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The Coal Resources of Great Britain.

TO all sections of the community, the state of the coal mining industry in Great Britain is a source of great anxiety. The real difficulties which the industry has to face depend upon causes which are very deeply rooted. We were the first nation to develop our coal resources extensively and, owing to the fact that we had originally magnificent coal seams lying at no great depths, and above all, that our coal-fields lay close to the seaboard and within easy access of excellent harbours, we built up the magnificent coal trade upon which we justly pride ourselves. Coal, our main national asset, is unfortunately a wasting asset; once extracted it can never be replaced. At the present moment we are practically producing 23 per cent. of the world's coal output, whilst we have only 2½ per cent. of the world's coal resources; in other words, we are drawing upon our coal reserves nine times as fast as the rest of the world, and these reserves are therefore gradually approaching extinction.

At the present moment, however, what we have to fear is not the exhaustion of our coal supplies so much as the increased cost of our coal production, which makes it impossible for us to compete with other nations for the coal trade of the world. This increase in price is no doubt to some extent due to natural causes, but to a far greater extent has been brought about artificially. Unless we can produce coal as cheaply as the nations with whom we are brought into competition, our coal trade, and with it the whole nation, must decline. The cost of coal production is made up of many items, into all of which wages enter to a greater or lesser extent, but direct wages make up about two-thirds of that cost. It depends, therefore, entirely upon labour whether our coal trade is to prosper or to suffer gradual annihilation. It must be emphasised in the strongest possible terms that this insistent demand for cheap production does not by any means necessarily imply low wages per man employed; it does require a low wages cost per ton of coal produced; in other words, the key to the situation lies in the maximum production per worker engaged in the industry.

In the United States of America, the cost of coal production is roughly two-thirds of what it is in Great Britain (12*s.* 8·4*d.* per ton as against 19*s.* 0·69*d.*); nevertheless, the men engaged earn much better wages, simply because the output per man is so much higher (3·82 tons per shift as against 0·928 ton). This fact is due in part beyond doubt to natural causes, but is also due to the fact that the men themselves work hard and that the Trade Unions have always opposed anything like a "ca' canny" policy. These same reasons furthermore help American collieries to develop extensively mechanical methods of machine mining. It is often overlooked that a severe limitation of the hours of labour, such as we have in Britain, prevents the extensive adoption of coal-cutting machines; these can only be used to advantage if they are kept actively employed. A colliery cannot afford to put capital into such machines if they are only to be worked six hours out of the twenty-four, and this consideration doubly handicaps our coal industry.

When the future of the industry comes to be considered, it may well be found that neither American nor German competition will prove so formidable as competition from China, India, and South Africa. The price of coal at the pit's mouth in these countries is only about one-third of our own, and their immense coal resources necessarily bring them into prominence in discussing the future of the British coal industry. It is true that we have the advantage of a well-established coal trade, which has developed as a natural consequence of so many of the British coalfields being so well situated geographically, and it is true that trade is loth to leave the channels in which it has been accustomed to flow. Certain of our labour leaders, however, by their continuously repeated threats of strikes, are demolishing that confidence in Britain's ability to supply the goods as and when customers require them, which formed the real basis of Britain's supremacy in the coal trade, and without which the maintenance of that trade is impossible. Once that South Africa has developed and organised suitable transport facilities and has built up for itself the trade which our internal dissensions have turned from us, our chance of competing is gone. Even now it is going; for some years past Natal has been competing successfully in the Bombay markets with British and Indian coals.

It seems impossible to avoid the conclusion that we cannot hope to regain the position which we once held, that of the world's chief manufacturers, as this was based essentially upon the fact that we were able to produce coal in any desired quantity more cheaply than could any of our competitors, and the question which to-day is the most insistent is whether anything can be done, if not to restore our lost supremacy, at any rate to find some new method of utilising our coal to advantage, so as to save us from national extinction.

The situation is reviewed in an interesting article by Mr. Lancelot Lawton on "Coal and the Future" in the August issue of the *Fortnightly Review*. With most of the views therein expressed the majority of serious students of the economics of the coal industry will cordially agree, although there are several points to which exception may be taken. Thus the author commences with the statement that "the critical condition of the British coal-mining industry is due to the fact that to a large extent thicker seams at moderate depths are being exhausted"; the fact of this exhaustion is sufficiently well known, but working at moderate and even considerable depths is to-day no longer a serious problem. With modern methods of engineering, the increase in the working cost of winning coal from deep-lying seams is negligible, as witness the fact that the only collieries in Britain that are working to-day under anything like satisfactory conditions are the deep pits in the concealed Yorkshire coalfield. The real crux in the working of deep seams lies in the vastly greater initial outlay required, but, once capital can be assured that it will get an adequate return for its employment in such a relatively risky undertaking, depths of even of a thousand yards can no longer be considered a real obstacle to economic working. It may fairly be said that in spite of the wild talk of Socialists, one of the serious problems that confronts the coal industry is how to inspire capitalists with this assurance; collieries inevitably become exhausted in the process of time, and if our coal trade is to be maintained, new pits must be sunk and new collieries opened out. Needless to say, this can only be done if the capitalist is assured that the investment involves only a fair business risk.

Like many others, Mr. Lawton pins his faith in the regeneration of the coal industry upon the general employment of low temperature carbonisation, with its attendant production of oil and other bye-products. Low temperature carbonisation is, however, by no means yet as assured of success as many seem to think, for they generally overlook not only the mechanical difficulties, but also the chemical difficulties which the process presents, such as are well indicated in the paper on the "Study of the Tars and Oils obtained from Coal," by Messrs. Sinnatt and King, read at Leeds at the recent meeting of the Chemical Engineering Group of the Society of Chemical Industry. Furthermore, there are other processes to be taken into account; it may fairly be said that for the production of oil from coal the Bergius process would seem to promise to rival, if not to surpass, low temperature carbonisation; the "Synthol process," based upon the interaction between carbonic oxide and hydrogen, also must not be left out of account, although this is not an industrial process to-day. Fischer, in his recent work on the conversion of coal into oil, translated by Lessing, says: "The Synthol Process, combined with primary tar production, likewise indicates the possibility of a total conversion, and indeed offers, in my opinion, the best promise for the future."

In view of these and many other possibilities which the scientific research of coal, now actively pursued in many quarters, is opening up, it is more than doubtful whether it would be a wise policy to-day to embark upon the construction of costly low-temperature carbonisation plants. A few years may well see this process relegated to the background and displaced by some more profitable method.

Capitalists are surely wise in waiting to see which process is likely to be the most advantageous before spending money on plants, which, for all we know to-day, in a few years may have only a scrap-iron value.

It is greatly to be feared that any remedy based upon the treatment of coal after it is won would not help the situation. As Mr. Lawton truly enough points out, any improvements in the utilisation of coal cannot possibly be confined to Britain, but will be universally adopted by other nations engaged in coal production, so that we necessarily come back to the economic proposition that the future of coal rests with those nations that can produce it cheaply. There is, in fact, only one remedy for the present critical position of the British coal industry, and that is the cheaper production of coal, which, as already said, means a greater output per man employed in the industry. A colliery that is unable to produce coal at a price less than the coal is worth in the world's markets is not a national asset but a national liability so long as it continues to work, and no method of treating the coal after it has been raised can possibly alter that cardinal fact.

HENRY LOUIS.

Science on Exhibition.

Phases of Modern Science. Published in connexion with the Science Exhibit arranged by a Committee of the Royal Society in the Pavilion of His Majesty's Government at the British Empire Exhibition, 1925. Pp. vii+232. (London: A. and F. Denny, Ltd., 1925.) 3s. 6d.

THAT a space should have been set aside for scientific exhibits at the British Empire Exhibition is a compliment, well deserved but not the less welcome, to the progress of modern science. That the task of filling this space should fall upon the Royal Society was inevitable, and it would certainly be difficult to conceive, and impossible to convene, a stronger committee than that appointed by the Society for the purpose. The volume which we have before us, with the title "Phases of Modern Science," contains a record of its second and revised version of a scientific exhibition. The actual guide to the exhibits occupies the second and smaller portion of the book. The first and larger part consists of articles, by many of our most eminent men of science, dealing, more or less directly, with the subjects which the exhibits are intended to illustrate. Chemistry is not dealt with, the exhibits in this branch of science having been arranged by the Association of British Chemical Manufacturers in the Palace of Industry.

There is a notion current that scientific workers are shockingly bad showmen. They are accused of being in possession of all kinds of fascinating secrets which they are either unwilling or more probably incompetent to communicate. They are supposed, through some defect in their education, to be unable to speak in language understanded by the people, and from time to time journalists have attempted to translate this scientific jargon into their own, with results which have not always been happy. We think that a careful study of the articles in this volume should convince any unprejudiced reader that the accusation is without any real basis. It is difficult to imagine how the present state of our knowledge of radiation, for example, could be expressed more simply and, we may add, more delightfully than in Sir Oliver Lodge's introductory article on "Radiation," or how recent advances in astronomy, made as they were by a masterly combination of physical imagination and mathematical analysis, could be conveyed more happily than in Prof. Eddington's article on "The Interior of a Star." If it is not invidious to pick out one article when so many are good, this contribution of Prof. Eddington, which is abstracted from a Royal Institution discourse, strikes us as a model of popular scientific exposition. Sir Ernest Rutherford on "Electricity and Matter," and Dr. Aston on "Atoms and Isotopes," are almost equally successful.

It is not, of course, to be assumed that these articles can be followed entirely without effort by a reader devoid of scientific knowledge. The temple of science is, unfortunately, not furnished with lifts, and whosoever would ascend to the upper stories, where building is in progress, must be prepared to do a little climbing, however skilful his guide may be. The phases of modern science dealt with in this volume are the culmination of many years of scientific discovery and research, and some knowledge of this preliminary work is necessary, not merely for understanding but even for enjoyment. The delight of the spectators when a conjurer produces a rabbit from a top-hat is founded on their previous knowledge of the natural history of top-hats and rabbits, and the thrill which the scientific world experienced when Sir Ernest Rutherford produced hydrogen from nitrogen is similarly based on some previous knowledge of the chemistry of these substances, and is not to be achieved by one to whom both hydrogen and nitrogen are equally unknown. It is to such inherent difficulties, and not to any lack of showmanship, that we must ascribe the hiatus which we all deplore between the scientific worker and the public.

All parts of science do not present equal difficulties, and, it must be confessed, all eminent men of science do not possess the same facility for popular exposition. In the "Circulation of the Atmosphere," and in the "Water in the Atmosphere," Sir Napier Shaw and Dr. G. C. Simpson have subjects which appeal to the man in the street, ever interested in that perennial source of conversation, the weather, and deal with them in a way which will appeal not only to the general reader but also to the scientific worker who has not hitherto chanced to stray down the interesting bypath of meteorology. Prof. Fowler, on the other hand, in the "Origin of Spectra," and Dr. Chree in "Atmospheric Electricity," are clearly writing for students of science, and make no attempt to reach the uninitiated. Both articles are good of their kind, and Dr. Chree's, in particular, is a valuable summary of facts and phenomena which the physicist does not usually stumble across in his ordinary reading.

Of the biological articles, which occupy a somewhat unduly small space in the volume, the majority deal more or less directly with the theory of evolution and natural selection. The conclusions drawn are not such as would commend themselves to the stalwart "Fundamentalists" of Tennessee. In this portion of the book the present reviewer can claim to be in the position of the general reader, and can testify from personal experience that, though he can understand the complaints which are lodged sometimes of too free a use of technical language by scientific writers, these biologists have certainly succeeded in "getting their ideas across." His only regret is that they do not fill a larger space in the bill. There are, however, strict limits to the amount of printed matter which can be sold at the modest price of this volume.

Of the exhibits themselves it may be said, in conclusion, that they prove that to his own peculiar audience, the man of science can be an incomparably fine showman. The fact that the exhibits are confined almost wholly to the more recent developments of science makes it inevitable that their principal appeal should be to the serious student of science. To the younger students, and particularly to those from the smaller seats of learning, somewhat remote from the larger institutions where the tide of research flows at its fullest, this collection has been a source of inspiration and delight. By them, at any rate, this little volume will be cherished as a memento of a memorable event, while many others may find in its introductory articles a pleasant and convenient means of learning, on the best authority, the present position of knowledge and conjecture in phases of modern science which are not peculiarly their own.

The Realm of Plants.

Plants and Man: a Series of Essays relating to the Botany of Ordinary Life. By Prof. F. O. Bower. Pp. xii+365. (London: Macmillan and Co., Ltd., 1925.) 14*s*. net.

