742–43. One, marked Standard Yard 1758, was presented to the House as the legal standard of length. Both were compared in 1768 with the Royal Society standard, while in 1785 a scale made for General Roy's measurement of an arc of the meridian on Hounslow Heath was graduated in terms of the same standard. Bills were presented to the House of Commons in 1765 to give effect to the recommendations of this and of a subsequent committee, but from some accident they did not become law and the country remained without legal standards for the next sixty years.

The modern method, employing micrometer microscopes, was used for the first time by Troughton in his comparison of a line standard constructed in 1792 for Sir George Shuckburgh. In 1814 a report was presented to the House of Commons by a new committee which asked Dr. Hyde Wollaston and Prof. Playfair for advice. They stated that the length of the pendulum vibrating seconds had been found to be 39·13047 in. and that the metre of platina measured, at the temperature of 55°, 39·3828 English inches, representing at 32° the ten-millionth part of the quadrant of the meridian. They recommended, upon the suggestion of Dr. Wollaston, "that a gallon containing ten pounds of pure water should be adopted as a substitute for the ale and corn gallons".

In 1816 there still remained considerable doubt both as to the length of the seconds pendulum and the relation of the metre to the inch; the Astronomer Royal, Dr. Pond, was instructed by Parliament to make the measurements necessary to remove the doubt. He asked for the assistance of the Royal Society, and a committee was appointed for the purpose.

A number of experiments were made by various methods (Capt. Kater's pendulum work is described in the *Phil. Trans.* for 1826, 1830, and 1831), and in 1818 a Commission was appointed, under writ of the Privy Seal, "to discuss the matter more minutely than could be done with convenience before a Committee of either House of Parliament".

The report of this Commission drawn up by Dr. Young is of great interest; and as a result a Bill giving effect to their conclusions was brought into the House of Commons by Sir George Clerk in 1822, and again, with a few amendments, in 1823. This was nearly identical with an Act passed on June 17, 1824, which came into force on Jan. 1, 1826.

The Commissioners ultimately recommended for the legal determination of the standard yard Bird's standard of 1760. It was found to agree very closely with Sir George Shuckburgh's yard, with which the length of the pendulum and the metre had been compared, and a facsimile of which was known to exist at Geneva, and the Act enacted "that the straight line or distance between the centre of the two points in the gold studs in the straight brass rod now in the custody of the Clerk to the House of Commons whereon the words and figures Standard Yard 1760 are engraved shall be and the same is hereby declared to be the original and genuine standard of that measure of length or linear dimension called a yard". The distance when the rod was at a temperature of 62° Fah. was denominated the Imperial Standard Yard, and all other measures of extension were to be multiples or sub-multiples of this standard.

For the standard of weight the Commissioners recommended in 1823: "That the Standard brass weight of one pound Troy weight in the year 1758 now in the custody of the Clerk of the House of Commons shall be, and the same is hereby declared to be the original and genuine standard of weight; and that such brass weight shall be and is hereby denominated the Imperial Standard Troy Pound". This troy pound was declared to contain 5760 grains, "and 7000 such grains shall be and are hereby declared to be a pound Avoirdupois".

For the recovery of the standards if lost, destroyed, defaced, or otherwise injured, suitable provision was made in the Act; the yard was to be recovered from the length of the seconds pendulum, which when vibrating in a vacuum at sea level in the latitude of London was stated to be 39·1393 in., while it was held that the pound could be reconstructed from the fact that a cubic inch of distilled water weighed by brass weights in a vacuum at a temperature of 62° had been found to weigh 252·724 grains.

The Modern Standards.

The need for reconstruction came all too soon. In 1834 the Houses of Parliament were destroyed by fire; the pound standard was lost entirely, the yard standard was damaged, one of the gold plugs having been melted so that its centre point could no longer be determined with accuracy.

In 1838 the Chancellor of the Exchequer, the Right Hon. T. Spring Rice, set up a Commission to advise as to the steps necessary to replace the standards.

Meanwhile, since 1824 a number of criticisms of the means suggested for recovering the standards had been made. Certain of the corrections employed by Kater in determining the length of the seconds pendulum were shown to be in error; while the agreement among the various determinations of the weight of a cubic inch of water left the true value in doubt, and the committee of 1838, accepting these criticisms, threw over the methods provided in the Act of 1824 and advised, with regard to the pound, that it should be recovered by comparison with copies which were known to exist and that the pound avoirdupois should be the standard. As to the yard, it was stated that "Several measures now exist which were most accurately compared with the Standard yard . . . and by the use of these the values of the original standards can be respectively restored without sensible error". The committee, therefore, recommended a material standard, "the distance between two points or lines engraved on metal, but that the standard be in no way defined by reference to any natural basis, such as the length of a degree of a meridian on the earth's surface in an assigned latitude or the length of a pendulum vibrating seconds in a given place ".

The Government approved this recommendation and appointed a scientific committee in 1843 to reconstruct new Parliamentary standards of length and weight.

The Pound.

Prof. Miller was entrusted with the construction of the pound, Mr. Baily with that of the yard. Prof. Miller has described his work very fully in a Royal Society paper.[7] The standard weight of 1824, made of platinum, was known as *U*. It had been compared in 1824–25 by Capt. Kater with five gun-metal standards deposited at the Exchequer, the Royal Mint, and with the civic authorities in London, Edinburgh, and Dublin.

In 1829, *U* had been compared by Capt. V. Nehus with a platinum pound (*R.S.*) belonging to the Royal Society, and also with two brass pounds and a platinum pound (*Sp.*) in the custody of Prof. Schumacher. These weights, with a number of gun-metal copies, were available for the construction of the new pound. The comparison showed considerable discrepancies in the values of the gun-metal and brass weights, and in the end it was resolved, " with the consent of the Astronomer Royal, to rest for the evidence of the weight of the lost Standard entirely on the comparisons of the two platinum Standards *Sp.* and *R.S.*"

As the result of this work, and the corresponding work on the yard, our present standards came into existence, and the Weights and Measures Act of 1855 prescribes that :

" Whereas by Act of the Fifth Year of King George IV. a standard brass weight of one pound troy, made in the year 1758, then in the custody of the Clerk of the House of Commons, should be the genuine standard of weight, and whereas there exist weights which had been accurately compared with the said Standard Pound Troy which afforded sufficient means for restoring such original Standard:

" The said weight of Platinum marked P.S. 1844 1 lb. deposited in the Office of the Exchequer as aforesaid shall be and be denominated the Imperial Standard Pound Avoirdupois. The one 7000th part of this shall be a grain and 5760 such grains shall be a Pound Troy."

Provision is made in the Act for recovery of the standard if lost by comparison with copies made and distributed among various authorities. Thus the pound avoirdupois became our standard of weight, and the pound troy followed in the path of the King's Tower pound.

The Yard.

Mr. Baily, at the request of the committee, undertook the reconstruction of the yard. The account[8] of the work is given by Sir George Airy as chairman in a paper in the *Philosophical Transactions* of the Royal Society.

In addition to the damaged standard, the following were available for comparison : a scale, No. 46, belonging to the Royal Society, a scale belonging to the Royal Astronomical Society, two three-foot bars of the Ordnance Society. There was also the Shuckburgh scale of 1792, but on account of certain imperfections little importance was attached to it.

The standard was to be of bell metal or steel, a rectangular bar of about 1 in. square in section, with the ends notched away to half the thickness. The marks defining the length were to be on plugs inserted flush with the surface, and the standard was to be correct at 61° or 62° F. The ends were cut away in order that the marks might be in the median plane of the bar and the effect of flexure when supported at two points minimised. For the standard finally settled on, an alloy, since known as Baily's metal, consisting of copper 16 parts, tin $2\frac{1}{2}$ parts, and zinc 1 part, was used.

Faraday was consulted somewhat later as to the stability of such an alloy, and wrote : " I do not see why a pure metal should be particularly free from internal changes. . . . I suppose the labour would be too great to lay down the standard on different metals and substances, and yet the comparison of these might be very important hereafter, for twenty years do seem to do or tell a great deal in relation to standard measures."

Baily also introduced the method of drilling a hole in the bar down to the median section, and fixing the plug with the mark at the bottom of this instead of notching the end as Kater had done. His work was cut short by his death in August 1844.

At this stage, Sheepshanks offered to take Baily's place, and the question immediately before the committee was whether to attempt to restore the damaged legal standard or to construct a standard from the available material. It was plain that in

[7] On the Construction of the New Imperial Standard Pound by Prof. W. H. Miller, *Phil. Trans.*, 1856.

[8] Account of the Construction of the New National Standard of Length by G. B. Airy, Esq., Astronomer Royal, *Phil. Trans.*, 1857.

the strictly legal or scientific sense the restoration of the standard must be indefinite and the latter plan was approved. Sheepshanks suggested that the necessary apparatus for his comparisons should be set up in the cellar of Somerset House, and made a report on the questions involved, the stability of the material, the thermometric difficulties, etc., as well as on the method he proposed to adopt.

A meeting of the committee was held on June 4, 1847, to inspect these arrangements, and the minutes record that—

" The Committee approve entirely of the course followed by Mr. Sheepshanks and request Mr. Airy to take measures for the exam^{n} and discharge of the instrument makers accounts."

Airy's paper already referred to gives very full details of the construction of the standards; it also contains his investigation of the effect of flexure and the determination of best points of support.

Ultimately, six standards of Baily's metal were constructed which were found to have the length of 1 yard at the temperatures indicated below :

No. 1.	. . .	Correct at 62° F.
2.	. . .	,, ,, 61·94 F.
2.	. . .	,, ,, 62·10 F.
4.	. . .	,, ,, 61·98 F.
5.	. . .	,, ,, 62·16 F.
6.	. . .	,, ,, 62·0 F.

Of these, it was arranged that No. 1 should become the standard yard, while 2, 3, 4, and 5 should be known as Parliamentary copies, and No. 6 should be retained by some officer of the Government for the comparison of other standard bars or for other scientific purposes.

Sheepshanks was taken ill while actually engaged in his comparisons ; he died the day before Royal Assent was given in 1855 to the Act establishing the new measures. Thus as a result of the death of the two men who had done most of the work, the Royal Society paper in which an account of it is to be found was written by Airy. The Act (July 30, 1855) provides that :

" The straight Line or Distance between the Centres of the two Gold Plugs in the Bronze Bar deposited in the Office of the Exchequer as aforesaid shall be the genuine standard of that Measure of Length called a Yard and the said straight Line or Distance between the Centres of the said Gold Plugs or Pins in the said Bronze Bar (the Bronze being at a temperature of Sixty two Degrees by Fahrenheit's Thermometer) shall and be deemed to be the Imperial Standard Yard."

Thirty-seven copies were made and distributed. Such were the conclusions enacted in the Weights and Measures Act of 1855, and they have remained unaltered up to the present time.

Since that date there have been various supplementary or consolidating Acts. In 1864 the Metric Weights and Measures Act was passed. It provided that " No contract . . . shall be deemed to be invalid or open to objection . . . on the ground that the Weights and Measures expressed . . . are Weights or Measures of the Metric System ", and it gives a schedule of tables of metric measures expressed by means of legalised denominations of weights and measures in Great Britain, thus legalising the metric system but not providing any metric standards for purposes of comparison and verification.

In 1866 the custody of the Imperial standards of length and weight and of all secondary standards was transferred by Act of Parliament to the Board of Trade. Parliamentary copies of the yard and pound were placed at the Royal Mint, with the Royal Society, and at the Royal Observatory, Greenwich, and it became the duty of the Board to cause these to be compared every ten years with the standards in their charge. For this and other purposes connected with standards, the Board was to constitute a department to be called the Standards Office, and " shall appoint as Head of that Department an Officer to be called the Warden of the Standards ", with assistants, clerks, etc., and the Act lays down the duty of the Warden.

The procedure was modified by an Act of 1878 which provided that the Board of Trade shall discharge the duties previously assigned to the Warden.

This Act also gives a schedule of metric equivalents and a list of metric standards in the custody of the Board, and provides (par. 38) : " Whereas the Board of Trade have obtained accurate copies of the Metric Standards and it is expedient to make provision for the verification of Metric Weights, the Board of Trade may, if they think fit, cause to be compared with the metric standards in their custody all metric weights and measures submitted for the purpose ".

A Metric Convention (Convention du Mètre) had been agreed to among a large number of nations in 1875. To this, Great Britain adhered in 1884, and comparisons between the metric and British measures were set on foot. In 1889 certified copies of the metre and kilogramme were deposited at the Board of Trade.

As a result of the comparisons carried out with great care by Mr. Chaney on behalf of the Board of Trade and M. Benôit of the Bureau des Poids et

Mesures, the value 1 metre, 39·370113 inches became the legal equivalent under an Act of 1897.

This gave to the Queen in Council power to make a table of metric equivalents in substitution for the table in the schedule to the Act of 1878 and provided that the Board of Trade standards, which may be made under par. (8) of the Act of 1878, shall include standards from the Metre No. 16 and the Kilogramme No. 18 deposited with the Board of Trade.

Under the provisions of this Act a table of metric equivalents was issued in 1898 according to which

1 metre = 39·370113 in.
1 kilogramme = 2·2046223 lb.

The most recent comparison of the yard and metre is that made at the National Physical Laboratory in 1927, which leads to the result that

1 metre = 39·370147 in.
1 inch = 25·399956 mm.

Here, perhaps, a reference to the Metric Convention is desirable. An International Metric Commission was convened at Paris in 1872 to consider the question of the construction and issue of metric standards of weight and measure. A committee was appointed to make the necessary preliminary investigations, and as the result a convention was agreed to on May 20, 1875, by a large number of States. Great Britain adhered to the Convention in 1884. The Convention provided that the contracting parties should set up at Sèvres an International Bureau of Weights and Measures at which the International prototypes of the kilogramme and metre were to be kept.

For the control of the Bureau an International Committee of weights and measures was established, consisting of fourteen members belonging to different countries. This committee was placed under the authority of a general Conference of weights and measures formed of delegates from all countries adhering to the Convention, which meets whenever convoked by the International Committee and in any case once in every six years.

Inter-Dominion Standards.

Before leaving this part of our subject—the present position of our national standards—a brief reference should be made to the Conference on Standardisation [9] held at the Board of Trade in October 1930 under the chairmanship of Mr. W. R. Smith, M.P., Parliamentary Secretary to the Board. The Conference was attended by representatives of Great Britain and Northern Ireland, the Dominions of Canada, Australia, New Zealand, the Union of South Africa, the Irish Free State, and India.

The work of the Conference was divided into two parts relating respectively to fundamental standards and to industrial standardisation. Sir Joseph Petavel acted as chairman of the section dealing with fundamental standards. The Imperial Conference held at the same time accepted the Report of the Conference on Standardisation and adopted the resolutions submitted therewith.

These resolutions, so far as they deal with fundamental standards, were:

(1) That it is desirable that there should be uniformity between the standards employed for all units of measurement which are in common use among the British Commonwealth of Nations.

(2) In order to secure uniformity arrangements should be made: (*a*) To provide in each Dominion and in India suitable reference standards for each unit of measurement required for use in that country where not already available; and (*b*) to introduce suitable procedure whereby all such standards shall be periodically compared with the corresponding standards at the Board of Trade or at the National Physical Laboratory.

(3) At least one member of the Commonwealth should undertake research work with the object of enabling the fundamental standards to be referred ultimately to natural standards such as the wavelength of light. It would be a great advantage if it were possible for research work of this character to be carried out independently by more than one member.

The Report of the Fundamental Standards Committee defines the fundamental standards both on the British system and on the metric system which constitute the fundamental units of measurement legal for use throughout the British Commonwealth of Nations. It is noted that in India the railway system of weights in common use is defined in terms of the pound.

It is explained that the term "reference standard" is used to denote a standard of suitable form and construction preserved under suitable conditions to serve as the basis of reference for the determination of any unit of measurement within one of the Dominions or of India.

In accordance with the recommendation of the Report, the errors, if any, of such reference standards in relation to the fundamental standards or to the theoretical definitions of the units they represent are to be ascertained from time to time by comparison with the corresponding standards in use in the United Kingdom, and are to be allowed for in the use of the reference standards.

The Report concludes with a list of the principal units for which reference standards are likely to be required, with suggested procedure in regard to each. Thus a simple and definite system has been

[9] Report of the Conference on Standardisation (including Resolutions adopted by the Imperial Conference). Presented to Parliament by command of His Majesty, Nov. 1930. Cmd. 3716. 1930.

set up by the Imperial Conference of 1930 for securing uniformity of standards throughout Great Britain, the Dominions, and India.

Standards of Time and Electrical Standards.

In addition to this account of the development of standards of length and mass, Sir Richard Glazebrook dealt briefly with time. After noting that the measurement of time rested on astronomical observations and referring to various ancient means of indicating its passage, he described in some detail the clock recently developed by Mr. Shortt in association with the Synchronome Company and the crystal vibrator constructed by Mr. Marrison, of the Bell Telephone Company, referring in connexion with these to Mr. Loomis' paper read recently before the Royal Astronomical Society. In this connexion he mentioned work now in progress at the National Physical Laboratory.

As to electrical standards, Sir Richard recalled the fact that these had been dealt with very fully up to the year 1913 in his Kelvin Lecture before the Institution of Electrical Engineers, and he restated briefly some of the principal conclusions of that lecture. Coming to more recent times, he quoted the important resolution of the International Committee of Weights and Measures of Oct. 4, 1927, approving the organisation of a Consultative Committee for Electricity to advise the International Committee of Weights and Measures on questions relating to systems of measurement of electrical standards, and, after discussing the difference between the material standards of length and mass and electrical standards for which no permanent material standards can exist, he explained the plan approved by the Committee for their work.

It is not possible to equip the Bureau with invariable material standards against which national standards can be compared. Recourse must be had to experimental determinations of the fundamental electrical units in terms of the units of length, mass, and time. The national and other laboratories of several countries are already equipped for such work, and the staffs have considerable experience. It has been agreed, therefore, to leave all such work to these laboratories, and arrangements have been made with this object; the national laboratories will from time to time send the results of their work to Sèvres. Meanwhile, the International Bureau will organise the systematic exchange of standards (étalons) and secure the co-ordination (assurer la synthèse) of the results of comparisons made by the national laboratories, and will set up a collection of working and reference standards together with the laboratory equipment for the comparison with these of the material standards sent by various countries for exact determination.

In this way, while the experimental work of realising the material standards from the electrical units of the C.G.S. system will rest with the national laboratories, the International Committee will have the responsibility of fixing and promulgating the values to be employed for practical standards, and of fixing the date of any fresh revision.

As to the values of the present international units, Dr. Dye has prepared the following table :

Values of International Units (1831) in Terms of C.G.S. Units.

International ohm .	$(1{\cdot}00051 \pm 0{\cdot}00002)\ 10^9$
,, ampere .	$(1 - 0{\cdot}00006 \pm 0{\cdot}00006)\ 10^1$
,, volt .	$(1{\cdot}00045 \pm 0{\cdot}00008)\ 10^8$
,, watt .	$(1{\cdot}00039 \pm 0{\cdot}00014)\ 10^7$
E.M.F. of Weston Normal Cell at 20° C. . .	$1{\cdot}01876 \times 10^8$ C.G.S. units.

Natural and Arbitrary Standards.

If we look back over the history of the past, we may note some interesting changes in the views of scientific men as to the bases on which to rest their standards of measurement.

It is obvious that weights and measures began with some natural objects selected for their convenience and sufficiently constant in quantity for the simple needs of the times. Such were the length of a man's forearm or the weight of corn—possibly of water—contained in a vessel approximately constant in volume.

In time, uniformity became more important, and so we pass from the length of the king's arm to the scale engraved on the wall or floor of the cathedral, and from the weight of so many grains of wheat taken from the middle of the ear to the mass of a lump of metal.

The jury of Queen Elizabeth's time, to which we owe our modern system, paid little attention, it is probable, to the origin of the yard or the pound ; they fixed on the length of a metal bar and the weight of a lump of iron and prescribed that these were to be the standards, trusting to the permanence of these material objects rather than to any natural laws which might serve for their definition. They were, no doubt, severely practical ; a change came in England in the early days of the Royal Society, when we find Caswell and Walker endeavouring to connect the weight and volume of a quantity of water and thus establish a natural standard of weight in terms of the standard of length—trying possibly to repeat what had been done in Egypt long ago.

Then, some fifty years later, Graham, realising that there was a definite relation between the period of a body in oscillation, its dimensions, and the distribution of its mass, endeavoured to connect the period of a seconds pendulum with its length, and set about the comparison of existing material standards, to find one in terms of which to express the length of the pendulum, thus leading to the Report of Lord Macclesfield's Committee in 1743.

Inter-comparisons between existing standards continued to be made, and the idea of basing that of length on the seconds pendulum increased in favour, until in 1814 the House of Commons asked for a formal statement of the length, and two years later the Astronomer Royal was instructed to determine it. Kater's work followed, with the result that, while in 1824 certain material standards—Bird's bar of 1760 and a brass weight of 1 lb. troy dated 1758—were made the legal standards, they were to be recovered, if lost, by reference to natural standards, the length of the seconds pendulum and the weight of a cubic inch of water.

This recourse to natural standards did not last long. Scientific men discovered that it was simpler to compare a standard with its copies, and to recover its value, if lost, by the aid of those copies, than to determine the length of the seconds pendulum or the mass of a cubic inch of water, and so, in 1843, the recommendations of 1824 were thrown over; the scientific committee, appointed to advise, recommended that the standards which had been lost in the fire of 1834 should be recovered from their copies, "and that the Standard be in no way defined by reference to any natural basis". More trust could be placed in the permanence of a material standard and on the accuracy with which it could be recovered by the inter-comparison of its copies, than on the result of any attempt to reconstruct it, based on some natural law; and so it has remained up to the present.

In France the history has been the same. The Constituent Assembly entrusted the Academy of Sciences with the duty of introducing a new system of measures, and in 1788 a report was issued on the choice of a unit of measure drawn up by Borda, Lagrange, Laplace, Monge, and Condorcet.

The report discussed the advantages of employing either the length of the seconds pendulum or that of a meridian of the earth as the basis of length measurement, and decided in favour of the latter, which, in the words of Laplace, "appears to be of very high antiquity". So the metric system came into being. Delambre and Mechain measured the length of an arc from Dunkirk to Barcelona, and hence calculated the length of the quadrant as 5,130,740 of a certain iron Toise, when at a temperature of 61·5° F. The metre was fixed as one ten-millionth of this length, and a standard metre constructed to represent it, while the kilogramme was to be the mass of a cubic decimetre of water at the temperature of its maximum density, and a platinum weight was constructed with great care to have this mass when weighed *in vacuo*.

While these material standards continue to exist, research has shown that they no longer represent the definitions. The metre is still the distance between the marks on a certain bar of platinum iridium, but the earth's quadrant is not 10^7 of these metres, while different meridians differ in length; the earth is not a spheroid. The best mean figure obtainable seems to be 1 meridianal earth quadrant =10,002,090 m.

The platinum mass, known as the Kilogramme des Archives, is still the standard kilogramme, but the mass of a cubic decimetre of water, at 4° C. approximately, has been found to be 999·972 grammes; or alternately 1000·028 c.c. is the volume of a kilogramme of water at the temperature of its maximum density and under normal atmospheric pressure.

Neither the seconds pendulum nor a quadrant of the earth has proved to be more satisfactory than the material standard. This was the case when Michelson in 1889, realising that the wave-length of light of a given frequency was invariable, suggested its use as an ultimate standard of length. There was the difficulty of stepping from so small a unit as a wave-length of light up to the metre, but he pointed out that one can bridge over the distance by using a number of standards each approximately, but not quite, double the distance of the last, employing interference methods to determine the difference between the length of the larger standard and twice that of the smaller. Light directed so as to traverse the smaller distance twice was made to interfere with light which has only once traversed the longer distance. Michelson had an opportunity of carrying this idea into practice somewhat later at the Bureau des Poids et Mesures at Sèvres, and found from observations on the red line of cadmium that its wave-length is given by

$$\lambda_R = 0{\cdot}64384722 \times 10^{-6} \text{ metre.}$$

Somewhat later, in 1913, Messrs. Benoit, Fabry and Perot at the Bureau International repeated the measurement, using a modification of the method, and found

$$\lambda_R = 0{\cdot}64384704 \times 10^{-6} \text{ metre.}$$

Since that date measurements have been made in Japan by Messrs. Watambe and Timaszumi, leading to the value

$$\lambda_R = 0{\cdot}64384685 \times 10^{-6} \text{ metre,}$$

while Dr. Tutton communicated to the Royal Society on April 30 last his results, which gave

$$\lambda_R = 0{\cdot}64384698 \times 10^{-6} \text{ metre.}$$

A provisional value found at the National Physical Laboratory is

$$\lambda_R = 0{\cdot}64384714 \times 10^{-6} \text{ metre.}$$

At its meeting in 1925 the International Committee of Weights and Measures agreed in principle to define the unit of length by means of the wave-length of light, subject to the determination by the national laboratories of the most satisfactory method of realisation.

As a result, work has been in progress at the National Physical Laboratory for some time, and now is approaching conclusion, while work is also in progress at the Reichsanstalt and the U.S. Bureau of Standards.

Thus it will be seen that the International Committee is prepared to refer the standard metre to a natural standard against which it can be compared. This natural standard will thus be represented by the distance between two marks on a bar of platinum-iridium, and the constancy of this distance will be checked from time to time by comparison with the wave-length of light of definite period.

Hence there is a prospect that a natural standard of length will in time be generally accepted.

As to a standard of mass, up to the present it is not probable that the kilogramme, the mass of a lump of platinum, will be disturbed until we reach the condition when the mass of an atom of hydrogen or (say) an electron can be determined with sufficient accuracy. For a time unit, we already have a natural standard in the sidereal day, and while the frequency of a quartz or other oscillator will certainly be used for comparatively short intervals, it will not replace the day and hour for longer periods.

In electrical standards also a transference to natural standards is taking place. One of the first duties of the Comité Consultatif d'Électricité set up in 1927, as has been stated, is to determine the units in terms of which electromotive force, current, and resistance are to be measured. At present, while the units are defined in terms of the C.G.S. units of length, mass, and time, the standards used in daily work are the International Ohm, Ampere, and Volt. The definitions of these, as has already been explained, were agreed to at the International Conference in London in 1908.

The appliances needed for an absolute determination of the electrical units are elaborate and expensive. At the time of the London Conference it was realised that the necessary measurements could be made only in a few well-equipped standardising laboratories, while it was felt that the standards for daily use should be such as could be set up without serious difficulty in any laboratory provided with ordinary measuring and weighing apparatus of adequate precision. Hence the adoption of International Standards.

The arrangements proposed at Sèvres by the Comité Consultatif d'Électricité have altered this. When these are complete, any country can have its electrical standards compared against standards maintained at the Bureau, while by the collaboration of countries possessing laboratories, equipped for absolute measurements, these standards can be realised and maintained in much closer agreement with the C.G.S. units than is now the case with the International Ohm, Volt, and Ampere.

Since 1928, and indeed previously to that date, work has been in progress at the National Physical Laboratory in connexion with all the units.

The Ampere balance has been reconstituted; work has been put in hand on a novel method of measuring a resistance suggested some years since by Albert Campbell; preparations are going forward for further measurements with the Viriamu Jones Memorial Lorenz apparatus, and for a re-determination of the electromotive force of a Weston cell.

At the second meeting of the Comité Consultatif d'Électricité in 1930, reports as to progress were received from the National Physical Laboratory, the U.S. Bureau of Standards, the Central Chamber of Weights and Measures of Russia, and the Electrotechnical Laboratory of Tokyo.

While, of course, it will be necessary to have at Sèvres material standards or apparatus embodying the results of these various absolute measurements, the standards and apparatus will represent, with all the accuracy possible, multiples of the C.G.S. units themselves, and not standards adopted because, at the time they were defined, they were believed to represent the theoretical units to the highest accuracy then possible.

Thus in electricity we go back through the C.G.S. units to the natural standards of length and time, the wave-length of the red line of cadmium and the sidereal second.

Printed in Great Britain by R. & R. CLARK, LIMITED, *Edinburgh.*

evidence of a large increase in public interest in the Exhibition Galleries in the Institute, the attendance during the year being 608,900, as compared with 398,000 in 1929. The more important work of the Institute, however, in advising as to the utilisation of the resources of raw materials in the British Empire and in promoting the production within the Empire of crops and products which at present are mainly obtained elsewhere, is still hampered by lack of funds. The Research Committee of the Imperial Conference, which met in London in 1930, investigated the Intelligence and Investigation Departments, which are mainly concerned with this vital but less publicly known work of the Institute, and recorded its opinion that this work could be carried out more efficiently and less expensively through the utilisation of the services of the Imperial Institute than in any other manner. During the present Empire-wide depression, no further Government funds are available to extend the Institute's work, but in March 1931 the Secretary of State for the Dominions was able to announce that Mr. Benjamin Drage had contributed £36,000 to the Empire Marketing Fund with the proviso that the sum, to be spread over a period of seven years, should be used to augment the income of the Imperial Institute. The Institute not only advises the Colonies and Dominions upon mineral resources ; it is also busy trying to develop the production of commodities like tung oil, pyrethrum flowers, and so on within the British Empire, and is able to report that the London County Council has approved five Empire woods as fire-resisting timbers. The perusal of the Director's brief report will show how wide-flung are its activities.

Mr. J. Milton Offord has contributed to the March *Journal* of the Quekett Microscopical Club some interesting recollections of his association with the Club since 1878. At the meeting in January 1879, at which he was elected a member of the Club, Huxley was in the chair and E. T. Newton showed a model of the brain of the cockroach, constructed from slices of wood of appropriate thickness representing the successive serial microscopic sections of the brain. The outlines of the section had been drawn on the slices with the help of a camera lucida and cut out by a fret-saw. These prepared slices when fitted together formed the model—one of the early examples of a method which, after modifications, was, especially in the next twenty years, and still is, regularly employed in many laboratories. Mr. Offord refers to the large conversaziones which were a feature of the society's activities, and directs attention to one held in University College, London, in 1879, at which there were 185 microscopes, and 1050 persons were present. This was regarded as a small attendance for a conversazione and " was put down to the inclement weather, and it being held during Lent ".

On June 27, Prof. G. M. Trevelyan, O.M., representing the National Trust, accepted the deeds of the property of the Longshaw estate for the Trust. This estate is 750 acres in extent, and is the first acquisition made by the National Trust in the Peak district of Derbyshire. It is a beautiful stretch of high woodland and moorland, surrounded by picturesque heights. When it was offered for sale, a sum of £15,000 was asked for the complete estate, and, since it was threatened to be disposed of as building sites, the Sheffield Council of Social Service and the Sheffield and Peak District branch of the Council for the Preservation of Rural England took steps to save the estate. £11,000 came from the city and neighbourhood of Sheffield and £3580 from other parts of the country, chiefly through the National Trust. The deeds of the estate were handed over to Prof. Trevelyan by Mrs. Gallimore, honorary secretary of the Longshaw committee.