IF an extra-terrestrial observer, gifted with superhuman powers of ocular accommodation and unhampered by human prejudices as to man's position in the scheme of things, were given the opportunity of surveying with detachment the myriad-patterned pellicle of life that invests the earth, the function of the human species might afford him material for confusing speculation. As he gazed on some parts of the planet he might be driven to entertain an Erewhonian conception of man's relation to machinery, but, surveying the greater part of the land surface, he might well be excused for concluding that man's chief function was the distribution of certain dominant species of plants, for he would see almost everywhere men toiling to spread the triumphant grasses and a host of other less dominant but still powerful green organisms. In this view of man's relation to plants, our extra-planetary philosopher would not be without a certain amount of human concurrence, for to a large section of humanity a seductive species of Rosaceæ represents the primal cause of man's introduction to that distasteful (?) form of activity known as work.

Although in his latest book Prof. Bower has not expounded the polity of plants from quite such a Saturnian point of view, both the order of its title, "Plants and Man," and the presentation of its matter, are not without a tincture of such significance. His theme is the mutual reactions of plants and man, skilfully leading on to the final vision of the fundamental dependence of man on his fellow-creatures the plants for all that he has become and yet may be. It is impossible within the compass of a review to give an adequate idea of the multifarious relations between plants and man so succinctly and clearly presented in the thirty essays that form the book, and an attempt at a general indication of its contents must suffice. The first five essays are devoted to the green cell that tints the continents and islands, and is the foundation of all life thereon and in the sea, and to the general scheme of construction and the vital processes of the complicated commonwealth of cells that forms plants. The influence of the seasons is touched upon in another essay, and after this general introduction the reader is taken in pleasant and suggestive discourse by meadow and pasture, through woodland, over moor and mountain, and along the shore.

From these varied and extensive excursions we come to the only relation that plants have to "play." The struggle for existence and supremacy amongst themselves, although it might permit rest, would allow of no indulgence in "play," even if it were not inhibited by the line of life they have chosen, but in the share they take in the formation of golf links and playing fields, plants make some amends to man for his expulsion from an idle Eden. After play comes consideration of man's most intimate active relation with plants, that fundamental form of work, cultivation, which under flowers and fruits, vegetables and grains, is discussed with a wealth of allusion and illustration. Human interest in a derivative form of work, engineering, gives the keynote to three essays on the mechanical construction of plants, and on the methods by which they have solved the mechanical problems forced upon them by the conditions of their life, and have anticipated many of man's engineering devices. The physical properties of wood and bast, which permit of an amazing range of application from house-building and cloth-weaving to the divine music of the violin, are the subject of two chapters. In their final function in completing the full circle of the wheel of life, which starting from the inorganic, through the green cell returns to the inorganic through fungi and bacteria, plants are shown as the earth's prime sanitary agents and indispensable to man in his most advanced sanitary practice.

The close social life of plants and the various expedients—ranging from mutually beneficial co-operation to the worst forms of parasitism—by which plants attempt to cope with the ever-pressing problems of over-population and unrestricted competition are admirably outlined in several chapters. These same problems bid fair to be the supreme ones of the future for humanity also, and in the human handling of them the world of plants is not only a living lesson and a warning, but will dictate some of the most important conditions for their solution. It is, therefore, well that the note of the concluding essays should be man's dependence and influence on vegetation. Prof. Bower rightly emphasises the tragic aspects of man's interference with the balance of plant life—and, as a consequence thereof, with animal life also. In this, as in other things, the evil wrought by one generation lives after it to plague those that follow. Happily one need not yet conjure up the dreadful vision of a day when man will have brought it about that over all the earth the desert will be the only contrast to the sown, but much depends on man using his powers with more discrimination in the future than he has in the past. It is in helping to spread appreciation of this, no less than in its enjoyable presentation of the life and work of plants themselves, that Prof. Bower's book has a value all its own.

Ether and Erdgeist.

Ether and Reality: a Series of Discourses on the many Functions of the Ether of Space. By Sir Oliver Lodge. (The Broadcast Library.) Pp. 179. (London: Hodder and Stoughton, Ltd., 1925.) 3*s.* 6*d.* net.

EVERYTHING that Sir Oliver Lodge writes bears so clear an imprint of his powerful and persuasive personality that a book bearing his name may be confidently anticipated to hold the reader's interest and stir his imagination. In the present little work such an expectation is not disappointed. Sir Oliver has a well-known enthusiasm for a massive, elastic, all-functioning ether of transcendent reality, and his whole-hearted belief finds expression in a lively, yet learned, eloquence which does justice to his theme. He treats of the ether in the most comprehensive spirit, and his book contains not only a survey of all the wider problems of physics in connexion with which an ether may be invoked, but also philosophy, elevating moral reflections, and an inspiring vision of the perfectibility of man.

The point of view is, perhaps, best expressed by a sentence taken from the chapter on "The Ultimate Physical Reality": "Speculatively and intuitively we feel to be more in direct touch with the ether than with matter." Sir Oliver regards the ether less as a working hypothesis than as a revealed reality. He sees in it a possible vehicle for psychical manifestations of man's individuality—consciousness, memory, and affection. "It is the primary instrument of Mind, the vehicle of Soul, the habitation of Spirit. Truly it may be called the living garment of God." It is in almost these words that the Erdgeist in Goethe's *Faust* speaks of his activities:

> "So schaff ich am sausenden Webstuhl der Zeit
> Und wirke der Gottheit lebendiges Kleid."

It is not on physical evidence alone that Sir Oliver relies, but on something of the mystic inspiration and psychic experiences which prompted the great poet's words.

In spite of the charm and simplicity with which the book is written, some difficulty may be experienced in understanding exactly what Sir Oliver wishes to lay down as regards the physical properties of the ether. For example, he says that the fact that the ether transmits waves proves that it must possess elasticity and inertia, because material bodies that transmit waves have these properties, and then says: "The possession of these properties makes the ether very real." But as the possession of a quasi-material mechanism must be postulated in order to endow the ether with these properties, this does not, to the present writer, appear convincing. Again, he says at one place that "Ether is not to be explained in terms of matter," but this, apparently, does not mean that the ether is not to be given many properties of matter. At the heading of one chapter he quotes a passage from Einstein containing the words: "But this ether may not be thought of as endowed with the quality characteristic of ponderable media," yet he nowhere discusses the difficulty presented by the fact that the ether cannot be used as a frame of reference. The present writer has no desire to carp: he gratefully acknowledges the pleasure he has got from reading the book, yet he cannot see what is gained by calculating a mass and an elasticity for an ether which has not the properties of a ponderable medium, so long as these properties of mass and elasticity serve only to explain the very transmission of waves which is the ground for their postulation. Of course, if they helped to understand cohesion or gravitation, of which Sir Oliver explains the ether to be the seat, or the behaviour of light in the neighbourhood of gravitating matter, every one would welcome them, but, as it is, to some they may well seem *entia praeter necessitatem multiplicata*. There is, by the way, nothing said of the possibilities of Silberstein's ether of variable density, condensed at the surface of material bodies, which recent experiments suggest will have to be seriously considered.

The book is, of course, intended for non-technical readers, and is bound to have a wide circulation and give delight to very many. The points that have troubled the present reviewer are very possibly not such as will trouble those approaching the book with a wider outlook. The general spirit of the little book is admirable, and, after all, that is what counts.

E. N. DA C. A.

The Study of Physical Chemistry.

(1) *Physical Chemistry for Students of Medicine.* By Prof. Alexander Findlay. Pp. ix+227. (London: Longmans, Green and Co., 1924.) 8*s.* 6*d.* net.

(2) *L'Énergétique des réactions chimiques: leçons professées à la Sorbonne.* Par Prof. G. Urbain. (Collection de Physique et Chimie.) Pp. viii+267. (Paris: Gaston Doin, 1925.) 25 francs.

(3) *Les notions fondamentales d'élément chimique et d'atome.* Par Georges Urbain. (Science et civilisation: Collection d'exposés synthétiques du savoir humain.) Pp. iv+172. (Paris: Gauthier-Villars et Cie, 1925.) 10 francs.

(4) *Inorganic Physical Chemistry.* By Prof. G. H. Cartledge. Pp. xvi+463. (Boston and London: Ginn and Co., Ltd., 1924.) 22*s.* 6*d.*

(1) PROF. FINDLAY'S "Physical Chemistry for Students of Medicine" recalls in its appearance as well as in its literary qualities the books by this author which are already familiar to all students of chemistry. It is, however, only necessary to read as far as the title of the second chapter, "The Aqueous Milieu of the Life Processes," in order to realise that the biological aspects of physical chemistry have been thrust into the forefront, in order to secure the interest and attention of the medical student, since it is not usual for a physical chemist to describe his favourite aqueous solutions and suspensions under so foreign a designation. The writer of such a book as this can achieve his object most readily by teaching the familiar and fundamental truths of his science with the help of novel illustrations derived from that field of applied science in which his readers are interested. We therefore find the problems of solubility, surface tension, viscosity and osmotic pressure illustrated by reference to the behaviour of blood and urine, and to the plasmolysis of cells or the hæmolysis of blood-corpuscles. This method, when used by a teacher of experience, not only interests the reader, but also has the further advantage of showing him how to apply the methods of pure science to his own specialised studies. No proof is needed to establish Prof. Findlay's skill as a writer on physical chemistry: the present volume appears to the reviewer to prove that he has at least familiarised himself sufficiently with the biochemical aspects of his subject to enable him to provide a useful guide for biological workers who wish to join him in this field of work.

The author will perhaps pardon, as a personal weakness of the reviewer, the prejudice which makes him regard it as a retrograde step, after teaching the student to write the formula of an amino-acid as an internal salt, $\overset{+}{N}H_3 . CH_2 . CO . \overset{-}{O}$, to finish by asking him to regard this ion as having neutralised its two charges by swallowing its own tail, after the manner of a fried whiting. It is not every fish that can be induced to perform this acrobatic feat, and Pfeiffer's proof that "distance is no object" in preparing a betaine from an amino-acid, since these can be produced from *meta* and *para* as readily as from *ortho* aminobenzoic acid, seems to provide conclusive evidence that the amino-acids are under no obligation to strain their backbones in the manner suggested.

(2) Prof. Urbain's book on "The Energetics of Chemical Reactions" is the third volume of a new "Collection de Physique et Chimie," of which two preceding volumes, on "Colour and Chemical Constitution" and on "Thermochemistry," have already been reviewed in these columns (May 24, 1924, p. 739, and August 16, 1924, p. 240). Prof. Urbain claims that physical chemistry is not merely the overlapping section of physics and chemistry, but that it is a pioneer science which opens up new fields, which are afterwards added to the domain of these two sciences. He gives to his illustrious colleague, Le Chatelier, the credit for having been the first in France to introduce thermodynamics into chemistry, and asserts that "at the present time no one can call himself a chemist if he ignores the principles of thermodynamics and the method of applying them correctly to chemical phenomena in general, and more particularly to chemical equilibria." Such a test, if applied rigidly, would certainly exclude from the author's chemical "kingdom of heaven" some of our very "rich men," whose wealth of knowledge and experience could not be squeezed through the "needle's eye" of chemical thermodynamics. Whilst, however, we may repudiate the idea of excommunicating all those of our colleagues who are repelled instead of being attracted by the mathematical treatment of chemical problems, there is much to be said for the author's policy of writing a book on thermodynamics from the point of view of the chemist, rather than of the physicist or mathematician, and so minimising the difficulties of assimilating this method of treatment.

The book is in three parts, an introduction, which covers the general principles of thermodynamics, a very short section on thermochemistry (which has already formed the subject of a separate volume of this series), and a third section, filling more than half the volume, on the "Modern Theory of Affinity." The treatment ignores all "atomic" explanations, not because they are regarded as of no value, but simply because they are superfluous to the object immediately in view. A further volume of the same collection is promised, in which the applications of the principles now taught will be discussed for their own sake, instead of being used merely as illustrations of general principles.

(3) Prof. Urbain's book on elements and atoms is issued under the general heading of "Science and Civilisation" instead of "Physics and Chemistry." It deals with the definition of an element, radioactive elements, the constituents and structure of the atom, the relation between the properties of elements and the constitution of their atoms, and finally with isotopes. The International Table of Radioactive Elements is given on a folded sheet at the end of the volume. The author's style is attractive and interesting, and although he is addressing himself to an audience of general readers, his views on the question of how an element should be defined have a special interest at the present time for chemists. This question is discussed in a chapter of 50 pages, which occupies nearly one-third of the book; and the final conclusion, that the International Commission of the Chemical Elements was right, when in 1923 it reported that "an atomic number is necessary and sufficient to define a chemical element," is qualified by a final paragraph which contains a single brief sentence, asking whether "in the physical sciences, all definitions must not be only provisional?"