On June 24 the Royal Society of Tropical Medicine and Hygiene moved its offices from Chandos Street to Manson House, 26 Portland Place, which has been secured as its permanent home and as a memorial to the late Sir Patrick Manson. With the help of Joseph Chamberlain, then Colonial Secretary, Manson founded the London School of Tropical Medicine in 1897 ; other countries followed suit and similar institutes have been set up in Hamburg, Amsterdam, Paris, and other centres. It was soon realised that this new knowledge should be co-ordinated, and in 1907 Sir James Cantlie, Dr. Carmichael Low, and others founded the Society of Tropical Medicine and Hygiene, with Sir Patrick Manson as its first president. Though Manson died in 1922, there was no adequate memorial to him, and last year the council of the Society resolved to buy and equip a house which should be known as Manson House in memory of Sir Patrick, and at the same time form a permanent home for the Society. A sum of about £11,000 has been collected and subscribed for this purpose, but a further £17,000 is required to complete the scheme. Any donations, great or small, will be gratefully acknowledged if sent to the president, Manson House, 26 Portland Place, London, W.1.

Sir Sidney F. Harmer, formerly Director of the Natural History Departments of the British Museum, has been elected an honorary member of the Société Zoologique de France.

The South Africa Medal for 1931 of the South African Association for the Advancement of Science has been awarded to Prof. H. B. Fantham, of the Department of Zoology and Comparative Anatomy in the University of the Witwatersrand, Johannesburg, for his researches on parasitic protozoa, soil protozoa, and heredity. The medal is being presented to Prof. Fantham at the Grahamstown meeting of the Association on July 6.

The Museums Association will hold its annual conference this year at Plymouth on July 6–11. All meetings of the Association will be held in the Abbey Hall. July 6 will be spent in committee meetings, and the president, Sir Henry Miers, will deliver his presidential address on July 7. The president's address will probably include some indication of a proposed survey of all the museums in the British Empire, to be financed by the Carnegie Corporation of New York. Among the papers to be read are : " A Suggested System of Museum Registration ", by Mr. K. de B. Codrington, and " Paper for Museum Labels ", by Dr. L. J. Spencer, on July 8 ; " Taxonomy in the

Museum", by Dr. W. T. Calman, "Present-Day Problems of Provincial Museums", by Mr. H. J. M. Maltby, and "The Preservation of Marine Life, Wet or Dry Specimens", by Dr. E. J. Allen, on July 9; and "Museum Problems in Canada", by Prof. J. H. Iliffe, "A Simple Way to test Museum Value", by Dr. Hay Murray, and "Why do we use Plate-Glass in Museums?" by Mr. Frank Loney, on July 10. All communications concerning the Conference should be addressed to the local honorary secretary, Mr. A. J. Caddie, Museum and Art Gallery and Cottonian Collection, Plymouth.

THE Report of Map Publication and Office Work of the Survey of India for 1929–1930 (Calcutta, 1*s.* 9*d.*) is chiefly useful for the detailed index sheets of published maps of India and adjacent countries. Good progress is being made with all the maps. The 'million' map is now practically complete for India, Burma, and adjacent countries. The modern '1-inch' map is making progress, and the modern '¼-inch' covers considerable areas in the most important parts of India. Additions have also been made to several other series.

THE last issue of the League of Nations *Quarterly Bulletin of Information on the Work of International Organisations*, No. 2, vol. 3, April 1931, contains brief reports of some three dozen conferences held and also a list of more than sixty forthcoming conferences to be held during the present year. It is desired to make this register as complete as possible. Information about coming scientific conferences of international importance would be particularly welcome and may be addressed to the Section of International Bureaux, League of Nations, Geneva.

MESSRS. Wheldon and Wesley, Ltd., 2 Arthur Street, W.C.2, have just circulated an important catalogue (New Series, 25) of second-hand works (more than 2000 in number) on entomology and arachnology, including the collection of pamphlets formed by the late W. F. Kirby. The list is obtainable upon application.

A USEFUL catalogue (No. 458) of about 900 second-hand books on philosophy, including many from the library of the late W. E. Johnson, Sidgwick lecturer in moral science in the University of Cambridge, has just been received from Messrs. Bowes and Bowes of Cambridge. Copies can be had from the publishers upon application.

MESSRS. H. K. Lewis and Co., Ltd., have just issued a supplement (1928–1930) to the catalogue of their Medical and Scientific Circulating Library which should be of service not only to users of the library, but also to others who may wish for particulars of books relating to science in its various branches. The supplement is arranged alphabetically, but a classified list of subjects included, with the names of the respective authors, is given at the end. The price to subscribers is 1*s.* net., to others 2*s.* net.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—An assistant quantity surveyor on the staff of the Miners' Welfare Committee of the Mines Department—The Under-Secretary for Mines, Establishment Branch, Mines Department, Dean Stanley Street, S.W.1 (July 8). A secretary of the Institution of Sanitary Engineers—The Chairman of Council of the Institution of Sanitary Engineers, 120-122 Victoria Street, S.W.1 (July 8). A visiting teacher of science capable of teaching physics and chemistry, hygiene, and some biology in the junior day school of the Smithfield Institute—The Education Officer (T.1), County Hall, S.E.1 (July 10). An assistant in the natural history division, National Museum, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin, C.8 (July 10). A lecturer in mining at the Sunderland Technical College—The Chief Education Officer, Education Office, 15 John Street, Sunderland (July 11). A full-time lecturer in charge of the electrical engineering department of the Chesterfield Technical College—The Principal, Technical College, Chesterfield (July 11). An assistant master at the Bolton Municipal Technical College, to teach mainly science subjects in the junior technical school and engineering departments of the College—The Director of Education, Education Offices, Nelson Square, Bolton (July 11). A librarian of University College, Nottingham—The Registrar, University College, Nottingham (July 13). A principal of the Neath Mining and Technical Institute—The Director of Education, County Hall, Cardiff (July 13). An assistant lecturer in physics at University College, Nottingham—The Registrar, University College, Nottingham (July 13). An assistant organising lecturer at University College, Nottingham, under the Miners' Welfare Adult Education Joint Committee—H. L. Featherstone, 14 Shakespeare Street, Nottingham (July 14). A woman senior demonstrator in pathology at the London (Royal Free Hospital) School of Medicine for Women and Royal Free Hospital—The Warden and Secretary, 8 Hunter Street, W.C.1, or the Secretary, Royal Free Hospital, W.C.1 (July 15). A lecturer in zoology at Birkbeck College—The Secretary, Birkbeck College, Fetter Lane, E.C.4 (July 15). A principal of the Harris Institute, Preston—Alderman H. Astley Bell, Harris Institute, Corporation Street, Preston (July 31). A keeper of archæology in the Liverpool Public Museums—The Town Clerk, Municipal Buildings, Dale Street, Liverpool (Aug. 1). An assistant town planner under the Government of Northern Rhodesia—The Crown Agents for the Colonies, 4 Millbank, S.W.1, quoting M/2748. A lecturer-in-charge of the building department of the Norwich Technical College—The Principal, Technical College, Norwich. Teachers of engineering drawing and mechanical engineering at the East Ham Technical College—The Secretary, Education Office, Town Hall, East Ham, E.6. A teacher of engineering at the Leyton Technical College—The Clerk to the Governors, 280 High Road, Leyton, E.10. A Principal of University College, Leicester—The Registrar, University College, Leicester.

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.*]

Embryology and the Theory of Polyhedra.

A NEW volume of *Proceedings* of the Bologna Mathematical Congress begins with a short paper by Max Brückner, on the old problem of how many different polyhedra are possible of *n* sides—with the limiting condition that all the corners shall be trihedral. In my book on " Growth and Form " I dealt with the kindred problem of the possible number of arrangements of a plane assemblage of cells, their partition-walls all meeting three-by-three, as is actually the case in a system of soap-bubbles or of living cells. The problem of the polyhedra is just as interesting to the biologist; for any natural clump of cells, such as a totally segmented egg or ' morula ', may be looked on as a polyhedron and may be studied accordingly.

Eighty years ago, Kirkman showed that the total number of 8-sided (convex, Eulerian) polyhedra, with trihedral corners, was *thirteen*; and Cayley, Steinitz, and others have extended the problem by a few stages. The number of possible arrangements increases rapidly; and now Brückner (whose results I only quote approximately) tells us that, for

$n=13$, 14, 15, 16, the number of n-sided polyhedra $= 5\times10^4$, 4×10^5, 3×10^6, $2{\cdot}7\times10^7$.

An 8-sided polyhedron, or 8-celled egg, may have its sides, or cells, arranged in 13 different ways; there is room for variety, but withal so limited that we must expect to find the same arrangement, or cell-pattern, repeated again and again in the 8-celled stages of divers organisms. But we no sooner come to the 16-celled stage than nearly 30 million arrangements of these sixteen cells are found to be possible. And it becomes plain that the study of ' cell-lineage ', or the mapping-out in detail of the cell-arrangements after repeated cell-divisions, is only possible under the severest limitations—if it be possible at all.

D'ARCY W. THOMPSON.
St. Andrews.

Effect of Certain Substances and of Heat on Cells of *Abraxas*.

IN continuation of the work already carried out last year on the effects of phosphorised olive oil on the male germ cells of *Abraxas*, we have investigated material from larvæ injected into distilled water, 2 per cent NaCl in water, phosphoric acid, and phosphorus in paraffin oil. We have also tried various temperatures for several hours.

In many of the preparations, in addition to the cytoplasmic inclusions, the spindle bridges, or parts thereof, swell up and form separate bodies, which are very similar to the abortive acroblasts already described. In material treated with phosphoric acid, heat, 2 per cent NaCl in water, and phosphorised paraffin oil, no very large bodies of the type already described[1] have yet been found. There is at present some doubt as to the actual mode of origin of some of these large elements in the spermatocytes and spermatids of *Abraxas*.

J. BRONTË GATENBY.
JOYCE C. HILL.
Trinity College, Dublin.

[1] Gatenby, J. Brontë, *Jour. Exper. Zool.*, vol. 58; 1931.

Paramagnetism of Bivalent Silver.

IN collaboration with Mr. F. H. Burstall, one of us has recently prepared a series of silver salts of the type [Ag 3 dipy]X_2 in which dipy represents αα′-dipyridyl ($C_{10}H_8N_2$) and X a univalent anion (*J.C.S.*, 2594; 1930). The complex kation is therefore bivalent.

If this is due to the presence of bivalent silver, then an electron must have been extracted from the inner levels (probably the N level) of the silver atom, which consequently should be paramagnetic. We have therefore measured by the Gouy method the susceptibility of the chlorate at 20°. Parallel measurements were made in the same apparatus with copper sulphate, since the bivalent copper ion contains a similar incomplete sub-group. The following results were obtained:

Substance.	χ.	χ_M.	p.
$CuSO_4{\cdot}5H_2O$	$5{\cdot}86\times10^{-6}$	1457×10^{-6}	9·2
[Ag 3dipy]$(ClO_3)_2$	$1{\cdot}93\times10^{-6}$	1434×10^{-6}	9·1

The molecular mass susceptibilities of the silver and copper compounds are equal within the limits of the experimental error (5 per cent). The Weiss magneton number p is calculated on the assumption that the Curie law holds, and no allowance has been made for the diamagnetism of the rest of the molecule. The values are, however, in fair agreement with those found for other atoms in which a sub-group lacks one electron: for example, $Cu^{\cdot\cdot}$, 9·2; NO, 9·2; $VOSO_4$, $3\frac{1}{2}H_2O$, 8·95, $V_2O_2Cl_4{\cdot}5H_2O$ 7·94. These values are taken from the International Critical Tables.

G. T. MORGAN.
Chemical Research Laboratory,
Teddington, Middlesex.
S. SUGDEN.
Birkbeck College,
Fetter Lane, E.C.4.

Forestry Practice and Research.

THE leader on forestry research in NATURE of May 16, and previous letters from Dr. Rayner and Prof. Tansley, would suggest that attempts to grow timber on poor land are in their infancy, and that the work of the Forestry Commission and other State forest departments throughout Europe is being carried on in complete ignorance of fundamental principles. It is fairly evident that no representation of this kind was intended, but at the same time the impression might be conveyed to the casual reader (if such an individual ever reads NATURE) that research in connexion with afforestation has been practically ignored. This view may be perfectly correct in certain directions, but I think the practical forester is as fully aware of the value of genuine research as those engaged in any other industry influenced by biological factors. As regards the British forester, whether in the capacity of employer or employee, I scarcely think that he is guilty of the charge advanced by Prof. Tansley. Forest botany and pedology he may have failed to study through lack of opportunity, but in connexion with geographical botany, estate owners throughout the British Isles have carried out most valuable work for practically two centuries in testing exotic species on varying soils and situations. These tests of exotic species have already enabled two or three cubic feet of timber to be grown where only one grew before in connexion with the planting of species like Douglas fir or Sitka spruce, while they have conclusively proved the unsuitability of other species for the British climate, although strongly advocated by enthusiasts.

We know that many of the empirical methods adopted in farming and gardening have been explained, and in many cases justified, by science; others have been shown as useless or harmful; while in connexion with insects and fungi, invaluable weapons have been placed in the hands of the modern cultivator by science and research. But no one suggests that gardening or farming are industries which should have stood still until science had investigated them in all their aspects. Some years ago the Development Commission, which at that time was in charge of forestry development, adopted the principle that education and research should precede practical operations. Had this policy been adhered to, twenty years might have elapsed before a single plantation had been laid down with the aid of public money, while private planters in every direction had already provided, throughout the length and breadth of the British Isles, abundant examples of practical timber growing, good, bad, and indifferent.

The Forestry Commission only came into existence in 1919, and had a definite function to perform, namely, the building up of a timber reserve within a definite period. Had it been able to confine its operations to soils and sites comparable to those which had already carried successful timber crops, the problem, from a technical point of view, would have been comparatively simple. It is no secret, however, that many areas have been acquired which are not likely to fulfil all that was expected of them, and it is on these that the scientific worker might carry out invaluable work if given the opportunity and encouragement.

So far as the practical man is concerned, however, the soil is the raw material upon which he has to work, and it is no exaggeration to say that he knows practically nothing about it other than a few of its more obvious mechanical and physical features. But this does not prevent him from growing cabbages or potatoes satisfactorily. On similar lines the forester plants trees and produces timber which he considers will meet a local or general demand some day or other, but it does not follow from this that he is able to explain how these trees grow, nor can he anticipate the results of his work within exact limits. The man of science may be able to influence him as regards his methods to an appreciable extent, but every cultivator, whether of farm, garden, or forest crops, knows perfectly well that he does many things badly for the simple reason that he cannot do them in any other way under average conditions. Weather and other natural causes over which he has no control frequently dominate the most carefully conducted operation, and unless the latter can be carried out as cheaply as the more rough and ready process to which experience has accustomed him, he is naturally apt to view innovations with suspicion.

In connexion with the branch of research already alluded to, namely, the introduction of exotics from the more temperate parts of the world, several instances might be given to show that experience, when properly interpreted, is the only safe guide in the long run. For example, the success of Weymouth pine in the British Isles (apart from *Peridermium Strobi*) would lead one to suppose that other species growing within the same region would also succeed. Yet *Pinus resinosa*, a useful timber tree in Canada, fails in this country, although associated with Weymouth pine in its native habitat. In Eastern Canada, *Pinus Contorta* is, as its name implies, a scrub pine, while in North-western Europe it grows, in the earlier stages at least, faster than any coniferous species on the poorest type of soil. Many similar examples of this kind could be given, yet probably the scientific worker, basing his conclusions on meteorological data, would give erroneous advice on matters of this kind.

The moral of all this appears to be that practice and science must work side by side, and regard themselves within their own spheres as equally important, neither trying to influence the other until the problem at issue is thoroughly understood.

The practical man has no grievance against research workers. On the contrary, he has every reason to welcome them. But it frequently happens that research confines its attention to one particular problem, and is inclined to dogmatise upon it, whereas the industry to which it applies is made up of a complex system of science, practice, economics, and politics which the research worker has no particular reason to consider. Every practical forester recognises the fact that soil and the root functions of the tree growing in it are mysteries which he cannot unravel unaided, and the article in NATURE on May 16 will be welcomed by every unprejudiced worker in the forestry field. A. C. FORBES.

Dublin, June 15.

The Age of Flint.

A HUNDRED years have elapsed since Mantell opened the controversy regarding the formation of flint, but hitherto, despite a voluminous literature on the subject, the crucial point, the time of formation, has remained undecided. The main issue has been narrowed down to one of two possibilities: either the flint was formed contemporaneously, by precipitation of silica gels on the sea-floor, or it was formed subsequently to the deposition of the Chalk, by the solution and segregation of silica disseminated through the chalk chiefly from the remains of sponges. The arguments in favour of the rival views are fairly evenly divided, and a strong case can be made out for both contemporaneous and subsequent formation. In fact, almost every observation can be made to fit in equally well with either view; and, like the evidence, so the supporters of the theories, past and present, are evenly divided. An infallible criterion of the age of flint is, therefore, a prime necessity, and the purpose of this note is to suggest one, of which the only remarkable feature is its extreme simplicity. The condition of the sponge remains found in flint is in itself adequate proof that the formation was subsequent.

Siliceous sponges may be divided, according to their behaviour after death, into two classes, namely: (*a*) those in which the skeleton is composed of separate spicules and which rapidly disintegrate after death, the spicules becoming scattered; and (*b*), those in which the skeleton consists of a continuous framework, with separate spicules scattered in its meshes. To the latter belong the Lithistida and the Dictyonine Hexactinellida. Judging by experience of hauls of recent sponges from waters of all depths, it is probable that the time taken for the disintegration of those of class *a* may be from a few months, or less, to a year, seldom more. As to those of class *b*, although the interstitial spicules may be lost in a few months, or less, the dictyonine framework may persist for years. In fact, it is indestructible except by severe mechanical abrasion or continued action of solvents over a long period of time. Normally, therefore, the Dictyonine Hexactinellida and the Lithistida will stand the greatest chance of preservation where sedimentation is slow, and in any deposit laid down in depths of 100 to 1000 fathoms, where the two classes are approximately equally represented, the higher the rate of deposition the more of class *a* will be preserved as complete sponges, and the more likelihood of interstitial spicules being found in the skeleton of class *b*.

The sponge-remains in the English chalk belong predominately to class *b*; in fact, the number recorded for class *a* is negligible. Moreover, the interstitial spicules of the former are, practically without exception, lost. In other words, the sponge remains are precisely those which would be left after a long period of disintegration on the sea-bottom. These remarks apply equally well to remains found in chalk and in flint. Clearly, then, these remains suffered no rapid burial. Had the sponges found in flint been entombed by a fall of silica gel, a few complete and live sponges at least would have been embalmed in the process. It may, indeed, be said that the majority would be intact, and we should have had a large number of class *a* so preserved. Yet despite the numbers of flint nodules which must have been examined in the last century, we have nothing to show of class *a* except for isolated spicules. Nothing could be more decisive.

Frequently, one finds in flint the dictyonine framework of a sponge faintly portrayed in a brown stain, and the connexion between these and similar iron-stained impressions in the surrounding chalk is obvious. The replacement of the original silica by iron oxide must have taken place prior to the formation of the flint, showing clearly that that formation was not only subsequent, but also took place a long time after the burial of the sponge-remains.

There is yet one other factor, which also seems to have been completely overlooked. If flint had been formed by the relatively sudden precipitation of silica from solution, we have to explain why the remains of all forms of contemporary life found in it are so poor. Taking the Rhynie chert of Aberdeenshire as an example, in which remains of plants and animals, many of minute size, are so beautifully preserved, we should expect to find much better preservation of the fossils enclosed in flint. The famous Whittaker's three-inch, representing a continuous bed estimated at some 240 square miles in extent, should have embalmed a perfect representation of contemporary benthos. Yet this, and other flint similarly bedded, fails entirely in this respect.

The story of the formation is even yet far from complete, but that that formation was subsequent to the deposition of the chalk, nobody who has worked extensively at both recent and fossil sponges will deny.

Maurice Burton.

Department of Zoology,
British Museum (Nat. Hist.),
London, S.W.7.

Absorption Spectra of Crystals at Low Temperatures as References in the Measurement of Stellar Velocities.

The vast work of determining and cataloguing radial velocities has made the slitless spectrograph almost indispensable. A number of stars may then be photographed on the same plate at the same time. Such a method is possible only if the starlight passes through some medium which has sharp absorption lines so that the spectrum of each star has within it the absorption lines for references. A medium having sufficiently sharp lines in the proper spectral region does not seem to have been found. I would suggest the use of the crystals of the rare earths maintained at the temperature of liquid nitrogen. Both Dr. Joy, of the Mount Wilson Observatory, and Dr. Shane, of the University of California, have considered in this connexion the absorption spectra of crystals of gadolinium at room temperature.[1] The absorption lines occur, however, in an unfavourable region of the spectrum.

The spectrum of the dysprosium ion appears particularly adapted for the purpose. At room temperature its spectrum taken with a three prism Steinheil spectrograph contains some diffuse lines between 4000 A. and 4800 A. At the temperature of liquid nitrogen, the lines are as sharp as those of gases. The crystal studied was dysprosium ethyl sulphate. It is possible, though not easy, to grow this crystal perfectly clear. A few trials would doubtless discover a more amenable salt of dysprosium. The acetate is probably easy to grow. A crystal about 2 cm. × 2 cm. × 0·5 mm. of another rare earth, cerium, was grown almost as clear as glass by evaporating a saturated solution in a desiccator containing concentrated sulphuric acid. Much larger crystals can be obtained when some precautions are taken as in the method of Freed and Spedding.

Because of its constant boiling point, liquid nitrogen is preferable to liquid air, by means of which it may

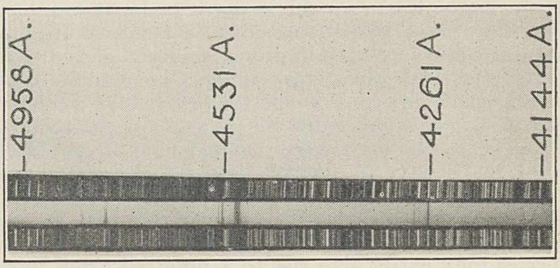

Fig. 1.—Absorption spectrum of dysprosium ethyl sulphate ($Dy_2(SO_4)_3 . 9H_2O$) at the temperature of liquid nitrogen.

readily be prepared. Also, it has the advantage of complete transparency should one desire to immerse the crystals in the refrigerating liquid.

The high cost of dysprosium might induce one to investigate other rare earths. Neodymium has also been found to possess sharp absorption lines in this spectral region, but they are not so fine as those of dysprosium. However, it is not necessary to employ pure salts of dysprosium. It may be desirable, also for spectrographic reasons, to make a mixed crystal with the corresponding colourless lanthanum salt.

No difficulty should be met in eliminating any serious change in temperature of the spectrograph because of the liquid nitrogen.

I wish to express my indebtedness to Mr. G. P. Kuiper, of the Leyden Observatory, for an interesting conversation. The work is one of a number made possible through the generous hospitality of Prof. W. J. de Haas. The Steinheil spectrograph was kindly placed at my disposal by Prof. W. H. Keesom.

Simon Freed
(Fellow of the John Simon Guggenheim Memorial Foundation).

Cryogenic Laboratory,
University of Leyden, Holland,
May 23.

[1] Freed and Spedding, Nature, **123**, 525; 1929: *Phys. Rev.*, **34**, 945; 1929.

Mortality among Plants and its Bearing on Natural Selection.

I have read with great interest the letters from Prof. Salisbury and Dr. J. Phillips which have appeared in Nature dealing with mortality in plants at different stages of their life histories. The observations are of the greatest importance, but I doubt whether the interpretation advanced by Prof. Salisbury in his letter of May 31, 1930, is supported by the facts. It seems to me that a distinction should be made between mortality and natural selection. The results obtained by Prof. Salisbury with *Silene conica L.* and *Verbascum Thapsus L.* would probably have been very similar if all the seeds in each case had been exactly alike, and, in any case, evolution under natural conditions is proceeding so slowly that individuals of any one species or variety in a taxonomic sense are very nearly identical. On the other hand, the seed yield of many individual plants runs into thousands and millions, which, combined with the losses between pollen production and germination, makes the chances against survival into the second generation of any single pair of gametes enormous. How far natural selection enters into this enormous mortality can never be known: for while accidental mortality deals equally with the less and the more favourable variation, competition verging on mortality puts a high premium on favourable variations, however small, as, for example, in competition for light or plant food.

With regard to the taxonomic characteristics of adult plants, it can for the moment be fairly assumed that they have been attained as a result of intense natural selection extending over millions of years, in which case little difference between individuals is to be expected, and little scope for progressive selection will exist. Whatever differences exist in the relative fitness of adult stages will be reflected in the seed yield, and I have frequently been struck by the wide variations in seed yield between different individuals of *Capsella Bursa-pastoris*, *Brassica Sinapis*, *Senecia vulgaris*, and *Bromus mollis*. One individual of these species may easily give rise to a hundred times more seed than another, so that even allowing for accidental differences of soil and situation the scope for natural selection in adult stages is fully comparable with that for seedlings.

The whole subject of seed yield, reproduction rate, and frequency of occurrence in plants needs careful study; since in all species a very delicate balance exists between rate of reproduction and mortality, and the slightest change in these should lead to striking changes in frequency in species with short life histories; yet observation shows that this is not the case. Assuming for the moment a habitat occupied by only one species, the number of adult individuals present would probably be very stable for wide differences in seed yield. If, however, *Lolium perenne*, *Dactylis glomerata*, *Bellis perennis*, *Taxacum Dens-leonis*, *Ranunculus bulbosus*, and *Carduus lanceolatus* are all present in one pasture, why does not one species drive out all the rest, and why is *Lolium perenne* usually more abundant than *Dactylis glomerata*, and *Ranunculus bulbosus* more common than *Taraxacum Dens-leonis*? In raising these questions, and in remembering rare individuals of still rarer species, one is driven to conclude that suitability to a given habitat plays a predominant rôle in the frequency of occurrence of a given species. One single favourable variation, when fully established, ought to have a marked influence on the frequency of a given species comparable with the results obtained by changing the habitat artificially, as, for example, by liming and draining. From the evidence before us, I must tentatively conclude either that nearly all mortality in plants is not progressively selective, or that progressive variations are occurring at such a rate that they are almost completely eliminated before they became established.

R. WEATHERALL.

Eton College, Windsor,
June 14.

The Heat of Dissociation of Fluorine.

THE heat of dissociation of chlorine, bromine, and iodine has been determined by thermal methods by Bodenstein and estimated respectively to be +56·8, +45·2, +35·6 kilo-cal. No data are yet known regarding the heat of dissociation of fluorine.

I have determined this quantity by reversing the arguments of Franck regarding the absorption spectra of molecules of alkali halogenides. It is well known that the alkali halogenide vapours like NaCl, etc., give a continuous absorption spectrum, the beginning of absorption corresponding to the atomic heat of formation $R = \text{Na} + \text{Cl} - \text{NaCl}$. R is connected with the ordinary heat of reaction $Q.\{Q = [\text{Na}] + \frac{1}{2}\text{Cl}_2 - [\text{NaCl}]\}$ by the relation $R = Q + \frac{1}{2}D_{\text{Cl}_2} + \lambda_{\text{Na}} - \lambda_{\text{NaCl}}$, where D_{Cl_2} is the heat of dissociation of Cl_2; λ_{Na} is the heat of vaporisation of Na, λ_{NaCl} is the heat of vaporisation of [NaCl] crystals. It is found that if ν_0 be the frequency of the beginning of absorption, then $h\nu_0$ corresponds almost exactly to the value of R calculated as above in the case of ionic compounds.

I took anhydrous NaF and KF and vaporised them within a silica tube placed within the vacuum graphite furnace of this laboratory, and obtained their absorption spectra. For NaF, the absorption became noticeable at λ2370; for KF at λ2245. We can then calculate D_{F_2} from the relation $\frac{1}{2}D_{\text{F}_2} = R - [Q + \lambda_M - \lambda_{MF}]$ in which R is calculated from the absorption spectrum data, the other quantities are taken from Landolt and Bornstein's tables. From NaF data, we get $D_{\text{F}_2} = 78$ kcl., from KF data we get 74 kcl. It appears, therefore, that the heat of dissociation of fluorine is: 76 ± 2 kcl.

I propose to complete the work by performing similar experiments with other alkali fluorides.

MANOHAR S. DESAI.

Physical Laboratory,
University of Allahabad,
May 18.

Hyperfine Structure in the Rubidium Spectrum.

IN a preliminary note[1] the lines of the rubidium doublet $1S_{\frac{1}{2}} - 3^2P_{\frac{3}{2}}$ and $1S_{\frac{1}{2}} - 3^2P_{\frac{1}{2}}$ were stated to possess a doublet hyperfine structure with separation of about 0·1 cm.$^{-1}$ and intensity ratio about 2 : 1. These results were obtained with a Fabry-Perot etalon. Meanwhile the lines have been investigated with a reflecting echelon of high resolving power in order to detect the presence of weak lines due to the less plentiful isotope. A third very much weaker component was observed; the three observed components being at 0·00, 0·11, and 0·19 cm.$^{-1}$, with ratios 6 : 3 : 1. This structure is the same for both lines of the doublet.

The two strong lines are evidently due to the more plentiful isotope Rb 85, and the weak line is due to Rb 87. But as the ratio of the sum of the intensities of lines due to Rb 85 to the sum of those due to Rb 87 must be about 4 : 1 (the proportion in which the two isotopes are present), Rb 87 must possess an unresolved component of intensity rather greater than 1. This must be obscured by one or other of the Rb 85 lines. It is more probably the stronger line (0·00), as this line appears broadened and somewhat asymmetrical.

On this view, Rb 85 possesses a doublet hyperfine structure with separation of 0·11 cm.$^{-1}$ and intensity ratio slightly less than 6 : 3; the probable value of i, the nuclear spin, being 3/2. Rb 87 also possesses a doublet structure, with separation nearly twice as great, and intensity ratio probably smaller.

It is interesting to note that the lines of the heavier isotope are displaced to the violet. A complete account of this work, with photographs of the fine structure, will appear elsewhere.

D. A. JACKSON.

Clarendon Laboratory,
Oxford.

[1] D. A. Jackson, NATURE, vol. 127, p. 924; 1931.

Hail Storm, June 14, at Doncaster.