(4) Prof. Cartledge's book appears to have been written in order to meet the need, in the curriculum of the Johns Hopkins University, of providing instruction in physical chemistry for undergraduate students, at such an early stage in their course that they cannot be assumed to be familiar with organic chemistry. This has led to the production of a book in which particular emphasis is placed upon the properties of aqueous solutions, including especially such subjects as hydrolysis, acidity and the formation of complex ions. Fortunately the author has not gone to the extreme limit of excluding *all* organic compounds from his consideration, since he has found it necessary to illustrate the vapour-pressures of aqueous solutions from the case of mannitol, their osmotic pressure by data for sugar-solutions, whilst the cryoscopic and ebullioscopic methods of determining molecular weights are illustrated by the use of benzene and other organic compounds as solvents. A still more notable example is that of "The Speed of Reactions," where the principal actions studied are derived from the field of organic chemistry.

Apart from sheer necessity, this subdivision of the field of physical chemistry appears to the reviewer to be wholly undesirable. Physical chemistry has now emerged from the grotesque stage in which it appeared to concern itself exclusively with the study of *dilute aqueous solutions*, and when Faraday was not classed as a physical chemist because his work was published before the foundation of the *Zeitschrift für physikalische Chemie*; the limitations imposed in the volume now under review have the effect of replacing the old fetters, and of making the least typical of liquids appear as the only typical solvent. Such limitations are entirely retrograde, and it is to be hoped that other universities will escape from the necessity of imposing them upon their teachers of physical chemistry.

T. M. LOWRY.

Climates of the Past.

Die Klimate der geologischen Vorzeit. Von Wladimir Köppen und Alfred Wegener. Pp. iv + 256. (Berlin: Gebrüder Borntraeger, 1924.) 11*s.* 6*d.*

THIS monograph on the climates of the past is essentially a supplement to Prof. Wegener's work on continental drift. It endeavours to show that the former variations of climate can be best explained by Wegener's theory that all the land on the earth was originally one continuous continent which has been broken up, that the pieces have drifted apart, and that the north and south poles have migrated to their present positions.

The authors first discuss the nature of the geological evidence of former climates, and they claim, amongst other points, that all the great coal formations have originated either on moraines or on beds that have been recently folded. They then describe the distribution of climate in the Carboniferous and Permian Periods, and one of the most useful contributions in the book is the account of the glaciation of parts of the ancient continent of Gondwanaland; the section on the South American evidence is especially valuable. They next discuss the climatic zones in the Mesozoic and the Kainozoic, and follow with a chapter on the records of pre-Carboniferous glaciation which accepts without hesitation some cases that are regarded by some authorities as highly doubtful, and omits reference to other records. The final chapter discusses the Quaternary glaciation, which it attributes to variations in solar radiation.

The book gives tables of the solar changes in radiation for the past 800,000 years, and endeavours to fix the date of the successive glaciations. The discussion of the causes of the Pleistocene glaciation by two distinguished meteorologists shows that the theory of its dependence on changes in solar radiation must be seriously considered.

The geological section of the book is a compilation of the facts which appear to support the authors' thesis, but it is often unconvincing from unfortunate selection of geological evidence. They accept, for example, the existence in the Silurian rocks of Bohemia and the Hartz Mountains, of Lepidodendron, Stigmaria, and Sphenopteridium—a conclusion which, if accepted, would render futile all recent palæo-botanical discussions on the beginning of the land flora. The authors' claim that the variations of former climates can be explained by a shift in the positions of the pole combined with a drift of the continents is not convincing even on their own evidence. Their work is most detailed in reference to the climate in the Carboniferous Period; yet the Squantum tillite occurs exactly on their Carboniferous equator; they reject that formation as pseudo-glacial, but it requires stronger evidence than the authors bring forward to explain it by any non-glacial theory. The distribution of the Jurassic climate also appears more consistent with Neumayr's view of zones concentric around the present poles than with the position the authors assign to the Jurassic poles, as they carry the boreal province within 20° of their equator.

The book has no index, which is an especially unfortunate defect, as its chief value rests on its extensive collection of information as to former glaciations and biological distribution from the scattered literature on those subjects. The book will be more useful from its summary of little-known facts than convincing of the authors' theory.

Our Bookshelf.

Contributions to Embryology. Vol. 16, Nos. 78-84. (Publication No. 361.) Pp. 276+32 plates. (Washington: Carnegie Institution, 1925.) n.p.

THANKS to the munificence of the late Mr. Andrew Carnegie, American embryologists are enabled to place the results of their inquiries before the world in a superb form. The sixteenth volume of "Contributions to Embryology" maintains the high standard set by its predecessors; text and illustrations are excellent and the "contributions" are deserving of them.

The present volume, which includes seven papers, illustrates the new departures which are being made from recognised orthodox methods by modern embryologists. Only three of the seven papers follow conventional lines. Dr. F. Payne gives clear and exact drawings of reconstructions made of a human embryo in the fourth week of development; Dr. Cecil M. West makes a welcome contribution to later stages in the development of the gums and tooth-buds of human fœtuses, while Dr. G. B. Wislocki describes certain new features in the placentation of the sloth (*Bradypus griseus*). Prof. Alex. Maximow approaches the problems of embryology from the experimental side. He describes the behaviour of parts taken from embryos of rabbits and kept alive for various periods by methods adopted for the culture of living tissues. The results throw light on that kind of tumour which occurs occasionally in human beings and is known as an embryoma.

In a series of three papers, Prof. Florence Sabin, in collaboration with Dr. C. A. Doan and R. S. Cunningham, attacks the old problem of the origin of blood corpuscles by a new route—a physiological route. They have studied the production of new blood corpuscles in animals which had been rendered anæmic, using vital stains for the detection of the various kinds of corpuscles which are then produced. The result is the construction of a new schema of the ancestry of all kinds of cells which appear in blood or free cells which may be encountered in the tissues outside blood-vessels. Of great clinical importance is their discrimination of two forms of phagocytes—the clasmatocyte, which arises from the endothelial cells lining capillaries, and the large monocyte which is produced from cells occurring in reticular connective tissues of all sorts; the latter, unlike the clasmatocyte, arises outside a capillary lumen. It will thus be seen that modern embryology becomes more and more a branch of experimental research.

General and Physiological Features of the Vegetation of the more Arid Portions of Southern Africa, with Notes on the Climatic Environment. (Publication No. 354.) By W. A. Cannon. Pp. viii + 159 + 31 plates. (Washington: Carnegie Institution, 1924.) n.p.

THE author of this volume spent six months' leave in South Africa in the latter half of 1921. During that time he introduced Livingston atmometers to South African botanists, distributed through the Director of the Union Botanical Survey a number of standardised atmometers at various stations through the Union, and arranged for the recording of weekly evaporation; he visited the principal arid and semi-arid regions, sampled the characteristic plants and the transpiring power of their leaves, examined the leaf anatomy and root systems of Karroo plants, and took a number of excellent photographs. In the volume under notice the photographs are beautifully reproduced and the data he collected are brought together.

South African botanists will find much to interest and stimulate them, and will welcome the impressions of an observer with so varied an experience of arid regions, who can compare from first-hand knowledge the vegetation of the drier parts of their country with that of other parts of the world under comparable climatic conditions. His example will strengthen the movement already evident, from purely floristic towards ecological investigation of the South African flora. He has directed attention to those features of the plants which are of special importance in connexion with their water relations; and he has demonstrated that with a few simple appliances physiological data of value can be obtained out on the veld. Observations were even made on the transpiration of *Welwitschia mirabilis* in the Namib desert; they suggest that the leaves of this curious plant transpire far more freely than might have been anticipated from their xerophytic structure and the extreme aridity of the environment.

The atmometric data are somewhat disappointing. It is clear that they require a scrutiny to which the author had not been able to subject them at the time of publication, and are not uniformly trustworthy. A "Fig. 8," representing some of the data graphically, is referred to on pp. 44 and 55, but is not to be found in the book. There are also a regrettable number of printers' errors which have escaped correction. For example, "casual" appears in two successive lines on p. 3, in one or other of which it should surely read "causal"; while two variants on "Matjesfontein" appear on pp. 68 and 71. The "typography" of a district is referred to on p. 69, "Protaceae" for "Proteaceae" on p. 110, and so on.

Mechanical Refrigeration: being a Practical Introduction to the Study of Cold Storage, Ice-making, and other Purposes to which Refrigeration is being Applied. By Hal Williams. New and enlarged edition. (The Specialists' Series.) Pp. x+501+6 plates. (London: Sir Isaac Pitman and Sons, Ltd., 1924.) 20*s.* net.

THE volume under review is a new edition of Mr. Hal Williams's well-known book on mechanical refrigeration, which has now been amplified and largely rewritten. It contains a useful summary of the present state of our knowledge of refrigeration in its broadest aspect, and, as it does not go unduly into minute detail of design and equipment, it will appeal to all interested in the vital problem of the conservation of the food supply of the nation.

The book is descriptive rather than theoretical in its treatment of the subject, and a valuable feature is the account given of recent applications of refrigeration to such industries as paraffin crystallisation, mine shaft freezing, and so on. Another noteworthy feature in the new edition is the attention given to the high-speed total enclosed compressor. This type of compressor is an important step in the development of refrigerating machinery which has been taking place in recent years.

The general lay-out of the book partakes more of the nature of a dictionary than a text-book, for each paragraph is sub-headed under such titles as "Unit of Pressure," "Liquid Coolers," "Buying Machinery." This facilitates the use of the volume as a work of reference. The illustrations are plentiful and include a number of folding plates, but it is questionable whether these justify their cost in a book of this character. The author has given a prominent place to one very important application of refrigeration, namely, the overseas transport of fruit, for this industry is destined to be a vital factor in the development of the British colonies.

E. G.

A Catalogue of the recent Sea-Urchins (Echinoidea) in the Collection of the British Museum (Natural History). By Hubert Lyman Clark. Pp. xxviii+250+12 plates. (London: British Museum (Natural History), 1925.) n.p.

DR. H. LYMAN CLARK, of the Museum of Comparative Zoology, Cambridge, Mass., who is one of the outstanding authorities on echinoderms, has given in this catalogue the results of his studies, extending over some months in 1924, of the British Museum collection. This has been known as one of the important collections of sea-urchins since the time of J. E. Gray's first connexion with the Museum in 1824, in which year he published a paper—dealing with about 50 species—which may be regarded as the foundation for a catalogue. For thirty years Gray continued his study and, at intervals, his publications on sea-urchins. Since his time the collection has received notable additions from the expeditions of the *Challenger, Alert, Penguin,* and *Egeria,* from the collections made by Prof. A. Willey and Prof. J. Stanley Gardiner, and from those made during the recent British Antarctic Expeditions; it now ranks as one of the foremost collections of the world. It contains about 8000 specimens representing 382 species grouped in 146 genera, and Dr. Clark directs attention to the wealth of large examples in many of the series. He gives a table showing that in the collection is type material of 111 forms, 25 of which are new species or varieties described in this volume.

Dr. Clark has made available to students of the Echinoidea an accurate account of this great collection, and his catalogue serves also as a handbook for the identification of most sea-urchins. Twelve excellent collotype plates provide illustrations of the new species.

Recent Advances in Medicine: Clinical, Laboratory, Therapeutic. By Dr. G. E. Beaumont and E. C. Dodds. Pp. xii+292. (London: J. and A. Churchill, 1924.) 10*s.* 6*d.* net.

THE rapidity with which the study of medicine advances makes it necessary for the physician and clinical pathologist to keep constantly in touch with new methods of investigating and treating disease. With limited time and material for research, it is impossible for the busy practitioner to test these for himself, or to isolate from the vast accumulation of recent medical literature what is likely to be of practical value. In "Recent Advances in Medicine" a physician and a biochemist collaborate to give an account of the more important changes in clinical and laboratory routine methods of the last decade, and to indicate the relative value of the results obtained. The book covers a very wide field, including such subjects as blood analysis, renal, hepatic, and pancreatic functions, test meals, the polygraph and electrocardiograph, artificial pneumothorax, and various cutaneous and serological tests. Some of these might with advantage have received less attention; for example, the electrocardiograph and its tracings are of little value except to the specialist. X-ray investigation of the stomach, to which less than a page is devoted, is of far more interest to practitioner and student.

The book will be welcomed as a very useful addition to the practitioner's library. It contains numerous references and is excellently indexed.

Conformal Representation. By Leo Lewent. Translated by Dr. R. Jones and D. H. Williams. Pp. viii+146. (London: Methuen and Co., Ltd., 1925.) 7*s.* 6*d.* net.