AROUND my home at Bessacarr, on the Great North Road, three miles E.S.E. of Doncaster, on June 14, at 5 P.M. B.S.T., heavy rain was followed by hail measuring three-quarters of an inch in diameter, then—after a five-minute interval—by hail measuring one and a quarter inches in diameter—with a density of 85 to the square yard. The duration of the second shower was only one minute. Sound elm twigs a quarter of an inch thick were cut off the trees in thousands. The largest stones weighed 20 grams ($\frac{2}{3}$ oz.): twenty per cent showed four growth rings about a white spherical nucleus a quarter of an inch in diameter. The intermediate transparent stages were one-eighth of an inch and the final growth three-eighths. None were angular, but a small number showed a quarter of an inch mosaic allotriomorphic crystallisation on their smooth ovoid surfaces.

A sandpit in the garden was temporarily flooded, and in the thin residual layer of mud the stones made excellent impressions. These were covered by waterproof fabric, and next day, after being sun dried, casts of many of these were taken and a reproduction of the surface made in plaster for the Doncaster Museum.

N. L. SILVESTER.

Waterdale, Doncaster,
June 19.

An Apparatus for Recording the Ultra-Violet Light of the Sky.

IN NATURE of June 13, p. 893, Dr. J. R. Ashworth describes a photographic apparatus for recording the ultra-violet light of the sky.

It may be doubted whether such a method can give quantitative results, or even relatively correct results on different days, for the following reasons.

First, 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.

Secondly, photographic paper can be used as a quantitative instrument only by a null method, if any reasonable degree of accuracy is required, since it does not respond in a regular way to light stimulus. For example, equal values of It do not necessarily involve equal response by the photographic paper, owing to the existence of the Schwarzchild effect, while the sensitivity of the paper varies according to the atmospheric conditions.

A method which involves a visual estimate of a small change is also open to criticism, since different people have different acuities.

P. W. CUNLIFFE.

Wool Industries Research Association,
Torridon, Headingley, Leeds,
June 24.

Records of Actinic Value of Daylight.

RECORDS of the actinic value of daylight are being regularly taken in connexion with the 'Jeremiah Horrocks' Observatory, Preston. Strips of sensitised paper carried on a rotating drum pass close behind a narrow slit through which light from the sky enters; the apparatus is set up so that the slit opening is fed with light from an area of the sky 45 degrees square, the centre of the area having an altitude of 45 degrees above the horizon toward the north.

The four records reproduced in Fig. 1 were taken on April 21, 22, 23, and 24 of this year and show the rapid variations of actinic value of diffused daylight. The records are positives, that is, the dark portions indicate absence of actinic light, and the slit width, approximately 0·5 millimetre, provided for an exposure of two minutes.

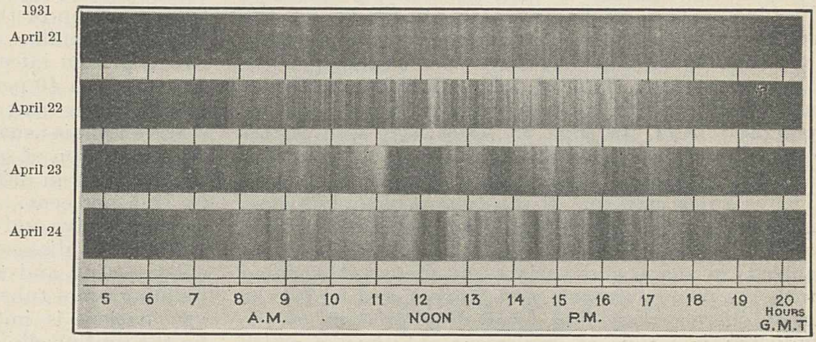

FIG. 1.

Records from three instruments have now been accumulating over a period of many months, and the work is still in progress.

GEO. J. GIBBS.

The 'Jeremiah Horrocks' Observatory,
Moor Park, Preston,
June 22.

Experiments in Prophylaxis.

THE scope of two agents, which are scarcely recognised in an external field, seems to need inquiry.

Creosote rapidly penetrates the skin: it removes the irritation of insect bites (mosquitoes, bugs, harvest-bugs), and then the circulation soon dissipates the swelling. If applied to eruptions at the incipient stage, it dries them, and the foreign matter is imperceptibly exuded. On tender skin it can be diluted with any grease. Will this be equally successful with bites of plague-fleas? What effect would it have on early pustules of small-pox?

Another external germicide is dry sulphate of quinine, which cannot, like iodine, cause serious injury. On an abrasion or cut of blood-vessels it prevents infection and promotes healing; on a badly infected wound I have known it make an entire cure in a week. Solution of quinine will rapidly cure ophthalmia which is resistant to zinc. The scope of such remedies, especially in the tropics, should be determined, as they can be safely entrusted to the ignorant.

FLINDERS PETRIE.

5 Cannon Place,
London, N.W.3.

Crystal Structure of Molybdenum Trioxide: A Correction.

I REGRET to say there are two errors in my letter on molybdenum trioxide, published in NATURE of Jan. 17. The length c should be 3·67 and not 3·57 A.; and u and v should be interchanged, making $u \sim 30°$, $v \sim 36°$.

NORA WOOSTER.

The Mineralogical Laboratory,
The Museums, Cambridge,
May 28.

Research Items.

Giant Crescents: a New Stone Age Industry from South Africa.—Mr. C. van Riet Lowe describes a new stone age industry from South Africa in the *Trans. of the Royal Society of South Africa*, vol. 19, pt. 3. It consists of an assemblage of stone implements hitherto unrecorded from Mazeppa Bay, at the mouth of the Kogha River, halfway between the Great Kei and Bashee rivers on the Transkeian coast of the Cape Province. The implements are all found on the surface, so that there is no actual evidence of date; but their technique suggests a late Middle [Palæolithic] Stone Age. Material, debris, technique, weathering, show that they belong to a single industry practised from Mazeppa to Algoa Bay and as far inland as the south bank of the Orange River, that is over an area of approximately 20,000 sq. miles. This is a new culture. It is a typical blade-industry, including characteristically long blade-like implements, principally more or less isoscelene (acute angled) in shape and variants of these. Associated with the points, scrapers, and gravers, and by far the most characteristic and interesting product of the industry, is a type of implement only one of which had hitherto been found and recorded in the Union. It is an implement shaped like the quarter of an orange. The flat surfaces meet to form a more or less straight cutting-edge, and there is a strongly curved upper surface away from the cutting edge, coarsely flaked and retaining a portion of the original surface untouched in the middle. The implement may be regarded as a giant crescent. The specimen originally described came from the Kasougu River and was unassociated; but similar and finer specimens are now associated with a definite industry, the present collection coming from Mazeppa Bay. The average size for five specimens is 9·65 cm. by 3·35 cm. by 1·73 cm. Probably the industry represents a transition from the Middle to the Later [Palæolithic] Stone Age, and is an integral part of a cultural admixture from a contact between neanthropic and palæanthropic man.

The Vole Cycle in Britain.—Continuing his study of the fluctuations of voles (*Microtus*) in Britain, A. D. Middleton gives the results of a further series of trapping experiments (*Jour. Ecol.*, vol. 19, p. 190, 1931). As an accurate index of the numbers of voles present in a district the trapping system has proved to be somewhat unreliable, and recourse has been made to the field observations of local reporters. They show that 1930 was a year of uncertain fluctuations, for while in some areas the numbers definitely increased, in others they increased less markedly or even decreased. In some places, therefore, 1929 was a peak year, and in others 1930 seems to be on the way to ushering in another peak year. The conclusion is that the comparatively regular four-year cycle which the author has previously described for British voles is considerably modified by local conditions, and in some areas may not appear at all. The author states that the regular cycle may be evident, or may be quite obscured, according to the favourable or unfavourable nature of the local conditions. But this assumption of favourable or unfavourable local conditions requires proof; the suggestion which the author's vole map makes, since it is founded on more particular observations than were available before, is that even the four-year cycle is a little uncertain in its rotation.

Bovine Tuberculosis and the Pasteurisation of Milk.—The Ministry of Health has issued a memorandum on bovine tuberculosis in man with special reference to infection by milk (*Reps. on Pub. Health and Med. Subjects*, No. 63, London: H.M. Stationery Office, 6*d*. net). A large proportion of tuberculous disease in children less than fifteen years of age is caused by the bovine type of the tubercle bacillus, and it is estimated that more than 1000 children less than fifteen years of age die annually in England and Wales from infection of this origin, which is derived mainly from cow's milk. The proportion of milch cows in Great Britain infected with tuberculosis is probably not less than 40 per cent, of which probably between 1 and 2 per cent yield tuberculous milk. But as market milk is usually the mixed milk of several cows, the proportion of samples of milk containing tubercle bacilli varies in different areas from about 5 per cent to 12·5 per cent. Although much may be done by administrative and other measures to diminish bovine tuberculous disease, complete eradication by tuberculin testing and slaughter of reacting animals, the building up of tuberculosis-free herds, and preventive vaccination, is impracticable. Much may be done by the routine clinical examination of cattle, the testing of milk by microscopic and biological methods, and the keeping of the milch cows under hygienic conditions. The campaign in favour of clean raw milk, as by the use of certified and Grade A milks, while of great potential value, has hitherto met with limited success, probably due largely to the increased cost of such milks. So long as this remains the case, the pasteurisation of milk by retaining it at a temperature of 145° C. for 30 minutes constitutes the best safeguard against bovine tuberculosis derived from milk. The opinion is expressed that pasteurisation carried out in a suitable apparatus and under strict scientific control is capable of protecting the consumer from the danger of infection with the tubercle bacillus, and that milk so treated appears to retain its valuable food properties practically unimpaired.

Biological Research in Hawaii.—Nos. 6, 7, and 10 of Volume 9 of the *Occasional Papers* of the Bernice P. Bishop Museum (Honolulu, Hawaii, 1930) consist of papers by C. H. Edmundson, "New Hawaiian Medusæ", "Effect of Ultraviolet Rays in Regeneration of Chelipeds", and "New Hawaiian Crustacea"; whilst No. 11 is by C. Montague Cooke, jun., and H. E. Crampton on "New Species of *Partula*". The medusæ dealt with belong to the genus *Eleutheria*, which is characterised by the branched tentacles bearing groups of nematocysts or suckers, or both, and having a brood pouch dorsal to the stomach. Many of these medusæ, like the common British form *Eleutheria dichotoma*, creep about by means of their tentacles. Four species new to science are here recorded from Hawaii, chiefly differing from one another and from previously known members of the genus in the position of the clusters of nematocysts and in the margin of the umbrella. They represent the first creeping medusæ to be recorded from the North Pacific Ocean. A new species of *Kishinouyea*, one of the *Stauromedusæ*, is also described. Amongst the Hawaiian crustacea, new species of *Processa*, *Jousseaumea*, and *Axiopsis* are described, and a new genus of the Portunidæ. This new genus *Cœlocarcinus*, containing one new species, has very peculiarly modified fifth legs, having the last two joints developed into rounded foliaceous swimming paddles. The gastropod genus *Partula* is always interesting on account of the geographical distribution of the species, which are, as a rule, each characteristic of certain islands or groups of islands. Four new species are here described—*Partula cytherea* from remote mountain slopes of Tahiti, *Partula lanceolata* from Mango Island in Fiji, 200 to 500 feet, *Partula thurstoni* from Ofu Island, Samoa, and *Partula montana* from the high forest of the Afiamalu region, about 2500 feet, Upolu, Samoa.

A New Parasitic Copepod.—Mr. Isokiti Harada in his paper, "A New Copepod Species Parasitic on Formosan Fresh-water Fishes" ("Studies on the Fresh-water Fauna of Formosa": (1) Contributions from the Zoological Laboratory, Taihoku Imperial University, Formosa, Japan. Journal of the Society of Tropical Agriculture, **2**, 71-76, 1930), describes a new ergasilid, which he names *Ergasilus japonicus*, parasitic on the two fishes from Lake Jitsugetasan, Formosa, *Cultriculus kneri* and *Pseudorasbora parva*. All the species of *Ergasilus* hitherto known live upon the gill filaments or within the gill cavities of their hosts, but this one lives on the outside of the body, especially on the mucous membrane at the base of the fins and occasionally on the outer surface of the operculum. None were found on the gill filaments, gill cavities, or elsewhere on the body surface. The cyprinoid fishes *Pararasbora moltrechti* and *Zacco temminckii* were also found to be parasitised by this species. All those on the fishes were females. The males are free-swimming and were collected on several occasions. Free-swimming females were also observed. *Ergasilus japonicus* differs from the other species of the genus in its habitat as well as in the arrangement of the spines and setæ of the legs, in their structure, and in the characteristic flattened swimming plate of the first swimming legs in the female.

A Liverwort as Pioneer on Burnt Forest Land.—Marie Lilienstern has recently attempted to throw some light on the occurrence of *Marchantia polymorpha* as a pioneer plant on burnt-out forest land (*Travaux de la Société des Naturalistes de Léningrad*, vol. 60, livre 3, 1930. Russian with French résumé). Pure culture work shows that *Marchantia* ceases to grow and develops very few gemmæ in the absence of potassium. On the other hand, the cultures show that high concentrations of potassium are not injurious, nor is exposure to guaiacol or pyrogallic acid, which are products of dry distillation of wood and occur in the surface layers of soil in burnt-out forests. *Marchantia* shows a preference for slightly acid conditions, which are also associated with the soil in such localities. It is still a little difficult to gauge the significance of these results without comparative cultures of other liverworts, which do not show any tendency to repopulate burnt forest land. It would be of interest to know whether any similar resistance to relatively high concentrations of potassium and to the presence of distillation products of wood is shown by any of the other plants that one associates with localities where there has been a fire—for example, *Funaria hygrometrica*, *Pyronema confluens*, and *Epilobium angustifolium*.

Irrigation in India.—The review of "Irrigation in India" for 1928-29 (Government of India: Public Works Branch, 2*s*.) gives a statistical and financial summary of the irrigation works in every province of British India. The rainfall in the year under review was on the whole normal, though in the plain areas there was a deficiency of about five per cent, and in the Central Provinces of eleven to twenty-two per cent. The total area irrigated by government works of all kinds was well over thirty million acres, which was nearly three million acres more than in the previous triennium. This total was slightly more than twelve per cent of the total area sown. In Sind it was as high as 90 per cent of the area sown, in the Punjab 30 per cent, and in Bengal as low as 0·3 per cent. Details of the irrigation scheme in project and works in progress are given.

Deep Trench on the North Sea Floor.—In recent surveys of the North Sea the surprising discovery of a trench 130 fathoms deep has been made about 100 miles east of Montrose. The Devil's Pit, as it has been called, is the deepest of a group of depressions found in a floor which was previously supposed to be an undulating plain at 38 to 50 fathoms. Another group of depressions, with a greatest depth of 87 fathoms, occurs farther south, about 65 miles east of Berwick. Prof. J. W. Gregory discusses the nature and significance of these depressions in the *Geographical Journal* for June. He gives reasons for not accepting the suggestion that they have a connexion with the earthquake that was felt in eastern Scotland and southern Norway on January 24, 1927, and he believes that the features are not new but were formerly missed by soundings having been too far apart. Recent soundings in the immediate vicinity of these trenches agree entirely with earlier records of shallow water. Prof. Gregory argues that the trenches are remains of the pre-glacial valley of the Rhine and date from the days when the Rhine and its British tributaries discharged to the North Sea about a hundred miles east of Kinnaird Head. He further points out that the existence of these pre-glacial trenches adds to the improbability of a Scandinavian ice-sheet having reached the British coast, since it would have filled the trenches with moraine matter. In this case floating ice must have been responsible for the transport of Scandinavian boulders to eastern England.