THE work under notice is a translation of Dr. Leo Lewent's "Conforme Abbildung" (Teubner). It opens with an account of functions of a complex variable from the Cauchy-Riemann point of view. A long chapter is devoted to special transformations, with detailed discussion of linear transformations and stereographic projections, but without reference to group theory. The account of algebraic transformations necessarily introduces Riemann surfaces, the two-sheeted ones being mainly considered. Riemann's conjecture, that any simply connected surface can be represented uniquely, continuously, and conformally on the area of a circle, has been made the foundation of many brilliant investigations by such mathematicians as Heine, Schwarz, Weierstrass, Osgood, Poincaré, and Koebe. A general account of the whole question is given in the book before us, without entering into the necessarily elaborate pure mathematics involved in much of the work on the subject. The last chapter, dealing with conformal representation by means of elliptic functions, was written by Dr. Blaschke, Dr. Lewent having died before his plan was completed. In the present translation, Dr. Jones and Mr. Williams have provided a very readable introduction to the theory of conformal representation. Some matters are discussed in the German text in a descriptive (rather than a scientific) way, but the translation is none the less acceptable on that account. W. E. H. B.

Kolloidchemie der Protoplasmas. Von Prof. Dr. E. Lepeschkin. (Monographien aus dem Gesamtgebiet der Physiologie der Pflanzen und der Tiere, Band 7.) Pp. xi + 228. (Berlin: Julius Springer, 1924.) 9 gold marks.

THE author has catered for the student in a very thorough manner, and devotes the first quarter of the book to a complete survey of the various physico-chemical phenomena associated with colloids, particularly proteins. The colloid chemistry of protoplasm is then developed and discussed from different points of view until finally the author presents a detailed and up-to-date account of the behaviour of protoplasm under the action of physical agents, such as temperature, light, and electricity, and that produced chemically by acids, alkalis, neutral salts, and non-electrolytes. One feels, however, that more might have been made of the effects of low temperatures and particularly of freezing temperatures, including, as it does, not only the temperature factor but also those due to desiccation and probably change in acidity. The book will appeal in particular to the plant physiologist.

There is one very fine plate containing twenty-two microphotographs of several living systems under different conditions, but surely a book of this nature is lacking in having no diagrams whatsoever. It is, nevertheless, well written, covers a wide field, and treats a difficult subject in a most interesting and clear manner.

A Monograph of the Birds of Prey (Order Accipitres). By H. Kirke Swann. Part I. Pp. xi + 52 + 5 plates. (London: Wheldon and Wesley, Ltd., 1924.) 26*s.* net.

IN this monograph, which is being issued in twelve parts, Mr. Swann is bringing up-to-date the results of his recent intensive study of the diurnal birds of prey. In his introduction, which includes a chapter on falconry and hawking, it is stated that he now recognises 322 species and 692 subspecies or forms, while the genera employed number 100. In 1874 Sharpe (Catalogue of the Birds in the British Museum, vol. 1) gave the number of species as 377, but many of these are now considered subspecies. It will therefore be seen that in the last fifty years the number of apparently distinguishable forms has nearly doubled.

Part I. deals with the New World vultures and some of those of the Old World. Each form is separately discussed; its synonymy is given, then its distribution and different plumages in detail, followed by general remarks and notes on food and nesting. We are glad to observe that the status of each species is clearly shown; the typical race is first described; any subspecies bears the same number with the addition of a letter. This arrangement, we think, might with advantage be adopted by modern authors. The changes in nomenclature are many, and are in strict accordance with the rules of priority.

The letterpress and paper are excellent, and the coloured plates, which are by Mr. Gronvold, leave nothing to be desired. We heartily congratulate the author on the production of this work. The edition is limited to 412 copies.

Chemistry in the Service of Man. By Prof. Alexander Findlay. Third edition, revised and enlarged. Pp. xix + 300 + 4 plates. (London: Longmans, Green and Co., 1925.) 6*s.* net.

PROF. FINDLAY'S book, which has now reached a third edition since its first appearance in 1916, is one of the best accounts of modern chemistry for the lay reader. Unlike many books of this kind, it is written in a dignified style and without insistence on commercialism. The subjects dealt with cover various fields, and the book cannot fail to continue to be popular. It is very suitable for general reading by pupils in higher forms of schools as well as for those older readers who have not specialised in chemistry, since it supplements the ordinary text-books. Three new chapters on radioactivity and atomic structure, on the rare gases of the atmosphere, and on metals and their alloys, have been added in the new edition, and the whole has been revised and brought up-to-date.

The Rare Earths: their Occurrence, Chemistry, and Technology. By Dr. S. I. Levy. Second edition. Pp. xvi + 362. (London: E. Arnold and Co., 1924.) 18*s.* net.

THE volume under notice is especially characterised by its eminently readable style. The subject is dealt with exhaustively, yet the material is presented in such a way that an honours student could read the whole with profit, whilst the expert will find full references to recent work apart from the detailed treatment in the text. Methods of separation and tests are dealt with as well as the chemical properties of the elements, and the names, occurrence, and composition of the minerals. The book will be welcomed by chemists, and is well printed, and provided with an adequate index. Theoretical considerations of classification and atomic structure are considered, but a just sense of proportion has been preserved. The book contains all the information that the chemist who is not a specialist in this department will require.

Letters to the Editor.

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

The Shapes of Birds' Eggs.

ANY notable geometrical symmetry in natural productions invites examination, and among such cases of symmetry the forms of hard-shelled eggs may be included. I remember, on chucking certain eggs in a lathe, being surprised to find that they ran nearly as true as if they had been turned, and there are several points of interest both in respect of the close conformity of their shapes to solids of revolution and also in regard to the character of their generating curves.

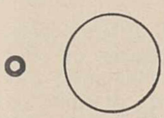

FIG. 1.—Capsule with walls of uniform thickness before and after inflation.

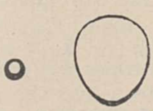

FIG. 2.—Capsule with walls of varying thickness before and after inflation.

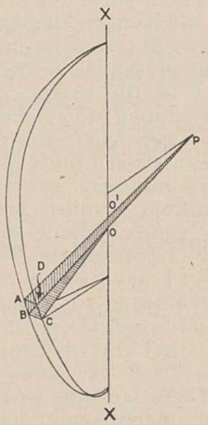

FIG. 3.—To indicate the relation between the principal stresses and principal radii of curvature in a closed vessel.

Symmetry of this kind must have the same sort of origin as that of an inflated balloon, or of the aneurism which forms in an india-rubber tube when the internal pressure exceeds a certain limit.

No doubt the oviduct in which the shell is developed supplies the necessary pressure, whether acting merely as an elastic coat stretched by the growth of the contents, or by actual muscular stress in the non-striated fibres in its walls; the near approach, however, of the transverse sections to true circles implies that the pressure (measured in terms of head) is large compared with any difference of pressure between the upper and lower parts of the egg cavity; for although the pressure of the various parts in external contact with the oviduct must tend to balance the gravitational head in the interior, it is not likely that this balance is at all exact, and, as may easily be shown, small differences of pressure round the periphery of a transverse section would, in the absence of contractive force in the walls, produce comparatively large departures from the circular form.

From the measures given below, I should estimate that the pressure within the oviduct is of the order of a hundred times that given by a column of water of the linear dimensions of the shell. The forms of the generating curve of the solid of revolution must depend either on a variation of thickness in the elastic walls of the oviduct or a variation of muscular stress in its fibres.

This may be illustrated experimentally by the inflation of india-rubber capsules, as shown in Figs. 1 and 2. When the walls are of uniform thickness, inflation produces a sphere; if the cavity is eccentric, on inflation it assumes the egg shape. All the known shapes of eggs can in this way be reproduced by suitably adjusting the thickness of the walls.

The relation of the principal stresses and principal radii of curvature in a shell in which there is internal pressure can be deduced from Fig. 3.

Let the internal pressure be P, and let XX be the axis of revolution of the generating curve of the shell, and ABCD an element of the surface of revolution. Also let AP($=\rho_M$) be the meridional radius of curvature and CO($=\rho_L$) that of the curvature in latitude. The tension T_M in the shell in the direction of the meridian is equal to P × area BCO ÷ BC × thickness of the shell (t), and in the direction of the latitude it is P × area ABOO′ ÷ AB × t. From this statement it can easily be shown that

$$T_M = P\ \rho_L/2t \text{ and } T_L = P(2\rho_M\rho_L - \rho_L^2)/\rho_M t;$$

also, since the sum of the radial components of the tension must be equal to P,

$$P = T_M/\rho_M + T\ /\rho_L,^1$$

and the ratio of T_L to T_M

$$(2\rho_M - \rho_L)/\rho_M.$$

If the solid of revolution is a cylinder, *i.e.* if $\rho_M = \propto$, this ratio, as is well known, is 2.

The forms of birds' eggs range from nearly spherical through ovals to bluntly pointed or peg-top shapes, and in this respect are, so far as my observation goes, much more variable than the hard-shelled reptilian or molluscan eggs; but in all cases there is a big and little end, and in laying, the big end comes out first.

A selection of typical forms of birds' eggs is given in Fig. 4. The eggs were placed on a photographic plate, vertically under a distant pin-hole, and the definition of the shadow picture is sufficiently good

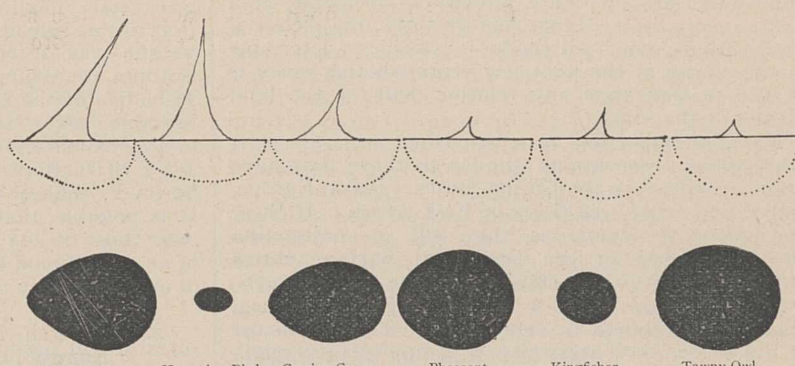

FIG. 4.—Typical forms of birds' eggs.

Figures below are pinhole photographs of the eggs (about one-third natural size). Figures above (drawn to a uniform scale) show the generating curves as dotted lines, and the evolutes in full lines.

[1] Since this was written I have been given a reference to a paper by Prof. D'Arcy W. Thompson (NATURE, June 4, 1908) on the shape of eggs. The relations given there between tension and curvature, due apparently to Prof. W. Peddie, are incorrectly stated.

to allow of the determination of the curvature with considerable accuracy.

Above each figure (and on a scale which makes the long axis of all the eggs equal in length) is the evolute, which is more characteristic than the generating curve itself. The evolutes were produced by drawing normals to the generating curve at many points round the periphery, and though individual normals might in some instances be not quite correctly drawn, there could be no doubt about the shape of their envelope (*i.e.* the evolute). The ρ_L radii for any given latitude were so nearly constant that their variations could not be satisfactorily determined.

I give below, however, a few measures of the greatest and least equatorial diameters of ostrich eggs (too large to be photographed with the apparatus I was using), for in such large eggs, if anywhere, one might expect to find evidence of gravitational deformation.

OSTRICH EGGS.

No.	Locality.	Greatest diameter.	Least diameter.	Difference in parts per 1000.	Remarks.
1	Masailand . .	4·872 in.	4·865 in.	1·4	
2	,,	5·042 ,,	5·021 ,,	4·0	Surface of shell rough.
3	Kilimanjaro .	4·892 ,,	4·890 ,,	0·42	
4	,,	5·290 ,,	5·243 ,,	9·0	Surface of shell rough.
5	Wady Abiadh (?)	4·617 ,,	4·601 ,,	3·5	
6	,, ,,	4·542 ,,	4·535 ,,	2·0	

I have to thank the authorities of the British Museum (Natural History), at South Kensington, for facilities in making these measures.

A. MALLOCK.

9 Baring Crescent, Exeter.

Science in South Africa.

EVERY man of science will welcome General Smuts' interesting survey, appearing in NATURE of August 15, p. 245, of the problems that present themselves for solution in South Africa, for there is no more promising field of research, especially in geophysics.

The great astronomical observatories of the southern hemisphere are no doubt already co-operating in a daily comparison of wireless records and celestial observations, which will render it possible to determine in the course of the next few years whether there is at the present time any relative drift of the land masses of the south.

Not less important is a provision for systematic gravimetric observations, similar to those that have been carried out in the United States, Central Europe, India, and what was German East Africa. If these are sufficiently numerous, they will, in conjunction with the work of the Geological Survey, throw important light on the structure of the earth's crust.

At the same time, a number of seismological observatories should be established. The initial cost of the Milne-Shaw apparatus is comparatively small. As the records must be influenced by the geological structure at and near the receiving station, a careful and systematic comparison of the records at different stations of the same earthquakes should be very valuable.

Observations on the tidal movements and others of similar periods in the earth's crust, such as were made by Hecker at Potsdam, are also needed in South Africa for comparison with those in other parts of the world. They, too, will throw light on crustal structures.

For these and other lines of research South Africa affords unequalled opportunities of obtaining important results, and every one must look forward to see her take a place in the commonwealth of science equal to that of the most advanced of older communities.

JOHN W. EVANS.

Transformation of Mercury into Gold.

THE experiments on the transformation of mercury into gold (A. Miethe and H. Stammreich, H. Nagaoka) and the suggested explanation of the process (F. Soddy) lead me to make the following observations. The possibility of the transformation of a nucleus into that of the element next below it by the absorption of one electron is most likely to be detected when both nuclei are stable. This occurs most obviously when the elements have a mass in common, an isobare, and, since even mass-numbers are not found in non-radioactive elements of odd atomic number, an isobare of odd mass-number.

At the present time there is no direct experimental evidence of the existence of isobares of odd mass-number among non-radioactive elements, but there are two cases where the possibility of their existence may be inferred from experimental work. These are the mass-numbers 205 and 199. The existence of the thallium isotope 205 is probable from F. W. Aston's general results for elements of odd atomic number and from the value, 204·4, for the atomic weight; I have given reasons for the existence of the lead isotope 205 (*Phil. Mag.*, 1924, [vi], 48, 365). From the atomic weight of gold, 197·2, it may be inferred that this element has isotopes 197 and 199; mercury, as F. W. Aston has shown, has the isotope 199. There are thus two pairs of elements, lead and thallium, mercury and gold, in which the transformation of the type under discussion may occur. I suggest therefore that the transformation of lead into thallium is as possible as that of mercury into gold, and that the masses of the thallium and the gold produced are 205 and 199 respectively.

There is a possibility that the transformation of lead into thallium by the process under discussion has already occurred in Nature. It has been pointed out by me that when any element of odd atomic number possesses two isotopes, the heavier is never in excess. Thallium did not appear to be an exception to this rule at the time it was made, as its atomic weight was accepted as 204·0 (the masses of its isotopes are assumed to be 203 and 205); it appeared to be one of the elements of odd atomic number like bromine, silver, and antimony, which have isotopes in approximately equal proportions. The new value, 204·4, of thallium's atomic weight, recently obtained, however, makes this element a definite exception. It is possible that the excess of the masses of 205 over those of 203 is the result of a process in Nature of an exceptional kind, for example, of the absorption of an electron by the nucleus of the lead mass 205.

A. S. RUSSELL.

Christ Church, Oxford,
August 12.

Gibbs' Phenomenon in Fourier's Integrals.

FOURIER'S integral $\frac{1}{\pi}\int_0^\infty d\alpha\int_{-\infty}^\infty f(\beta)\cos\alpha(\beta-x)d\beta$ is known, under certain general conditions, to have the value $f(x)$ at a point where $f(x)$ is continuous and $\frac{1}{2}\{f(x+0)+f(x-0)\}$ at an ordinary point of discontinuity.

It would be natural to expect that the curves

$$y = I_a(x) = \frac{1}{\pi}\int_0^a d\alpha \int_{-\infty}^{\infty} f(\beta)\cos\alpha(\beta - x)d\beta,$$

for large values of a, would tend, in the neighbourhood of $x=0$, to coincide with the line

$$x=0,\ f(-0) \leqq y \leqq f(+0),$$

when $f(-0)<f(+0)$, the inequalities being reversed when $f(-0)>f(+0)$. However, as we shall now show, this line has to be produced above and below $f(\pm 0)$ by an amount

$$\frac{D}{\pi}\left|\int_\pi^\infty \frac{\sin u}{u}du\right|,$$

where $D = |f(+0)-f(-0)|$, *i.e.* by about 9 per cent. of the jump D. This corresponds exactly to Gibbs' phenomenon in Fourier's series to which attention was directed by Gibbs in NATURE, vol. 59, p. 606 (1899).

It is sufficient to prove the theorem for a special case: from the known properties of Fourier's integral at a point of continuity of the arbitrary function, it can then be extended to the general case.

We take $f(x)=1$, when $0<x<l$, and $f(x)=-1$, when $-l<x<0$, and equal to zero elsewhere: so that $D=2$ at $x=0$.

Then it will be seen that

$$I_a(x) = \frac{1}{\pi}\int_0^a d\alpha\left\{\int_0^l \cos\alpha(\beta - x)d\beta - \int_0^l \cos\alpha(\beta + x)d\beta\right\}$$

$$= \frac{1}{\pi}\int_0^l \frac{\sin a(\beta - x)}{\beta - x}d\beta - \frac{1}{\pi}\int_0^l \frac{\sin a(\beta + x)}{\beta + x}d\beta$$

$$= \frac{2}{\pi}\int_0^{ax}\frac{\sin u}{u}du - \frac{1}{\pi}\int_{a(l-x)}^{a(l+x)}\frac{\sin u}{u}du.$$

It is easy to show that the second integral tends to zero when a tends to infinity; or, stated more carefully, to the arbitrary positive number ϵ, there correspond positive numbers A and η, such that

$$\left| I_a(x) - \frac{2}{\pi}\int_0^{ax}\frac{\sin u}{u}du \right| < \epsilon, \text{ when } \begin{cases} a \geqq A \\ 0 \leqq x \leqq \eta \end{cases}.$$

Now the curve

$$y = \frac{2}{\pi}\int_0^x \frac{\sin u}{u}du \text{ for } x>0$$

is situated above the axis of x and cuts the line $y=1$ an infinite number of times. Its maxima occur when $x=\pi, 3\pi, 5\pi, \ldots$ and continually diminish, tending to $y=1$ in the end. Its minima occur when $x=2\pi, 4\pi, 6\pi, \ldots$ and continually increase, tending also in the end to $y=1$.

Further the curve

$$y = \frac{2}{\pi}\int_0^{ax}\frac{\sin u}{u}du$$

is this curve, with the abscissæ reduced in the ratio $1:a$. Therefore for large values of a the curve

$$y = I_a(x), \text{ when } x>0,$$

rises from the origin to a point very nearly coincident with

$$x=0,\ y = \frac{2}{\pi}\int_0^\pi \frac{\sin u}{u}du = 1 - \frac{2}{\pi}\int_\pi^\infty \frac{\sin u}{u}du = 1 + \frac{0{\cdot}56\ldots}{\pi}.$$

A word or two of a historical nature may be added regarding Gibbs' phenomenon in Fourier's series. As a matter of fact it had been described for the series mentioned by Gibbs in a paper entitled "On a Certain Periodic Function," in the *Camb. and Dublin Math. Journal*, vol. 3 (1848), by Wilbraham (B.A., Trin. Coll. Camb.). To this point my attention was directed some time ago by Prof. G. N. Watson (see also *Enc. d. math. Wissenschaften*, II. A, 12, p. 1049, and II. C, 10, p. 1203). Wilbraham's paper seems not to have attracted any notice, and it had been completely forgotten when Gibbs sent his letter to NATURE in 1899.

Du Bois Reymond dealt with the behaviour of the approximation curves for series and integrals in *Math. Annalen*, Bd. 7 (1874), in his paper "Über die sprungweisen Werthänderungen analytischer Funktionen." This memoir would have contained an account of Gibbs' phenomenon in both Fourier's series and integrals, if he had not made a curious slip with regard to the possible values of the integral $\int_0^{nx}\frac{\sin u}{u}du$, when x tends to zero and n to infinity simultaneously.

Prof. Wilton, of Adelaide, noticed the existence of the phenomenon in Fourier's integrals in a paper, "On Gibbs' Phenomenon in Fourier's Series and Integrals" communicated to the *London Math. Society* in 1921. But his argument required further development and this paper has not been published.

The occurrence, or non-occurrence, of the phenomenon in Bessel's and Legendre's series, and in divergent Fourier's series, which can be summed by other means, has been discussed by various writers. It will be interesting to find if analogous results can be obtained in the case of Fourier's integral and other integrals equal to the arbitrary function.

H. S. CARSLAW.

Sydney, June 16.

The Action of Silica on Electrolytes.

FROM Dr. Joseph's letter in NATURE of March 28, p. 460, it appears that our differences are mainly with regard to observation of facts. I therefore describe below the method of preparation of the hydrated silica used in most of our experiments: it was obtained from the hydrolysis of twice-distilled pure silicon tetrachloride. The silicon tetrachloride in the final distillation was collected in a *transparent fused silica flask*. The liquid was hydrolysed in the same vessel, and in the subsequent treatment only fused silica vessels were used. The silica was dried in air at room temperature in a place free from fumes. If Dr. Joseph finds difficulty in preparing the samples, I shall be glad to send him a sufficient quantity for his experiments. I would, however, point out that the silica used by Dr. Joseph differs from ours in one respect in that the silica was heated to 180°. We have found that, on ignition, the adsorptive capacity of hydrated silica diminished markedly, and probably the failure of Dr. Joseph to confirm our results is to be attributed to his having used samples which were "finally dried and heated to 180°."

We would request Dr. Joseph to repeat the following experiment with silica prepared in the manner given above: The silica is washed until the wash water after twenty-four hours' contact shows no opalescence with silver nitrate. It is separated in two equal portions to one of which a definite volume of pure water and to the other a definite volume of saturated solution of potassium nitrate free from chlorides are added respectively. If the two liquids are carefully decanted, the potassium nitrate solution shows perceptible opalescence with silver nitrate, while the other does not. But if, however, the washing of the silica is carried on for a long time, even after the P_H of the wash water has become equal to that of the water used, the potassium nitrate solution fails to show any trace of a chloride.

Regarding the statement in par. 4 of his letter, I think Dr. Joseph is scarcely doing me justice in suggesting that these obvious precautions were not taken. The silica or the solutions never came in contact with filter papers. Transparent fused silica vessels were mostly used. Where glass vessels were used (resistance glass) it was ascertained that the results were not due to a reaction with the vessel. We have several times repeated and confirmed our observations.

Dr. Joseph says nothing about the increase in the negative charge of the surface at low concentrations of neutral salts, which to my mind definitely proves the primary adsorption of anions, and consequently of electrolytes including acids which contain these anions.

Similar experiments have been done with manganese dioxide, corroborating our point of view. We have communicated a paper to the Journal of the Indian Chemical Society, "On the Nature of Hydrolytic Adsorption, Pt. I.," in which the theoretical considerations advanced in previous papers have been developed, and a brief summary of the results obtained in this laboratory during the last four years has also been given. Full experimental results will be published later.

I would take this opportunity to point out that we distinguish between three types of adsorption: (1) primary adsorption, resulting from the chemical affinity of the atoms on the surface (cf. Langmuir), (2) electrical adsorption, and (3) adsorption of solutes (or rather solutions) resulting from the capacity of the substance to adsorb water. The adsorption referred to in my letter in NATURE of April 4 (p. 497) is of the last-mentioned type, and is different from the small amounts of primary adsorption referred to in my letter of January 31.

J. MUKHERJEE.
Physical Chemistry Laboratory,
University College of Science and Technology,
Calcutta.

Gas-pressure, Radiation-pressure, and Entropy in the Interior of a Star.

IN the simplest form of Eddington's theory of stellar constitution (*vide* papers in Mon. Not. R.A.S.; and *Astrophysical Journal*, 48, 205, 1918), the assumption is made that a certain quantity, β, is constant throughout a given star; β turns out to be the ratio of the gas-pressure to the total pressure (which is the sum of the gas-pressure and the radiation-pressure). The present note shows that the second law of thermodynamics provides a theoretical background for this assumption of Eddington's—justification of which has been largely empirical heretofore.

Write S for the entropy per unit volume at any point within a star, n for the number of molecules per unit volume, dV for a volume-element, and V for the total volume of the star. A feature of Eddington's method is that the volume, V, and the total number of molecules, $\int n\,dV$ (total mass divided by molecular weight), are supposed—at a certain point in the solution—to be given. Now S may be taken as a function of the two independent variables, V and n. Suppose that the distribution of matter within the star is infinitesimally varied, subject to the two restrictions mentioned; so that

$$\delta V = \delta \int dV = 0 \quad . \quad . \quad . \quad (1)$$

and

$$\int \delta n\, dV = 0, \quad . \quad . \quad . \quad . \quad (2)$$

where the integrations are performed throughout the entire volume of the star. The condition for stable equilibrium is that the total entropy is a maximum, or

$$\delta \int S\, dV = 0. \quad . \quad . \quad . \quad (3)$$

In consequence of (1), this is equivalent to

$$\int \frac{\partial S}{\partial n} \delta n\, dV = 0. \quad . \quad . \quad . \quad (4)$$

Comparison of (4) and (2) necessitates that

$$\frac{\partial S}{\partial n} = b, \quad . \quad . \quad . \quad . \quad . \quad (5)$$

a constant throughout V.