Long-Range α-Particles.—In the June issue of the *Proceedings of the Royal Society*, Lord Rutherford, F. A. B. Ward, and W. B. Lewis have described an investigation of the long-range α-particles from radium C by one of the new methods. Their results are most illuminating, as they show that, in addition to the well-known group with a normal range in air of 9 cm., there are at least eight other homogeneous groups with ranges between 7 cm. and 12 cm. Their numbers are, however, minute; for every million particles of the common 7 cm. group, there are only seventeen of the most frequent of the long-range groups (9 cm.), and between 0·2 and 1·3 of each of the others. No particles of range greater than 12 cm. were found, and if present, there is certainly less than one-tenth of a per cent of the number in the main set of range 9 cm. In discussing these results, it is pointed out that there must be some intimate connexion between the energy of these long-range particles and the energy of the gamma rays emitted by radium C, and the view is taken that the gamma rays arise from a transition of the α-particle within the nucleus between two different energy-levels. The energies of these levels can be found from the energy of the α-particles, and it is shown that the differences in energy between these levels and the normal level are in several cases in good accord with the energies of some of the stronger gamma rays.

Identification of Hydroxylic Compounds.—Phenylcarbimide has been employed in separating and characterising phenols from tar and tar products and also forms solid compounds with alcohols which have definite melting points. In some cases it can also be used to isolate several dihydric phenols from the aqueous liquors of low-temperature carbonisation, but with the less volatile phenols only oily products are formed. Morgan and Pettet, in the May number of the *Journal of the Chemical Society*, describe a more satisfactory alternative reagent, namely *p*-xenylcarbimide, the compounds of which, $C_6H_5.C_6H_4.NH.CO_2R$, are considerably less fusible than the corresponding phenylcarbamates, so that phenols which yield only oils with phenylcarbimide provide crystalline *p*-xenyl derivatives and, in addition, solubility relationships are modified. The paper includes a table of melting points of *p*-xenylcarbamates and phenylcarbamates, in which compounds formed from several alcohols and phenols appear.

Syntheses of Ethyl Alcohol.—In a paper in the June number of the *Proceedings of the Royal Society*, on ethyl alcohol as a product of high-pressure syntheses, G. T. Morgan and R. Taylor, after reviewing briefly the conflicting results which have been reported in attempts to prepare this substance from carbon monoxide and hydrogen interacting in the presence of catalysts, describe some new experiments which they have performed yielding positive results. The catalyst most used was prepared from cobalt nitrate and zinc permanganate, and the synthesis carried out at 400° and 200 atmospheres, about 75 c.c. of a composite liquid product being obtained per hour. From about four litres of this, the alcohol was separated and identified conclusively by a number of physical and chemical tests. Two acetals have also been separated from the crude products of the catalysis and identified, the more volatile one being ethylidene dimethyl ether, and the less volatile one propylidene dimethyl ether. Six other catalysts are described, each of which was found to induce the formation of appreciable quantities of ethyl alcohol.

Molecular Weight Determinations.—Rast, in 1922, suggested (without reference to the earlier work of Jouniaux in 1912) the use of fused camphor as a cryoscopic solvent, the novelty claimed being that the molecular depression of freezing point for this substance was so large that ordinary melting-point apparatus could be adapted to a micro-method for the determination of molecular weight. The value of the molecular depression constant for camphor was calculated as 400 by Rast from some results on the melting points of mixtures of salol and camphor obtained by Caille, whereas Jouniaux had obtained the higher value 498 from a study of a number of cooling curves of pure substances dissolved in camphor. In the May number of the *Journal of the Chemical Society*, Le Fèvre and Webb show that Caille's results appear to be erroneous, and that the higher value of the constant is to be preferred. They also show that bornyl chloride is a suitable cryoscopic solvent, having the very high constant of about 500. It has a lower melting point than camphor, and is less volatile. The results given are somewhat erratic and great accuracy is not claimed for them, but the method appears to be capable of development.

Astronomical Topics.

Encke's Comet.—Telegrams from Profs. Shapley and Strömgren report the detection of this comet by Mr. Bobone at Cordoba (Argentine), on June 21, at 22 h. 23·2 m. U.T. in R.A. 7 h. 35 m. 24 s., N. Decl. 8° 22′. The R.A. is 56 s. less and the Decl. 44′ less than the values predicted by Matkiewicz ; this implies that the time of perihelion is about 18 hours earlier than the predicted value, which was June 3·85 U.T. For most comets this would not be regarded as an unreasonable amount, but this comet has been so carefully studied ever since 1819 that the predictions are usually accurate to an hour. It is too large to be due to Mercury, though a little of it may be due to that planet, if Matkiewicz did not allow for its effect; it was not very far from the comet at the last perihelion passage. Possibly the accelerative effect, which was noted in the last century, but which had nearly died out, has revived again. This is the first detection of a comet for ten months; the cometary nature of the object reported by Prof. Nakamura last November is doubtful.

Calendar Reform.—A Circular from the International Fixed Calendar League reports that the preparatory committee on calendar reform at Geneva has completed its report, which will soon be issued; it will form the basis of discussion at the international conference on the subject, which has been convened by the League of Nations to meet on Oct. 26. Nearly all the schemes of reform include the suggestion that one day in each year (two in leap years) should lie outside the sequence of weekdays, so that every year should begin with the same weekday. There is widespread opposition to this plan, and it is scarcely likely to obtain the support necessary for its universal adoption. The schemes for making the lengths of the months follow a more orderly plan are less controversial; but the reformers are fairly equally divided between the 12-months and 13-months division of the year. The advantage of the latter is the equality of all the months, except for the one extra day. Its chief drawback is that it does not divide into quarters. But it has been pointed out that the case would not be much worse than the present 'quarter-days', which do not all fall on the same day of the month. The discussions next October are likely to be lively.

Improvement in Time-Recording.—The great improvement in clocks, effected by Shortt, calls for a similar improvement in chronographs. Those in general use are limited to hundredths of a second. A paper by Alfred L. Loomis in *M.N.R.A.S.* for March gives a description of a very accurate form of chronograph. A broad sheet of paper is made to advance at a uniform speed past a comb of 100 teeth. The records on the paper are made by electric sparks from these teeth; the teeth are in electric connexion with a disc having 100 teeth, which rotates 10 times per second, so that each tooth corresponds to one-thousandth of a second. The results enable very accurate clock determinations to be made. These show that the maximum clock rate is attained when the pressure in the clock case is between 15 mm. and 25 mm. of mercury. Lowering the pressure from 15 mm. to 1 mm. caused the clock to lose a second a day; this unexpected result is due to the longer swing that occurs with low pressure. A paper immediately following this, by Prof. E. Brown and D. Brouwer, gives an analysis of the clock records extending over several months. The most interesting result is the detection of a small effect due to the moon. The theoretical amplitude is shown to be 0·000153 second, the period being half a lunar day. This is the direct action of the moon on the pendulum, but there are also indirect effects due to the change in the earth's attraction arising from tidal deformation. The analysis of the clock readings gave amplitudes varying from 0·000106 s. to 0·000150 s.; they are, therefore, of the right order for lunar effects. It is hoped that continuation of the observations, using four Shortt clocks, will make it possible to detect changes in the rate of the earth's rotation. The irregularities in the apparent motion of the moon and planets give grounds for believing that such changes occur.

Recent Advances in the Chemistry of the Vitamins.

AT the meeting of the Royal Society held on June 18, the President, Sir Frederick Gowland Hopkins, opened a discussion on the chemistry of the vitamins. He said that although many discoveries had been communicated in the past to the Society, there had been very few papers dealing with the vitamins. He felt great satisfaction that this discussion should occur during the first year of his presidency, especially as the subject was still growing in interest. The Society were to be congratulated on the presence of a number of foreign workers, so that the discussion would have an international character. As the subject was so vast, he proposed to limit it to the chemistry of the vitamins, and suggested that vitamins D, A, and the B complex be taken in that order.

VITAMIN D.

Prof. A. Windaus said that up to the present, investigations had had to be carried out on impure substances and chiefly by means of physical experiments. No stable equilibrium was formed between ergosterol and the products of irradiation. By further irradiation two crystalline substances could be obtained, neither of which could be converted into the other; it appeared therefore that two series of products were formed on irradiation. Reerink and van Wijk had found that no matter whether 10 or 50 per cent of the ergosterol was changed by long wave irradiation, the absorption spectrum of the product was always the same. He suggested that this was due to several substances being formed in constant proportion, and that the absorption spectrum was that of the mixture. None of the products of irradiation are precipitated by digitonin. Failure of precipitation, however, does not imply that a change has taken place in the hydroxyl group. On treatment with phenyl isocyanate the antirachitic activity of the irradiated ergosterol is destroyed. Treatment with warm caustic potash results in the reconversion of the phenyl urethane to vitamin D.

Prof. Windaus had found that the vitamin had the same molecular weight and formula as ergosterol and also contained three double bonds. The dihydro derivative obtained from irradiated ergosterol by treatment with sodium in alcoholic solution was inactive, but it is not certain that it is a derivative of vitamin D itself. The vitamin is more sensitive to a temperature of 180° than ergosterol; after heating, the absorption spectrum shows a band at 2820–2920 A.

Crude vitamin D is stable in oil, although the absorption spectrum and specific rotation rapidly change. The toxicity of the crude product varies with the potency, but it is still possible that the two properties may be due to different substances. The problem has not yet been solved. He had noticed that in vacuum tubes, in which crude vitamin D had been sealed, crystals appeared, but he had not been able to obtain them in a pure state by recrystallisation from cold acetone or by fractional precipitation. He had found, however, that when irradiated ergosterol was treated with maleic or citraconic anhydride in ethereal solution at room temperature for one to three days, a reaction occurred between certain of the substances present and the anhydride. When these inactive products were removed by solution in dilute caustic potash, crystals could be obtained from the ethereal layer on evaporation of the solvent. The yield was 50 per cent of the crude product, or 60–70 per cent of the material which failed to react with maleic anhydride.

Vitamin D crystallises in long needles of melting point 122°; $[a]_D^{18} = +136°$ in acetone, and $[a]_{Hg}^{18} = +168°$ in acetone.

The crystals show a band in the absorption spectrum at 2650–2700 A. Their potency was found to be $2–2\frac{1}{2}$ times that of the M.R.C. standard.

He considered that the product obtained by Reerink and van Wijk was different from his, since it had a lower specific rotation and an absorption spectrum of a different shape, but that Bourdillon's crystals were probably the same. He agreed with the suggestion of the latter that there might be several compounds showing vitamin D activity, but considered that his crystals were responsible at any rate for the chief part of it. Vitamin D is an isomer of ergosterol in which there has been a structural rearrangement with an increase in the spatial size of the molecule.

Prof. B. C. P. Jansen said that Reerink and van Wijk had now obtained crystals of a melting point 140°. Their former product with a lower melting point had contained ether of crystallisation.

Dr. R. B. Bourdillon said that the discovery of the method of obtaining crystals of vitamin D by means of maleic anhydride was of outstanding importance and likely to lead to a solution of the problem of its constitution. He and his co-workers had obtained very similar crystals by distillation of irradiated ergosterol in a high vacuum. Their melting point was 123–125°. The specific rotation to the mercury line in alcoholic solution was +250 to +260°. The maximum absorption occurred at 2700 A. and was greater than that of ergosterol. The potency was 18–22,000 M.R.C. U./mgm., that is approximately the same or slightly less than that shown by Prof. Windaus' crystals. They had been able to prepare an oxalate and acetate and reconvert these back to the original crystals. They had found the rotation and potency to remain constant for some weeks in dry air or in vacuo. Neither by distillation at a temperature of 160° nor by further irradiation with loss of two-thirds of the potency had they been able to separate their crystals into two separate compounds. Moreover, on irradiation the loss of antirachitic activity and the changes in the absorption coefficient and specific rotation were absolutely parallel. They therefore considered that their crystals were a definite chemical compound and had ventured to call it 'Calciferol'. However, the unity of the compound was not absolutely certain, owing to variations in the specific rotation of different preparations. They had recently obtained some crystals with a rotation of +290°. He suggested that there were at least two vitamins, isomorphic and with the same absorption spectra, the lævo form being very unstable, while the dextro form was stable. This suggestion would explain the discrepancies in his own work and that of other observers.

Dr. O. Rosenheim said he considered the work now reported was the most important since the original researches on vitamin D. He thought that Windaus' and Bourdillon's crystals were identical, although it was possible that there might be an impurity present as in Reerink and van Wijk's preparation. Spectroscopic methods had not led to much advance, but success had come from biological and organic chemical research, and especially from Bourdillon's method of fractional condensation. He pointed out that if ergosterol was irradiated until 20 per cent had been changed and the 80 per cent of inactive material removed, the activity of the residue was only the same as that of the original irradiated material. On distillation of the residue, 20 per cent was obtained as crystals, but the activity was only twice that of the crude product.

VITAMIN A.

Prof. H. von Euler said that it was early noticed that fat soluble growth-promoting material was frequently associated with a red or yellow coloration but that the converse was not true. Working with Karrer, he had found that of all red or yellow substances examined, only carotene had vitamin A activity. Carotene was usually supposed to be optically inactive, but he, as well as Rosenheim and Kuhn working independently, had found that it could be fractionated into two forms, one melting at 170° and optically active, and the other melting at 183° and optically inactive. Both forms had growth-promoting power. The latter gave an earlier growth response, but after three weeks the differences between the two disappeared. A dose of 0·003 mg. daily would produce a daily increase in weight of one gram in the rat. Complete hydrogenation of carotene inactivated it, but reduction with aluminium amalgam at first increased the activity. Hydrocarotene containing eight double bonds is much more active than carotene, the daily dose required being only 0.0005 mg. It also gives a higher blue value with the Carr and Price colour test. The absorption spectrum is very similar to that attributed to vitamin A in cod liver oil.

Moore considers that carotene is converted to vitamin A in the body of the rat. Prof. von Euler had tried to effect this conversion in vitro, but only with the serum of the hen had he found that carotene could be converted into a substance very similar to vitamin A although not spectroscopically identical. He considered it probable that the transformation occurs in the blood, and that vitamin A may act as a catalyser in oxidation. He had also examined the anti-infective action of carotene and had found that it did not affect hæmolysis in vitro nor react with amboceptor, but that when it was given in excess to rabbits, the amboceptor in their blood was increased.

Dr. Rosenheim said that carotene is a mixture which has not yet been completely separated, and that it is dangerous to attribute activity to any particular isomer. The optical activities obtained by different observers vary considerably. It is possible that the transformation of carotene into vitamin A in the body may be only the accumulation of vitamin A present as a contaminant in the carotene. The band in the absorption spectrum of cod liver oil at 3280 A. may not be due to vitamin A but to a substance accompanying it.

Dr. R. A. Morton said that if the band at 3280 A. is to be attributed to vitamin A, then the latter cannot be present in carotene as an impurity. Dihydrocarotene is not vitamin A, since the band in its absorption spectrum is at 3170 A., the blue colour given with antimony trichloride is not the same as that given by the vitamin, and the ratio of blue colour to intensity of absorption is different.

VITAMIN B.

Prof. B. C. P. Jansen said that when 100 kgm. of rice polishings were extracted with dilute acid alcohol, 30 kgm. went into solution. By treatment with acid clay it was possible to adsorb nearly all the vitamin B_1, but only 100 grams of contaminating solid material. The vitamin B_1 present accounted for only 1 per cent of the adsorbed material. By fractional precipitation with silver nitrate and baryta it was possible to remove impurities at a strongly acid reaction and to precipitate two-thirds of the vitamin at *p*H 4–7: above this *p*H impurities were precipitated as well.