It remains to express the relation between b and β. Taking the entropy as that of the radiation alone,

$$S = \frac{4}{3} a T^3 = \frac{4p'}{T},$$

where T is the absolute temperature of the elemental region; aT^4 the radiant energy per unit volume; and p' the radiation-pressure. Since the gas-pressure, p, is given by nRT (where R is the gas-constant per molecule),

$$S = 4nRp'/p. \quad . \quad . \quad . \quad . \quad (6)$$

Comparing with (5),

$$b = \frac{4Rp'}{p} = 4R\frac{1-\beta}{\beta};$$

and β is constant throughout the star.

This treatment neglects the entropy of the gas. Furthermore, owing to varying ionisation with the varying distributions of matter, (2) above is only an approximation. Consequently the way is left open for more refined theories, according to which β and b may not be constant throughout a given star.

JOHN Q. STEWART.
Princeton University Observatory,
July 28.

The Experimental Transmission of Cutaneous Leishmaniasis to Man from *Phlebotomus papatasii*.

SERGENT, ED. et Et., Parrot, L., Donatien, H., and Béguet, M. (C.R. Acad. Sci., vol. 173, No. 21, pp. 1030-1032), first successfully transmitted cutaneous Leishmaniasis to man from sandflies. Their experiment consisted of dividing a batch of 559 sandflies into 23 batches, crushing the sandflies in saline, and inoculating scarified points on the arms of volunteers. The sandflies were caught in Biskra, an endemic centre of cutaneous Leishmaniasis, and the experiment was performed in Algiers, where locally acquired cases of the disease are unknown. One experiment (from a batch of 7 specimens of *Phlebotomus papatasii*) was successful, Leishman-Donovan bodies being found from a papule which appeared 2 months and 24 days after the experiment.

A batch of 198 sandflies (191 *Phlebotomus papatasii*, 16 ♂♂ and 175 ♀♀, 7 *P. minutus*, 1 ♂ and 6 ♀♀) were caught in Jericho on June 25 last, and brought to Jerusalem for dissection. On June 26 a female *Phlebotomus papatasii* was found heavily infected with Herpetomonas, flagellates being present in the œsophagus, œsophageal diverticulum, midgut, and hindgut. The alimentary tract contained no trace of blood and the abdomen was full of ripe or almost ripe eggs. A large number of the flagellates were found attached to the under surface of the œsophageal valve. Only fully developed flagellates were present, and Leishmaniasis form parasites and intermediate forms were not observed. A part of the material was stained and mounted and the remainder was used for the experiment. Two points on the left forearm of a volunteer were scarified and inoculated with material containing flagellates on June 26. On July 31 a small papule which would normally have passed unobserved was noted on one of the inoculated points, and on examination Leishman-Donovan bodies were found, *i.e.* the incubation period was less than half of that noted by the Sergents and their collaborators. Nothing was noted on the other site of the inoculation, but it was examined and up to the time of writing has proved negative.

It must be further noted that the insect from which the material for the experiment was obtained was the only one from the batch of 198 which contained Herpetomonas.

The method of dissecting individual sandflies and experimenting with a positive individual is more satisfactory than crushing batches in saline and experimenting with the product, for in the latter case it is impossible to know whether a negative result is due to the fact that the sandflies contained no Herpetomonas or whether the Herpetomonas was non-infective.

For various reasons we do not think that the successful experiment of the Sergents and collaborators and our own experiment provide a complete explanation of the etiology of cutaneous Leishmaniasis, and we intend to discuss this point elsewhere. It must be pointed out that Patton has on several occasions pointed out the necessity of the experiment performed by the authors (Bull. Soc. Path. Exot., vol. 12, No. 8, pp. 500-504, and *Ind. Jour. Med. Res.*, vol. 9, No. 3, pp. 496-532.

S. ADLER.
O. THEODOR.
Microbiological Institute, Jerusalem,
P.O.B. 250, August 5.

Spiral Springs of Quartz.

MAY I express my interest in your recent correspondence on quartz spiral springs (NATURE, June 20, p. 943, and July 4, p. 14), and suggest a convenient laboratory method for the production of springs of extreme sensitivity. I refer to the use of fibres the diameter of which is 10^{-3} cm. or so.

One end of a length of fibre is weighted and the other attached to a transparent quartz tube by fusion. This is accomplished simply, by heating to incandescence a small portion of the tube in an oxy-gas flame and quickly lowering the heated spot on to the fibre, which is held at right angles to the axis of the tube. A perfectly strong joint is made and the loaded fibre may be wound up at the desired pitch (difficulties arise owing to air-currents if the tube is not lowered on to the fibre). A similar procedure serves to finish off the spiral: a small portion of the tube, say 1 cm. away from the windings, is heated to incandescence, and, tilting the tube, the last turn of the spiral is wound over the hot spot. The spiral with its supporting tube is now placed axially in a wire wound resistance furnace and heated rapidly in air above the annealing point of fused silica—1 minute at 1100° C. is adequate for a fibre 10^{-3} cm. diameter wound on a diameter of 1 cm. No trouble from devitrification is experienced and the elastic properties of the fibres are unimpaired; moreover, the curvature of the coil is uniform throughout.

Removal is best accomplished by unwinding slightly one of the end turns of the spiral; bending it outwards from the tube and away from the coils. In this position the end may be secured to a rigid support by any suitable adhesive, the remaining turns being similarly opened and wound off. In this process a single camel hair is useful to guide the motion of the fibre, and is best used without artificial aid to vision. As an example of sensitivity, a spring so made with which I have experimented has an expansion rate of 3×10^6 cm. per gram, this measured by deformation under its own weight.

By careful regulation of the time and temperature of heating, a coil may be made, which, when released at its ends, is of larger diameter than the tube on which it was wound. Incidentally, this technique for producing springs of varying curvature, under specified conditions of time and temperature, offers a very convenient method for the study of the annealing of vitreous bodies, since a simple series of experiments gives quantitative information as to the time rate of the release of strain.

H. D. H. DRANE,
Research Dept., Thermal Syndicate,
Wallsend.

Fish Poisons as Insecticides.

THE destruction of fresh-water fish by means of the poisonous properties of certain plants is almost as widespread as the use of the conventional form of fish trap in one or other of its common modifications. Like the savages of many tropical countries, the poachers of Southern Ireland employ a vegetable fish poison, and this they obtain from spurge (*Euphorbia hibernica*). The primitive method of use is merely to put the freshly gathered plant (leaves, stem, and root) into a sack and tread on this vigorously in the shallow water at the head of a pool. The expressed juices mingle with the water and rapidly render all fish helpless for, it may be, three-quarters of a mile downstream. It is said that affected fish never recover, and the amount of destruction wrought, especially in streams where quantities of salmon parr and small trout exist, can easily be imagined.

The more modern method of application is, I understand, to crush and chop the plant in a chaff cutter or some similar agricultural machine, collect the juice in a bottle, and put this into the stream either with, or without, the chopped-up plant.

If it were found that the spurge poison is also valuable as an insecticide, the plant would probably be more easily obtained, or cultivated, than some of the tropical forms.

Flax water, the scourge of certain rivers in Northern Ireland, is in its effects at least as deadly as spurge, but its effect is due to the product of the decomposition of the softer parts of the flax plant in water and not the juice of the plant itself.

W. J. M. MENZIES.
Fishery Board for Scotland,
Edinburgh, August 17.

The Word "Australopithecus" and Others.

NEITHER Dr. Bather nor Dr. Allen (NATURE, June 20, p. 947, July 25, p. 135) directs attention to the fact that the names of all well-regulated families or subfamilies should be based on a generic name, so that the term Homosimiidæ is ill advised. As for the name Australopithecus and any other combinations, it might be said that scientific names are not, strictly speaking, literature, though so regarded by the orthodox. Many years ago Le Conte, to show that a name need not necessarily mean anything, gave the name Guyascutus to a genus of beetle.

F. A. LUCAS,
Honorary Director.
The American Museum of Natural History,
New York City, August 6.

Moseley's Work on X-rays.

By Sir Ernest Rutherford, O.M., F.R.S.

To the many friends of the late H. G. J. Moseley, who was killed in action at Gallipoli in 1915, it has always been a matter of regret that no reasonable portrait of him could be found. Apparently Moseley had an objection to placing himself in the hands of the professional photographer. Recently, Mr. N. Garrod Thomas kindly sent me the negative of a snapshot of Moseley taken probably in the Balliol-Lincoln Laboratories at Oxford in the summer of 1910, about the time of his graduation and before he took up a post as lecturer in physics in the University of Manchester. A part of this negative has been enlarged by Mr. W. H. Hayles, of the Cavendish Laboratory, and is here reproduced.[1] I think all will agree this is an admirable portrait of Moseley. It is difficult to be certain of the apparatus in his hands, but it may have been connected with a repetition of some of the expansion experiments of Prof. C. T. R. Wilson, which it is known he carried out about that time.


Henry Gwyn Jeffreys Moseley, 1887–1915.

In an obituary notice in this journal (Sept. 9, 1915), and also in a special notice in the Proceedings of the Royal Society in 1916, I gave an account of Moseley's life and work, and directed attention to the fundamental importance of his two papers published in the *Philosophical Magazine* (Dec. 1913, April 1914), entitled "The High Frequency Spectra of the Elements." In these papers he formulated for the first time the law, now known as Moseley's Law, governing the X-ray spectra of the elements, and by its aid was able to fix definitely the number and order of the elements. While the importance of these brilliant researches was immediately recognised, now that a decade has elapsed we can appreciate even more clearly the significance and fundamental character of his discoveries and can estimate the extent to which his work has influenced the development of modern physics.

In this connexion it may not be inappropriate to recall briefly the theoretical position at the moment Moseley began his investigation and the subsequent developments. The nuclear theory of the atom had been advanced in 1911, and from the results of experiments on the scattering of α rays, it had been suggested that the nuclear charge of an atom might be given by the atomic or ordinal number of the element. On the nuclear theory, the properties of an atom are defined mainly by its nuclear charge, since this controls the number and arrangement of the outer electrons.

Following the discovery in 1912 by Laue, Friedrich, and Knipping of the diffraction of X-rays by crystals, W. H. and W. L. Bragg in 1913 had found evidence by the electric method of the presence of bright lines in the spectrum of platinum, using the method of reflection of crystal faces. These results were confirmed and extended by an investigation by Moseley and Darwin, published in the same year.

At this stage I remember well a discussion with Moseley, in which he proposed a research to test whether an examination of the X-ray spectra of a group of elements could give a decisive answer to the question whether the properties of an atom are defined by its atomic number, as suggested by the nuclear theory, or by its atomic weight, as indicated by the periodic law of the elements. As we know, his hopes were strikingly verified. He rapidly examined by the photographic method the *K* spectra of a group of the lighter elements and the *L* spectra of a number of the heavier elements. The conclusions reached by Moseley are clearly given in the terse summary in his second paper, which for its interest is reproduced here.

1. Every element from aluminium to gold is characterised by an integer *N*, which determines its X-ray spectrum. Every detail in the spectrum of an element can therefore be predicted from the spectra of its neighbours.

2. This integer *N*, the atomic number of the element, is identified with the number of units of positive units of electricity contained in the atomic nucleus.

3. The atomic numbers for all elements from Al to Au have been tabulated on the assumption that *N* for Al is 13.

[1] I have arranged with Mr. Hayles to provide copies of this enlargement at a small charge.

4. The order of the atomic numbers is the same as that of the atomic weights, except where the latter disagrees with the order of the chemical properties.

5. Known elements correspond with all the numbers between 13 and 79 except three. There are here three possible elements still undiscovered.

6. The frequency of any line in the X-ray spectrum is approximately proportional to $A(N-b)^2$, where A and b are constants.

Apart from (2), the conclusions drawn in Moseley's paper are a straightforward interpretation of the experimental facts and involve no theoretical assumption as to the nature of radiation or the structure of the atom.

Moseley's identification of the atomic number as a measure of the nuclear charge afforded an interpretation of the frequency law he had found in accord with Bohr's quantum theory of spectra, which had been published previously. The correctness of this identification has since been verified by Chadwick by direct measurement of the scattering of α rays by the nucleus.

As a result of these brilliant experiments of Moseley, a relation of unexpected simplicity is seen to hold for all the elements. The properties of an atom are defined by a whole number which represents the ordinal or atomic number of the element and, at the same time, its nuclear charge and the number of electrons external to the nucleus. The atomic weight turns out to be in a sense a secondary property and the periodic law of the elements is put on a wider and more philosophical basis by the substitution of the atomic number or nuclear charge for the atomic weight of the atom.

The work of Moseley has formed a solid and indispensable foundation for the subsequent attack by an army of researchers of the great problem of the constitution of the outer atom. His frequency law has proved an invaluable aid in interpreting the intricacies of X-ray spectra and their relation with atomic constitutions—a subject on which so much fine work has been done in recent years.

We have seen that Moseley showed that all possible elements, disregarding isotopes, had been discovered up to number 79 except three,[2] numbers 43, 61, and 75, and he stated " as the X-ray spectra of these elements can be confidently predicted, they should not be difficult to find." The study of the X-ray spectra affords a powerful and unique method of chemical analysis of a mixture of elements; subsequent research has shown that the presence of an element can be detected with certainty and its amount estimated by its X-ray spectrum even if it be present only to the extent of one part in a thousand. The first of these missing elements found by this method, namely, number 72, was called hafnium by Hevesy and Coster. In this case the method of X-ray analysis was all-important since hafnium is always found with zirconium, with which it is chemically so closely allied that separation is very difficult.

If the other missing elements existed in appreciable amount in minerals, their detection seemed certain. A few weeks ago it was announced by Dr. Noddack and Fräulein Tacke that the missing elements 43 and 75 had been identified by their X-ray spectra in material separated from certain platinum minerals. A preliminary account of their investigations has been given in this journal of July 11. One element, 61, in the rare earths remains unidentified; but for this, Moseley's list of numbers is complete from 1 to 84.

Moseley had the spirit and courage of the true pioneer in science, coupled with great original ability and powers of work. It is rare in the history of science that so young a man has achieved so much.

[2] In making this statement, Moseley assumed that number 72 had already been filled by a rare earth element celtium. As we now know, number 72 had not been isolated at the time Moseley wrote. There were not three but four gaps.

Concerning the Rate of Man's Evolution.[1]

By Sir ARTHUR KEITH, F.R.S.

BEFORE proceeding to discuss my subject—" The Rate of Man's Evolution "—it may be well to ask the question: Is evolution at work in England to-day? Are the Londoners of to-day taller than those of two, ten, or twenty centuries ago? Any one who sets out to answer this simple question is brought face to face with the difficulties which encompass the inquiries of the student of man's evolution. His difficulties are those of variability. The men and women we meet on the streets are of varying height; to strike a true average for the stature of Londoners we must measure hundreds of individuals in every district of this great city. Nor would our average for London hold for the men and women of Birmingham, Manchester and Newcastle, nor would the averages for these cities hold for their surrounding districts. To know the average stature of men and women now living in England entails the measurement of many thousand individuals.

Until the War we believed that the average Englishman stood 5 ft. 8 in. in height; figures gathered then compel us to reduce our estimate by nearly 2 in. When we search the ancient graveyards and burial-places of England to ascertain the average stature of the men and women buried in them, our difficulties are even greater. The people buried in ancient tombs differed in height just as much as we do; the numbers available for measurement are limited; we have to estimate stature from the length of their limb bones. If we are uncertain of our modern stature, we are still less certain of that of former times. Still, if for the moment we dispense with the precision of the biometrician, we may say that there has been no great change in the stature of the inhabitants of these islands since the close of the Ice Age, some 12,000 years ago. There have been " ups and downs," but the mean for modern Englishmen of 5 ft. 6 in. may be taken as the pivot on which the scales of stature have been balanced for thousands of years.

When we apply measurement to the size and form of head, and compare the dimensions of modern Englishmen with those of former times, we are again confronted with the perplexities of variability. In the third millennium B.C. the skulls of England were long and narrow. About the beginning of the second millennium the eastern and southern parts were settled by a people with short and wide skulls; in the first millennium,

[1] Discourse delivered at the Royal Institution on Friday, March 6.

probably as a result of a new influx, the long and narrow skull again asserted itself. In Roman times, and more particularly in Saxon times, the long and narrow skull prevailed. Measurements made on living Englishmen lead to the belief that the head-form has changed and is changing—becoming slightly shorter and slightly wider. There is evidence of a similar change in the head-form of the people in Egypt. So far as concerns the brain-capacity of the skull there is no evidence of increase. From the limited data at our disposal we must infer that the people who occupied western Europe at the close of the Ice Age stood distinctly above their successors of to-day in the matter of brain-size.

I have said that in certain details of bodily structure the Egyptians of to-day do differ from the men who built the great pyramids some 5000 years ago. This, however, is not the accepted opinion. Those who maintain that modern man has ceased to evolve cite the similarity between modern and ancient Egyptians to prove their contention. Only ten years ago I was of opinion that the evidence from England led to the same conclusion. My opinion was altered by certain investigations I carried out in 1914–15. I took fifty skulls (twenty-five of men and twenty-five of women) from English graves which were known to be 1000 years old or more ; some of them were as ancient as the pyramids. I instituted a minute comparison between these ancient skulls and those of corresponding numbers of men and women who had lived in England during the eighteenth and nineteenth centuries.

The result of this comparison was to convince me that evolution is now at work on our bodies. The chief change is to be seen in the size and shape of the palate ; the roof of the mouth tends to become reduced in size and to become narrower. The bony entrance to the nose shows alterations. It tends to become narrower and its lower margin to rise up so as to form a sharp bony sill. The jaws recede and the bony framework of the nose becomes more prominent. The sockets for the eyes become changed in form ; the lower margin or sill of the orbit tends to sink downwards in the face, thus increasing the distance between the lower and upper margins of the orbit. At the same time the orbits become narrower from side to side ; the breadth across the upper part of the face becomes less. The cheek bones lose their prominence, and there is a tendency for the face to grow narrower and longer.

It may be said that the changes I have described are due to a diminished use of the jaws in modern people, for the jaws form a large and intrinsic part of the face, and any reduction in size and strength in jaws must necessarily alter the whole face. I do not think we can accept a diminished use of the jaws as a true explanation, for this reason. The changes which I have described are confined to about 30 per cent. of the modern population ; 70 per cent. show no such change, and yet all live on approximately the same dietary. The cause lies deeper than a mere disuse of jaws ; certain stocks and families show these changes to a more marked degree and more frequently than do other stocks and families. Such evidence as I have gathered points to an increasing frequency of these new characters during recent centuries. Apparently evolution makes its conquests in the way just described ; progress is made by climbing the scale of percentages.

The result of this investigation took me rather by surprise, for I had been of opinion that men of our type had lived in England for a hundred thousand years or more and retained their essential characters almost unchanged. This belief was founded on a famous discovery made at Galley Hill in 1888. The schoolhouse of Galley Hill occupies a bluff on the southern bank of the Thames, half-way between Dartford and Gravesend. Standing by the schoolhouse we look northwards across the valley to the flat lands of Essex ; Tilbury docks, the scene of another famous discovery of ancient human remains, is clearly visible on the far bank of the river. The bluff on which the schoolhouse stands rises 100 feet above the level of the river ; between the bluff and the river lies a stretch of marsh fully a mile wide. On the bluff, close by the schoolhouse, is a pit, dug by cement-workers, now disused, but a busy place in 1888. The workmen had exposed a series of beds, consisting of gravel, sand and loam, which extended downwards fully 10 feet below the surface soil. In the lowest bed but one the workmen began to expose parts of a human skeleton ; it lay 8 feet below the original surface. At the same level large primitive flint implements had frequently been found. Was the skeleton thus discovered the remains of one who had helped to fabricate these instruments ?

Over the skeleton the original beds were seen to be intact ; if there had been a burial, these beds should have shown definite signs of having been broken. The workmen and two other observers, who examined the section while some of the bones were still untouched, were convinced that the skeleton had become naturally entombed when the beds of sand and gravel were being formed. As to the man thus brought to light there can be no doubt. I have spent many hours in examining his bones. His skull, jaws and limb bones are marked by certain primitive features, but every one of these can be matched in the skeletons of men who are living in England to-day or have lived in recent times. Galley Hill man was of the modern European type.[2]

Try as I could I did not see how the geological evidence at Galley Hill could be set aside, and I accepted the inevitable conclusion that Galley Hill man was as old as the strata in which he lay. How old are these strata ? They are records of the ancient history of the Thames valley. The river made the valley and wrote its records. The gravel deposits on the bluff at Galley Hill are but a fragment of the terraces which fringe both sides of the valley of the Thames at the 100 feet level. These fringing terraces were laid down in the bed of the river or on the shores of its estuary. They tell of a time when the land on which the older and richer parts of Westminster and London now stand lay fathoms beneath the waters of the estuary, and buried deeply by the deposits which accumulated as tides flowed and ebbed.

Geologists recognise other and later terraces of the Thames valley. There is an extensive series at the 50 feet level : Piccadilly runs along this terrace ; the foundations of the Royal Institution penetrate its sands, gravels and loams. There are still later deposits of the 25 feet terrace. The Admiralty Buildings, the Houses of Parliament and the Horse Guards stand on this

[2] The circumstances of this discovery and the characters of the skeleton are discussed in my " Antiquity of Man," second edition, 1925.

terrace. We find in this terrace deposits which mark the close of the Ice Age in England, a date which geologists regard as about 10,000 or 12,000 years distance from us. It is clear, then, that much has happened in the valley of the Thames since the river began to lay down the deposits which make up the 100 feet terrace. If geologists did think in terms of years, there are few who would limit the history of this period of the Thames valley to a term of 100,000 years; many, I am sure, would demand twice this sum. If Galley Hill man is as old as the deposit in which his bones lie, then the rate of man's evolution has been so slow as to be almost imperceptible.

In recent years a new light has been thrown on the history of the Thames valley by a simple discovery. Women know that every hat and coat is dated by its cut or design; they believe that fashion began her imperious sway in modern times. Archæologists and geologists groping amongst the dust heaps of the past have found that mankind has always been the slave of fashion. At all times man has shaped his implements according to the prevailing fashion of the place and period. His handiwork is just as datable as are our hats and houses. French archæologists, when they began to explore their caves methodically some sixty years ago, made this discovery; they began to work out the sequence of fashions. It was soon found that the system discovered in caves could be applied to the deposits or terraces of river valleys. The fashions of the river valleys went a long way further into the past than did those of the caves. The deposits of the 100 feet terrace of the Thames valley, for example, were found to contain fashions of three consecutive periods. For the deepest and oldest bed of all implements were worked in a pre-Chellean manner; in the strata just over the burial bed of Galley Hill man implements were of full Chellean workmanship; in the more superficial strata they were worked in the Acheulean manner. Thus, if we admit that Galley Hill man is truly of the same age as the 100 feet terrace, then his culture is that of Chellean man. The implements of this period often show evidence of high skill in the working of flint.

When the fossil remains of Galley Hill man were discovered, we had only geological data to assist us in fixing their antiquity. Since then a new source of evidence has come to light. In the deposits on the sides of our valley—in the strata of its terraces—there is a complete sequence of the cultural phases of the Pleistocene period. We can trace all the stages which link the cultural debris now being entombed by the Thames in its bed to the pre-Chellean implements which were engulfed when the deepest and oldest stratum of the 100 feet terrace was deposited. Galley Hill man lay in the middle or Chellean strata of that terrace. Those who have studied the sequence of Pleistocene cultures, and have assigned just estimates to each, suppose that the Chellean phase of culture was moving towards its zenith 100,000 years ago. If we base the age of Galley Hill man on cultural evidence, we have to assign to him an antiquity of 100,000 years. If we accept this age, then we have to infer that the type of man now found in Western Europe has come through the greater part of the Pleistocene period without undergoing any great degree of change.

Let us now look at the evidence relating to man's antiquity which has been accumulating these past years on the continent of Europe. The Neanderthal type of man, which we are to investigate first, belongs to the Mousterian phase of culture, one which is much more recent than the Chellean. Most authorities would date the beginning of the Mousterian phase at about 40,000 B.C., and its concluding phase as about 20,000 B.C. All the graves of this long period—from Gibraltar in the south to the centre of Germany in the north—contain remains of only one type of man, the primitive Neanderthal type. The bones of the modern type—Neanthropic man—are never met with. We must thus conclude that the European of the long Mousterian period was Neanderthal man.

Further, the discoveries made at Ehringsdorf, near Weimar, and in the Mauer sands near Heidelberg, have revealed older and more primitive representatives of the Neanderthal type. Heidelberg man is as old as the deepest bed of the 100 feet terrace of the Thames valley; he belongs to the opening phase of the Pleistocene period. Thus all the evidence from the continent leads us to believe that Europe was inhabited by men of the Neanderthal type throughout the greater part of the Pleistocene period. They underwent a considerable degree of evolution before their type was extinguished at the end of the Mousterian period. There are only two items of evidence which clash with this interpretation—namely, the discovery made at Galley Hill, and another at Clichy, in Paris, where human remains, very similar to those of Galley Hill, were found in a stratum of Chellean date.