Further purification could be effected by precipitation with phosphotungstic acid, and decomposition of the precipitate with baryta, and precipitation with platinum chloride from alcoholic solution. When the platinum was removed with powdered silver, 1·4 gram was obtained, of which 0·4 gram was pure vitamin. By numerous fractionations with acetone from solution in absolute alcohol, 30 mgm. of pure vitamin were obtained. The formula by analysis was $C_6H_{10}ON_2HCl$. The process he had devised was therefore very wasteful. It could be improved by the use of Peters' method of fractional precipitation with phosphotungstic acid. Prof. Jansen had found that silicotungstic acid was as suitable. When the original 100 grams obtained by adsorption on acid clay were treated with this reagent, two-thirds of the vitamin were precipitated, but only 20 per cent of the total solid. A further improvement had been effected by Seidell's benzoylation process, which removes impurities. By this method von Ween had obtained 140 mgm. of pure vitamin B_1 from 75 kgm. rice polishings.

Prof. A. Seidell said that Prof. Jansen had had success with a method that had failed in his hands. He had felt that precipitating agents ought to be avoided, and so was led to the method of benzoylation in chloroform solution, which removes a considerable amount of nitrogenous material. He had not succeeded in obtaining crystals, although his purest preparation was nearly as active on rats, but when tested on pigeons by Peters' method the activity was found to be only 1/5 to 1/10 that of the crystals.

Prof. R. A. Peters said that he had hoped to be able to use the animal as a test object only and not concern himself with the physiological side of the problem, but he had found that it was only possible to reach a final conclusion on the chemistry when the physiology was also taken into account. He had been able to confirm Prof. Jansen's process up to the platinum chloride stage. Working with yeast he had obtained purification by removal of inactive material with lead acetate and baryta followed by adsorption of the vitamin by charcoal. By fractional precipitation with phosphotungstic acid at *p*H 5–7, vitamin B_1 was obtained. Its activity was 0·012 mgm. per dose, while that of Prof. Jansen's crystals in his hands was 0·008 mgm. Both preparations gave the Pauly reaction with the same intensity. Miss Reader had shown that 25–50 per cent of Prof Jansen's crystals had vitamin B_4 activity. She had now been able to isolate vitamin B_1 from B_4 by fractional adsorption on to charcoal in the earlier stages of the purification, but the separation of B_4 from B_1 was less complete.

Dr. B. C. Guha said that he had been able to separate B_1 from B_2 by electrodialysis. Vitamin B_1 appeared to be a strong base, while B_2 was a neutral substance.

The President, in summing up the discussion, said that the progress of the last few years should make them optimistic. He expected that we should soon know the constitution of vitamin D. The chemical problems involved were *a priori* difficult, but workers were finding that the compounds were amenable to the methods of organic chemistry. He thanked the visitors from overseas for taking part in the discussion.

University and Educational Intelligence.

Cambridge.—Dr. C. E. Tilley, of Emmanuel College, has been elected to the professorship of mineralogy and petrology as from October 1.

Leeds.—The West Yorkshire Coal Owners' Association has offered the University of Leeds an additional grant of nearly £1300 a year for the purpose of financing a scheme of research into industrial fluctuations and other matters, with special reference to their bearing upon the coal-mining and allied industries. The University Council has gratefully accepted this offer, and the work will be carried out under the direction of Prof. J. H. Jones, head of the Department of Economics. The Mining Department of the University has enjoyed a large measure of support from the West Yorkshire Coal Owners' Association, which for some time past has been making a grant in aid of the Department of £1000 a year. The Association was also one of the largest donors to the appeal issued in 1925, its gift of £25,000 being one of the factors which allowed the Mining Department to be dealt with as the first item in the building scheme. The total of the contributions made by the Association to the University exceeds £40,000.

The Congress of Universities of the Empire, under the presidency of H.R.H. the Prince of Wales, opened in London on July 1. On the first day several educational institutions and medical schools were open for inspection to members of the Congress and there was a special exhibition of educational and cultural films at Bush House. On July 3 the Prince of Wales held a reception and addressed the Congress in the Guildhall. The rest of the time in London was spent in visiting other educational institutions in and around London. On July 6 the Congress proceeds to Edinburgh, where it will remain in session until July 11. On July 7 the Lord Provost of Edinburgh will deliver an address, and in the afternoon there will be a meeting of members of the Universities' Bureau of the British Empire. The Marquess of Linlithgow will address the Congress on July 8, and this will be followed by discussions on the position of the university graduate in commerce and industry, and the standard and conditions of candidature for the degree of Ph.D. in relation to other post-graduate qualifications. The former discussion will be opened by Sir Robert Waley Cohen and the latter by Prof. D. Nichol Smith. On July 9, Lord Meston will give an address and Prof. F. E. Sandbach will open a discussion on the conditions of admission to universities. Later, Prof. W. E. Collinson will open a discussion on the provision of schemes of study leading to general honours degrees. Sir Donald MacAlister, Bart., will address the Congress on July 10. On the same day there will be a discussion on post-graduate study in medicine and surgery in Great Britain, which will be opened by Dr. H. L. Eason, and Sir Thomas Holland will open the last discussion of the Congress on the facilities for overseas students in British universities. Many excursions to places of educational and other interest, also receptions, have been arranged for the entertainment of members.

Birthdays and Research Centres.

July 6, 1873.—Mr. S. G. Brown, F.R.S., electrical engineer.

I am at present engaged on gyroscopic problems concerned with the sea, land, and air, which have been placed before me by the British and foreign governments. I am always willing to deal with any problems, and in fact I welcome them.

I am also engaged at the moment with acoustical and sound reproduction apparatus, especially in connexion with talking picture equipments and adaptations.

I am convinced that there are still vast fields to be explored where my reed telephone and microphone sound relay can usefully be employed, and I am working on these. My latest invention is the Microbox pick-up, a gramophone pick-up which can be used without employing valves or high power amplifiers. The only energy required can be derived from an ordinary 6-volt battery, and the pick-up can be used with ordinary or portable gramophones and it replaces the ordinary electrical pick-up.

July 8, 1861.—Sir J. Arthur Thomson, formerly Regius professor of natural history in the University of Aberdeen.

Since I retired from my Aberdeen professorship last autumn, I have been completing, with the help of Miss Isobel Dean, a large memoir on the Alcyonacea of the Siboga Expedition. Before I stop this sort of Linnæan work, to which I have devoted so many years, I should like to follow others in giving a general survey of the evolution of the alcyonarians. Along with my teacher and friend Patrick Geddes, I have just completed a somewhat detailed unconventional outline of general biology. But most of all, I am afraid, I have just been enjoying the luxury of doing nothing.

July 9, 1869.—Dr. J. W. Mellor, F.R.S., principal of the Pottery Department, North Staffordshire Technical College, Stoke-on-Trent, and Director of Research of the British Refractories Research Association.

In the research laboratories, investigations are being conducted under the auspices of the British Refractories Research Association on the nature and properties of the materials employed in the silicate industries; on the nature of the action of industrial furnaces on refractory materials; and on the manufacture of materials best fitted to resist the destructive agencies in the different types of industrial furnaces.

July 10, 1854.—Dr. George Lindsay Johnson, ophthalmic surgeon to H.M. Forces in Natal.

I am now engaged in completing a large work which has occupied my attention during my spare moments for upwards of forty years, namely, the comparative anatomy and physiology of the vertebrate eye, embracing nearly all available living families and genera of the mammals, reptiles, and amphibians, with references to the eyes of the birds and fishes. Two abstracts of this work have already been published in the *Transactions* of the Royal Society (1901 and 1904), with more than a hundred illustrations in colour and numerous illustrations in black and white on plates and in the text. I hope to have this work published during the current year. My chief reason why its publication has been delayed is due to the great expense of printing the coloured drawings, of which there are more than three hundred.

The practical utility of this work lies in its affording help towards the classification of the Vertebrata, which in a great many instances requires modification. This is especially the case among the families and genera of the rodents. There are still a few animals' eyes to be examined and depicted which I have hitherto been unable to procure or depict. Finally, the optical problems of refraction and accommodation, especially of amphibian mammals, require to be restudied. I would appeal to my colleagues (especially mathematicians and oculists) to assist me in this latter undertaking.

Societies and Academies.

LONDON.

Mineralogical Society, June 9.—**G. E. L. Carter**: On an occurrence of vanadiferous nodules on the coast of South Devon. The author describes an occurrence of vanadiferous nodules in the red marls that underlie the Budleigh Salterton pebble beds on the coast of South Devon. These nodules consist of siliceous and argillaceous material impregnated with vanadium oxide and calcium carbonate. A typical nodule examined at the Imperial Institute showed a roughly concentric structure, ill-defined black shells alternating with shells of light-coloured material. Radiating black bands stood out as ribs on the surface of the nodule. Analyses by Miss Hilda Bennett showed that the black portion of the nodule contained 13·96 per cent of vanadium oxide, estimated as pentoxide. The light-coloured portion of the nodule contained only 1·91 per cent of vanadium oxide, and was relatively richer in calcareous and siliceous matter than the blacker and more vanadiferous portion.—**M. H. Hey**: Studies on the zeolites. Part 2: Thomsonite (including faroelite) and gonnardite. A chemical, optical, and X-ray study of a considerable number of thomsonite specimens has led to the conclusion that thomsonite and faroelite form a continuous isomorphous series. The true symmetry of thomsonite is shown to be didigonal polar (C_{2v}). The unit cell is shown to contain $(Ca,Na)_6(Al,Si)_{20}O_{40} . 12H_2O$. The mean refractive index ranges from 1·517 to 1·535, falling with increase in the Si/Al ratio. Apparatus has been designed and applied to measure the vapour pressure of thomsonite at various temperatures and degrees of dehydration, and it appears very probable that a dimorphous high-temperature form exists, the transition being readily reversible. Gonnardite is probably identical with the high-temperature dimorphous form of thomsonite (meta-thomsonite), and is therefore to be regarded as a separate species.—**A. Russell**: An account of British mineral collectors and dealers in the seventeenth, eighteenth, and nineteenth centuries. A second instalment: John Woodward (1665–1728) and Charles Francis Greville (1749–1809).—**L. J. Spencer**: Hoba (South-West Africa), the largest known meteorite. The large mass of meteoric iron discovered in 1920 on Hoba West farm, 12 miles west of Grootfontein, measures about 10 × 9 feet on its flat upper surface, and is estimated to weigh 60 metric tons. It belongs to the group of nickel-rich ataxities. Chemical analysis by Mr. M. H. Hey shows iron 83·44 per cent, nickel 16·24 per cent, with small amounts of cobalt, copper, sulphur, phosphorus, and carbon. Photomicrographs (× 820) by Dr. J. M. Robertson show a minute plessite-like structure.—**L. J. Spencer**: Twelfth list of new mineral names. Since the publication in 1928 of the eleventh list of this series (the first was in 1897), 120 names have been collected from the current literature. In addition to the bibliographical reference, a brief description of the essential characters of the mineral and derivation of the name are given.—**J. Drugman**: On different habits of fluorite crystals. In fluorite the cube is usually the predominating form. Crystals of other habits—octahedral, rhombic-dodecahedral, and triakis-octahedral—are described. The temperature during the growth of the crystal has perhaps influenced its habit.

EDINBURGH.

Royal Society, June 1.—**H. Briggs**: The relation between the yield of crude oil and the composition of retortable carbonaceous minerals. Using graphical methods, the author showed that, while on the one hand the yield is connected to the percentage of volatile hydrocarbons, and on the other hand to the C/H ratio, these relations are too intangible to be of value. A more definite relation exists between the yield and the percentage of volatiles diminished by twice the oxygen percentage—a conclusion leading to the formula $Y = 0{\cdot}47\ (V - 2O)^{4/3}$, in which Y is the yield of crude oil in British imperial gallons per ton, V the percentage of volatile hydrocarbons, and O the percentage of oxygen in the mineral retorted.—**C. H. O'Donoghue**: Abnormalities of the vascular system of the Anura. One or more striking abnormalities in the blood vascular systems of forty-two specimens of *Rana temporaria* are described. A consideration of the developmental history of the vessels shows that many abnormalities are due to the retention of larval arrangements, and some due to the failure of a portion of the adult system to develop. For others there appears to be no explanation at present available, as, for example, the absence of a precaval vein on one side accompanied by the development of a transverse anastomosis whereby the precaval drainage is transferred to the other side. Connexions between the visceral arteries and veins and the lung find no explanation in the development of vessels or lungs, but analogous vessels to and from the visceral trunks and the swim bladder are found in some Teleostomi. The abnormalities throw a light on the normal relationships of certain vessels in the adult, and often suggest homologies with those of the generalised elasmobranchs.—**G. L. Purser**: The early stages of development of the vertebrates. The only growth-centre is the organiser, the position of which, throughout the phylum, is correlated with the apical pole and a meridian of latitude on the egg which depends upon the amount of yolk. Gastrulation is the formation, under the influence of the organiser, of a meristematic ring, by the proliferation of which the primary germ layers are laid down and growth to any length is made possible. There is no concrescence and the origin of the mesoderm is the same throughout the phylum, except for variations in the head. The evolution of yolkier eggs made it necessary for this ring to be split into a yolk and an embryogenic blastopore, which evolve into the edge of blastoderm and primitive streak respectively. In mammals the homology of all primitive streaks makes the derivation of the trophoblast and Rauber's layer or *Träger* from the yolk-laden cells of lower forms essential. Loss of yolk began in correlation with mammary secretion. Blastula-formation within the confining coats of the zygote is impossible, and the slipping of the cells over one another causes the final enclosure of the apical cells by the abapical ones. The true and false amnia are products of the extra-embryonic cœlom, which allows the expansion of the life-preserving allantois. The 'doubleness' of the endoderm of the blastocyst is due to the absence of yolk and consequent continued extension of the endoderm from the meristematic ring, first seen in the frog.—**Richard Elmhirst**: Studies in the Scottish marine fauna: the Crustacea of the sandy and muddy areas of the tidal zone. A study of quantitative samples from various parts of the coast reveals definite specific zoning in the genera *Bathyporeia* and *Corophium*.

PARIS.

Academy of Sciences, May 11.—**Jean Pierre Robert**: Some properties of *n*-metaharmonic functions.—**J. Dieudonné**: Univalent functions.—**Edouard Callandreau**: The lines of slip of a pulverent mass.—**L. Escande** and **M. Teissié Solier**: The conditions of working of the Pitot tube.—**Georges Marboux**: An electrical oscillator of low frequency stabilised by a tuning fork. The apparatus described and figured is closely analogous with the apparatus using piezo-electric quartz. The tuning fork replaces the quartz.—M. Auméras and A. Tamisier: The constitution and stability of two copper-nitrogen complexes.—Dumanois, Mondain-Monval, and Quanquin: The presence of peroxides in the gases from internal combustion motors. An experimental proof of the formation of peroxides and of aldehydes under conditions of working of an ordinary internal combustion engine.

ROME.

Royal National Academy of the Lincei, Dec. 7.—T. Levi-Civita: Plane sections of a body and orthobaric directrices.—Enea Bortolotti: Specialised differential quadratic forms. Ricca's calculus is shown to be easily extensible to these forms.—F. Conforto: Metric and foundations of absolute differential calculus in a continuous functional space.—Miron Nicolesco: Metaharmonic functions in n variables.—E. Okhlopkova: Certain problems on the limits of the theory of logarithmic potential. The theory of the functions of the complex variable is applied to the solution of certain problems of the limits of the theory of logarithmic potential for the circle.—V. Hlavaty: The curvature of non-holonomous varieties.—D. Graffi: An observation on the equation of the motion of a body of variable mass.—A. Signorini: The profile of bridge piers. The variation in kinetic energy between a stream disturbed by bridge piers and the non-disturbed stream is found to be independent of the configuration of the profile of the piers.—E. Bossa: Correction to the note on "The Hall effect for the metals, nickel, iron, and copper, in feeble magnetic fields".—Remo de Fazi and Antonio Hemmeler: Reactions between organic and mineral compounds (1). Natural sulphides and certain acyclic compounds. Pyrites yields (1) ferrous and ferric chlorides, ferrous sulphide, sulphur, carbon, and thiophosgene when treated with carbon tetrachloride at 320°-400° or at 450°; (2) ethyl mercaptan and ethyl sulphide respectively with ethyl alcohol and ether at 450°-500°; (3) thioacetic acid, traces of methyl mercaptan, methyl sulphide, carbon dioxide, hydrogen sulphide, and sulphur with acetic acid at 480°-500°; (4) hydrogen sulphide, carbon and sulphur dioxides, and thioacetic anhydride with acetic anhydride at 450°-480°. Stibine gives carbon disulphide and antimony trichloride when treated with carbon tetrachloride at 300°-325°, and thioacetic anhydride and antimony trichloride when treated with acetyl chloride at 300°-350°.—A. Mazzucchelli: Electrolytic deposition of chromium from ammonium chromo-oxalate.—Carmela Ruiz: Strophomenides of the Permian of the Sosio basin (Palermo).—Constantino Gorini: Acido-proteolytes and thermophiles in the pasteurisation of milk. Experimental results confirm the importance of these organisms in the pasteurisation of milk, and emphasise the necessity of cooling the milk thoroughly immediately after pasteurisation and keeping it cool until it is consumed. Examination for these bacteria furnishes a means of judging of the efficiency of the pasteurisation.—G. Mezzadroli and E. Vareton: Action of ultra-short electromagnetic waves (2–3 metres) on amylase. These waves exert a favourable effect on the enzymes of seeds, especially on the amylase. When subjected to their action for 30 minutes prior to steeping, barley attains its maximum saccharifying power 0·5–1 day earlier than the untreated control, this period being increased to 2 days if irradiation is continued daily. Moreover, the absolute value of the maximum saccharifying power is increased by as much as 15 per cent.—D. Cattaneo: Observations on the structure of the vitreous.—B. Finzi: Tuberculin and anæsotuberculin.

VIENNA.

Academy of Sciences, Feb. 12.—E. Haberfelner: Graptoliths from the Upper Silurian of the Carnic Alps. Part I. Summit, north side.

Feb. 19.—A. Müller and E. Feld: The thermal decomposition of hydrochloric-1, 6-diamino-n-hexane.—A. Muller and E. Feld: Synthesis of γ-amino-n-capronic acid and of α'-ethyl-α-pyrrolidine.—E. Tschermak: Some flower anomalies and their mode of inheritance in primulas. Doubling of flowers is common in the plant world, but the formation of a corolla-like calyx, so-called 'calycanthemie', is only known in Primulaceæ and a few other orders. The inheritance of calycanthemie has been studied by crosses between these and normal forms of *Primula acaulis, elatior*, and *officinalis*, also by crosses with *P. Juliœ*. In double garden primroses, andrœcium and gynæceum become petaloid, but in double auricula the gynæceum generally remains intact, its doubling concerning the corolla. It is also possible to raise hybrid primulas in which doubling is combined with calycanthemie.—H. V. Graber: Report No. 5 on geological and petrographic researches in the Upper Austrian and Bohemian primitive rocks.—K. Fritsch: Contributions to the knowledge of the Gesneriaceæ. (3) The inflorescence of *Haberlea rhodopensis*.—G. Orban: Radium Institute communication No. 271. Investigations on the natural ionisation of air with the Wilson chamber using alcohol vapour.

Feb. 26.—A. Tornquist: The mineralisation phases of the younger east-alpine ore deposits.—A. Rollett: The course of esterification with mixed anhydrides and mixtures of anhydrides.—H. Lieb and M. Mladenovic: Elemic acid from Manila elemi-resin.—M. Mladenovic and H. Lieb: A new resinic acid from Manila elemi-resin.—F. Hölzl: Hexacyano-cobaltic-acid and methyl alcohol.—K. W. F. Kohlrausch: Additive nature of the atomic chemical combining force.—F. Werner and R. Ebner: Results of a zoological expedition to Morocco. Two new forms of fish and several previously undescribed Amphibia and Reptilia.—O. Pongracic: Contributions to the anatomy of the Gesneriaceæ.

March 5.—H. Rebel: The biological significance of societies of larvæ.

March 12.—M. Kohn and S. Fink: On dichlor-phenols, trichlor-phenols, and their bromination products. Thirty-sixth communication on bromo-phenols.—M. Kohn and L. Steiner: Brominated hydroquinone- and toluhydroquinone ether. Thirty-seventh communication.—M. Kohn: Debromination by benzol and aluminium chloride.—G. Orban: Radium Institute communication, No. 272. Researches on the radioactivity of the alkali metals by the cloud track method. No activity was detected with cæsium. The β-rays of potassium and rubidium were examined.—A. Schedler and M. Toperczer: First report on the distribution of declination in Austria at the epoch 1930·0. A new magnetic survey was undertaken in 1928, declination, inclination, and horizontal intensity being measured at more than a hundred evenly distributed points. A table of results is added.

Official Publications Received.

BRITISH.

Nyasaland Protectorate. Annual Report of the Geological Survey Department for the Year 1930. Pp. 16. (Zomba.)

The Empire Forestry Handbook, 1931. Edited by Fraser Story. Pp. 189. (London: Empire Forestry Association.) 3s. 6d.

Department of Scientific and Industrial Research. Report of the Food Investigation Board for the Year 1930. Pp. vii+175. (London: H.M. Stationery Office.) 3s. net.

The Lister Institute of Preventive Medicine. Report of the Governing Body, 1931. Pp. 32. (London.)
Transactions of the Institute of Marine Engineers, Incorporated. Session 1930, Vol. 42, May. Pp. 1045-1051+cxii. (London.)

FOREIGN.

Bodily Positions in Restful Sleep. By Dr. H. M. Johnson. Pp. 24 (Pittsburgh: Mellon Institute of Industrial Research.)
Spisy Lékařské Fakulty Masarykovy University (Publications de la Faculté de Médecine). Svazek 9, Spis 86-98. Pp. xvi+16+13+24+11+4+6+4+26+8+8+14+10+8. (Brno: A. Piša.) 30 Kč.
Biologické Spisy vysoké Školy Zvěrolékařské (Biologické Spisy Academiae Veterinariae). Svazek 8, Spis 111-126. Pp. iii+53+23+8+14+15+10+16+20+10+13+43+43+13+13+30+21. (Brno: A. Piša.)

CATALOGUES.

Ephedrine B.D.H. Pp. 10. Manganese Butyrate B.D.H. Pp. 7. (London: The British Drug Houses, Ltd.)
A Catalogue of Interesting and Scarce Books. (No. 459.) Pp. 36. (Cambridge: Bowes and Bowes.)
General Literature and Miscellaneous Subjects. (Catalogue No. 539.) Pp. 100. (London: Francis Edwards, Ltd.)
The Taylor-Hobson Outlook. Vol. 3, No. 19, June. Pp. 173-180. (Leicester and London: Taylor, Taylor and Hobson, Ltd.)
Colour in Photography. Pp. 16. (London: Burroughs Wellcome and Co.)

Diary of Societies.

FRIDAY, JULY 3.

GEOLOGISTS' ASSOCIATION (in Architectural Theatre, University College), at 7.30.—Dr. W. D. Lang: The Inland Lower Lias of Dorset.—Dr. W. F. Whittard: The Geology of the Ordovician and Valentian Rocks of the Shelve Country, Shropshire.
ASSOCIATION OF ECONOMIC BIOLOGISTS (Summer Meeting) (at Farnham House Parasite Laboratory, Farnham Royal).
ROYAL SOCIETY OF MEDICINE (Study of Disease in Children Section) (at Bath).

MONDAY, JULY 6.

ROYAL SOCIETY OF EDINBURGH, at 4.30.—Presentation to Dr. Nellie B. Eales of Makdougall-Brisbane Prize.—Dr. J. F. V. Phillips, J. D. Scott, and J. Y. Moggridge: Photochemical Measurements of Light-intensity in Two Common Vegetation Types in Tropical Africa, by means of an Improved Eder-Hecht Photometer. (*To be read by title.*)
ROYAL INSTITUTION OF GREAT BRITAIN, at 5.—General Meeting.

TUESDAY, JULY 7.

ROYAL SOCIETY OF MEDICINE, at 4.30.—Annual General Meeting.

WEDNESDAY, JULY 8.

BRITISH PSYCHOLOGICAL SOCIETY (Æsthetics Section) (at Bedford College), at 5.30.—E. J. Sullivan: The Grotesque in Art.

CONGRESSES.

JUNE 29 TO JULY 4.

INTERNATIONAL CONGRESS OF THE HISTORY OF SCIENCE AND TECHNOLOGY.
Friday, July 3, at 10 A.M. (at Science Museum).—Interdependence of Pure and Applied Science.
Saturday, July 4 (at Oxford).

JUNE 29 TO JULY 4.

CONGRESS OF NAVAL ARCHITECTS (Institution of Naval Architects and Association Technique Maritime et Aéronautique) (at Paris).
Saturday, July 4.—Papers on—
Shipbuilding.
Marine Engineering.
Civil Aviation.

JULY 1 TO 4.

CONGRESS OF UNIVERSITIES OF THE EMPIRE (in London).
Friday, July 3, at 11 A.M. (at Guildhall).—Reception, and Address by H.R.H. the Prince of Wales (President).
Saturday, July 4.—Visits.

JULY 6 TO 11 (IN EDINBURGH).

Tuesday, July 7, at 10.30 A.M.—Address by the Lord Provost of Edinburgh.
Wednesday, July 8, at 10.30 A.M.—Address by the Marquess of Linlithgow.
At 11 A.M.—Sir Robert Waley Cohen and others: Discussion on The University Graduate in Commerce and Industry.
Prof. D. Nicol Smith and others: Discussion on The Standard and the Conditions of Candidature for Ph.D. in relation to other Post-graduate Qualifications.
Thursday, July 9, at 10.30 A.M.—Address by Lord Meston.
At 11 A.M.—Prof. F. E. Sandbach and others: Discussion on Conditions of Admission to Universities and their Effects.
Prof. W. E. Collinson and others: Discussion on The Provision of Schemes of Study leading to General Honours Degrees.
Friday, July 10, at 10.30 A.M.—Address by Sir Donald Macalister, Bart.
At 11 A.M.—Dr. H. L. Eason and others: Discussion on Post-graduate Study in Medicine and Surgery in Great Britain.
Sir Thomas H. Holland and others: Discussion on Facilities for Overseas Students in British Universities.
Saturday, July 11.—Visits.

JULY 4 TO 11.

ROYAL SANITARY INSTITUTE (at Glasgow).—Subjects for Discussion:—
The Rôle of the Hospital Relative to the Development of Preventive Medicine.
The Proposals of the British Medical Association for a General Medical Service, from the Standpoint of Preventive Medicine, and in Relation to National Health Insurance.
Development of the National Health Insurance Scheme.
Administration of the Local Government Act, 1929.
Eugenic Sterilisation.
Health Certificates before Marriage.
Pregnancy and Tuberculosis.
Maternity and Child Welfare Work.

JULY 6 TO 11.

CONFERENCE OF MUSEUMS ASSOCIATION (at Plymouth).
Monday, July 6, at 5.15 P.M. and 8 P.M.
Tuesday, July 7, at 10 A.M.—Official Welcome by the Mayor.
At 10.20 A.M.—Sir Henry A. Miers: Presidential Address.
At 11.5 A.M.—Lt.-Col. J. M. Mitchell: Address.
At 11.45 A.M.—Discussion.
At 12 noon.—Councillor J. Bailey: The 1924 and 1931 Loans Acts.
At 3 P.M.—A. J. Caddie: Plymouth Porcelain.
Wednesday, July 8, at 9.30 A.M.—W. G. Constable: The Courtauld Institute of Art.
At 10.15 A.M.—S. C. Kaines Smith: Art Museum Problems.
At 11 A.M.—K. de B. Codrington: A Suggested System of Museum Registration.
At 11.45 A.M.—Dr. L. J. Spencer: Paper for Museum Labels.
At 6 P.M.—Meetings of Regional Federations.
Thursday, July 9, at 9.30 A.M.—Annual Business Meeting.
At 11.30 A.M.—Dr. W. T. Calman: Taxonomy in the Museum.
At 12.15 P.M.—H. J. M. Maltby: Present Day Problems of Provincial Museums.
At 2.30 P.M.—Dr. E. J. Allen: The Preservation of Marine Life, Wet or Dry Specimens.
Friday, July 10, at 9.30 A.M.—Prof. J. H. Iliffe: Museum Problems in Canada.
At 10.15 A.M.—Dr. H. Murray: A Simple Way to Test Museum Value.
At 11.30 A.M.—F. Loney: Why do we use Plate Glass in Museums?
Saturday, July 11.—Excursions.

JULY 9.

BRITISH ELECTRO-FARMING CONFERENCE (at Royal Agricultural Show, Warwick), at 3.—M. M. Harvey: Electricity on the Farm, including Dairy and Poultry Farming.

JULY 9 AND 10.

OPHTHALMOLOGICAL CONGRESS (at Oxford).
Thursday, June 9.—Symposium:—L. Paton, Sir Percy Sargent, Dr. H. M. Traquair, N. Dott, and Prof. A. Schüller: The Diagnosis of Intracranial New Growths.
Prof. G. Elliot Smith: The Evolution of the Instruments of Vision (Address).
Friday, June 10.—Dr. Baillart: Tonometry.
P. Adams: An Ophthalmological Mélange (Doyne Memorial Lecture).
J. Craig and Prof. Schüller: Discussion on Penetrating Wounds of the Eye.

GENERAL MEETING.

JULY 8 TO 10.

INSTITUTION OF MINING ENGINEERS (at Manchester).
Wednesday, July 8, at 11 A.M. (at College of Technology).
Dr. T. D. Jones and C. E. Morgan: The Candle-powers of Safety-lamps before and after Underground Shifts.
Prof. W. H. McMillan: Comparative Photometric Tests of Miners' Electric Hand Lamps.
Prof. R. V. Wheeler and D. W. Woodhead: The Flame Safety-lamp: The Use of Reflectors.
Discussion on The Problem of Lighting in and about Mines.
At 2.15.—Prof. H. Briggs: History of the Coal-oil Industry.
R. Faulkner: Roof Control in the Arley Seam, No. 1 Pit.
Thursday, July 9, and *Friday, July* 10.—Visits.

EXHIBITION.

JULY 6 TO 25.

EXHIBITION OF CANAANITE AND HYKSOS ANTIQUITIES (at University College, London).

Editorial and Publishing Offices:
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.

Editorial communications should be addressed to the Editor.
Advertisements and business letters to the Publishers.

Telephone Number: GERRARD 8830.
Telegraphic Address: PHUSIS, WESTRAND, LONDON.