All authorities are now agreed that the Mousterian period closed some 20,000 years B.C. with the sudden appearance in Europe of men of the modern type. These forerunners of the modern European were big-brained fellows, in every respect of our own type, save that all of them were strong-jawed and had countenances cast in a somewhat rugged mould. A little toning down of these characters would convert them into modern Europeans. It is clear that these forerunners which broke into Europe at the end of the Mousterian period had evolved elsewhere. We have not yet found their cradle-land. I suspect that it will be found in the northern stretches of the Sahara, or perhaps farther to the east—in Arabia or Southern Turkestan. If only we could discover the prototype of the European and assign a geological date to it, we should settle once and for all whether it was possible for men of the modern type to have made a settlement of Europe during the Chellean period, from which they were afterwards expelled by Neanderthal man, or whether his first appearance in Europe was that made at the end of the Mousterian period, when he conquered and extinguished Neanderthal man. If we accept the first alternative, then the evolution of the European type has been slow; if we accept the second, then it has been more rapid. Circumstances force me towards accepting the latter alternative.

Let us turn for a moment to another representative of mankind at the beginning of the Pleistocene period—Piltdown man. I think we are all agreed that his culture was pre-Chellean, and that his period is represented by the deepest and oldest bed of the 100 feet terrace. He thus belongs to an older and more primitive cultural period than that of Galley Hill man. In form of skull and in size and pattern of brain, this early representative of Pleistocene humanity does not differ markedly from living races; if not actually on our line of descent, the Piltdown type cannot be far removed from it. The anthropoid characteristics of his jaws and teeth are the chief obstacles to placing the Piltdown type on the direct line of our ancestry. We may presume, however, that our direct ancestor had reached as high a stage at the dawn of the Pleistocene period as that attained by Piltdown man. Even then evolution must work with some rapidity if the modern European is to be produced before the Pleistocene period had closed.

We must also take into consideration that remarkable fossil type of man discovered in Java, to which the name Pithecanthropus has been given. We may accept the date ascribed to him by his discoverer, Dr. Dubois, as late Pliocene. He is thus older than either Piltdown man or Heidelberg man. His brain possessed distinctively human features, but it is much smaller, much less evolved than any hitherto ascribed to man. His skull and his brain, so far as we know them, stand midway between the status of ape and man. To transform this ancient type of Java into the most primitive of living human types, evolution would have to proceed at an extremely quick pace. It is easier to believe that Pithecanthropus represents the persistence of an early Pliocene type than that it represents the stage reached in human evolution at the end of that period.

The discovery made in the Broken Hill mine, South Rhodesia, in the autumn of 1921, must also be taken into account. Here was brought to light the fossil remains of a primitive human type. Rhodesian man may be described as the cousin of Neanderthal man, but was more primitive in many respects than any example of Neanderthal man so far found in Europe. Neither the geological nor the cultural age of Rhodesian man is fixed as yet, but we shall not over-estimate his antiquity if we make him a contemporary of the men who lived in Europe at the beginning of the Mousterian period. Neanderthal man became extinct; he was not transformed into modern man. In this respect Rhodesian man differs from him; he could stand very well as an ancestor to men of the Australoid type; he might be on the line along which modern races have evolved. To transform the Rhodesian into the Australoid type within the compass of the Pleistocene period demands a moderately rapid progress; to transform the Rhodesian type into that of the modern European in this space of time would require evolution to move at a rapid rate.

The important discovery which Prof. Dart has made at Taungs, Bechuanaland, has no bearing on the problem we are discussing here. He has found the fossil remains of a young anthropoid ape; it is akin to the chimpanzee and to the gorilla. This discovery throws light on the history of anthropoid apes and upon their evolutionary proclivities, but not, I think, upon the pedigree of humanity.

I have stated the chief facts on which anthropologists have to base their judgment as to the rate at which man has come by the present characters of his body and brain. We are all agreed as to the primitive nature of the human types discovered at Piltdown, Heidelberg, Java and Rhodesia. There is also a broad agreement as to the early dates at which these types lived. If they represent the general stage which evolving humanity had reached in the opening phase of the Pleistocene period, then we must count that man's ascent to his present place has been one of rapid progress. On the other hand, we have the discoveries at Galley Hill and Clichy. The men found in those instances are of our type; if we accept the geological evidence, we have to presume that, so far as our ancestry is concerned, evolution has been stationary throughout the greater part of the Pleistocene period. As evidence accumulates, it becomes easier to reject the geological evidence relating to the discoveries at Galley Hill and Clichy, and more difficult to believe that man in his full-blown modern form could have been the contemporary of the uncouth types discovered at Piltdown, Heidelberg, Java and Rhodesia. In brief, the evidence which accumulates forces us to the conclusion that the evolution of man has been more rapid than many of us have hitherto believed.

I began by showing how much our anthropological inquiries are complicated by the rank degree of variability which prevails among all races of mankind. The same difficulty confronts us when we set out to search for our Pleistocene ancestry. The world of to-day is populated with races of the most diverse types. It was so in remote times, only the population was then sparse and scattered, and the racial types were infinitely more divergent than they now are. Of the early fossil types so far discovered only one—the Rhodesian man—has any claim to a place in the direct lineage of modern races. The stages which lead on to man of the Indo-European or Caucasian type have not been found as yet. It is not until we have unearthed these missing stages that we shall be in a position to pass a final judgment on the rate of man's evolution.

Current Topics and Events.

ON July 3 a deputation from the Australian National Research Council waited upon the Prime Minister of the Commonwealth to present a strong protest against acquiescence in the annexation by France of the Antarctic territory of Adelie Land, an action which was announced by French Presidential decree on November 24, 1924. On behalf of the Council, Sir David Masson (president) pointed out that since 1840, when d'Urville sighted and named, but did not land upon, Adelie Land, no attention has been given by France to this region. British expeditions, on the other hand, costing money and life, have made important additions to scientific knowledge of what, from its geographical position, has come to be known as the "Australian Sector." On the Mawson Expedition of 1911–14, which added 1000 miles of coastline to the map, Australia has already spent 70,000*l*., and elaboration and publication of valuable results is still in progress. To no other country will further investigation of this sector be of such interest and significance. The progress of meteorological science, for example, will probably make the establishment of observing stations exceedingly important for Australia, for it must be remembered that Adelie Land, due south of Adelaide, is nearer to Hobart (1467 nautical miles) than Hobart is to Perth. Economically, too, these lands must become of great value, and the framing and administering of laws regulating the exploitation of seals, whales, and other life in the neighbouring seas are matters urgently requiring attention. The question is whether France or Australia is the proper authority to take the required action.

There being no accepted international law in the matter of the administration of unclaimed polar territory, the Australian National Research Council urged the adoption of the principle applied by Canada in 1886 to Arctic lands. In effect this is that unclaimed polar lands should be administered by the most closely adjacent civilised Government. The assignment to Canada of the area between it and the Pole lying between the Canadian E. and W. meridians of longitude, to Norway of Spitsbergen, and to Russia of Wrangel Island, are all in accord with the principle: so was the establishment of the Falkland Islands Dependency in the Antarctic under British rule, and of the Ross Dependency under New Zealand (July 30, 1923). It is now proposed that Australia should claim international sanction for the administration of the whole of that part of the Antarctic continent between 90° E. and 160° E., and it was pointed out on behalf of the deputation to the Prime Minister of the Commonwealth that, on the same principle, France would be justified in claiming an area lying to the south of her various island possessions in the southern hemisphere. The whole matter is arousing considerable interest in Australia, particularly in scientific circles, and it is hoped that the result of Government inquiries and action will be a friendly solution of the difficulty in accordance with the Canadian principle.

The extending use of electricity in agriculture abroad has turned the attention of many supply engineers in Great Britain to the investigation of its possibilities, and a report on the subject has been published in the August Journal of the Institution of Electrical Engineers. The conditions which lead to an economic use of electrical power in farming are different in various countries. In Sweden, for example, the transmission lines from the waterfalls pass along the valleys in which the agricultural areas are situated. In this case, the lines can be readily tapped and the farmers supplied at a low price. In Holland, many lines are in existence traversing agricultural land on their way to supply towns or the electric pumps used for drainage purposes. In Switzerland also, the lines supplying the semi-domestic factories can be readily tapped. In France, however, the shortage of man power makes it necessary to use electric power, and military reasons make it advisable to maintain the agricultural areas at their maximum efficiency and make them as attractive as possible to the population, even at the expense of the State. In Italy, there is a superabundance of hydraulic power from the Alps in the summer time when the industrial demand is a minimum and the farming demand is a maximum. Financial assistance is given by the State to rural distribution lines in Italy, Canada, and Scandinavia. In some of the districts abroad the supply is remunerative and some progress has been made in Great Britain. Most electrical engineers believe that the electrical equipment of all our main line railways is merely a question of time. When it is accomplished, there will be many distribution systems in existence from which a supply to agricultural areas could easily be given at remunerative rates. The cost of an overhead system to supply farmers is about 500*l.* per mile; this is mainly due to strict government regulations. In Sweden the cost is sometimes so low as 100*l.* per mile. It looks as if we would have to wait until the advent of electric traction before much progress can be made in applying electricity for the benefit of British agriculture.

The opening meetings of the fifth Congress of the French Society of Chemical Industry will be held at Paris in the second week in October. As part of the proceedings, a special assembly will commemorate, on October 11, the one hundredth anniversary of the practical establishment of the soap industry by the French chemist, Michel Eugène Chevreul, who, in 1825, with J. L. Gay-Lussac, started a factory for the manufacture of stearic acid. Through his prolonged scientific researches Chevreul explained the process of saponification. The President of the French Republic, members of the Academy of Sciences, and those of kindred bodies will join in the forthcoming commemorative session. Born at Angers on August 31, 1786, Chevreul died in 1889, at the age of one hundred and three years. At seventeen Chevreul went to Paris, entering Vauquelin's chemical manufactory; ultimately he became director there of the laboratory. Later (1824) he took up the post of Director of the Dyeing Department and professor of dyeing at the tapestry works of the Gobelins. His well-known researches on the principles of harmony and contrast of colours were carried out at this period. In 1864 Chevreul was appointed Director of the Museum at the Jardin des Plantes, retiring in 1879. Elected a foreign member of the Royal Society in 1826, Chevreul was awarded the Copley Medal in 1857. The centenary of the birth of this distinguished chemist was celebrated in Paris with signal honour and many felicitous demonstrations. A great procession to the cathedral of Notre Dame took place on the occasion of Chevreul's funeral in 1889.

According to a message dated August 24 in the *Times*, Capt. Amundsen's ship, the *Maud*, has returned to Nome, Alaska, in charge of Capt. Wisting. It will be remembered that Capt. Amundsen set out in June 1922 with the *Maud*, intending to fly from Wainwright or Point Barrow, Alaska, across the Pole to Spitsbergen, and leaving the *Maud* to drift across the polar basin in the ice. Early in 1923 the position of the *Maud* was reported as lat. 74° N., long. 170° 30′ E., and the most northerly point recorded is now stated to be lat. 77° N., long. 146° W. Northwesterly cross-currents prevented the ship from drifting across the polar basin. The party found that polar bears were numerous. As is now well known, Capt. Amundsen changed his plans for the polar flight and set out from Spitsbergen in May last, returning there on June 18 after having reached lat. 87° 44′ N., long. 10° 20′ W.

WE welcome the appearance of a new German anthropological publication—*Zeitschrift für Völkerpsychologie*—which revives the title of a publication now defunct. It is edited by Dr. Richard Thurnwald, the well-known field worker and a sociologist of acknowledged merit. One of the objects of the new journal is to keep anthropologists in other countries, especially in England and in the United States of America, in touch with the latest results of continental work. It is even hinted that should the number of readers in England and the United States be sufficient, papers and reviews in English will be included in the contents. As an earnest of its international aim it may be mentioned that the editorial staff includes Dr. Malinowski, who is reader in social anthropology at the London School of Economics and Political Science, University of London. Should it be possible for the policy outlined by its editors to be carried out, the *Zeitschrift* should fill a serious gap. The loss by Germany of her colonies has brought about a serious curtailment of the sum total of the opportunities for and encouragement of anthropological research, which was a prominent feature in German public policy. The several annual expeditions fitted out by the Kolonialamt have necessarily ceased, and the publication of the *Mittheilungen aus den Deutschschutzgebieten*, the activities and publications of the Hamburg Institute, as well as of the many museums in the principal cities are now no more, or exist only in an attenuated form. It is not without misgivings that the British anthropologist views the disappearance in those territories now mandated of the official or officially encouraged study of the primitive population. In this respect, however, the mandated territories are, unfortunately, in no different case from most of the dependencies of the British empire.

THE thirteenth annual meeting of the Indian Science Congress will be held in Bombay on January 4-9 next. Sir Leslie Wilson, Governor of Bombay, has consented to be patron of the meeting, and Mr. A. Howard, Director of the Institute of Plant Industry, Indore, will be president. The Congress will meet in nine sections, dealing with agriculture, mathematics and physics, chemistry, zoology, botany, geology, anthropology, medical and veterinary research, and psychology respectively. Papers to be presented at the meeting should be forwarded to the general secretary, S. P. Agharkar, 35 Ballyganj Circular Road, Calcutta, or to the president of the appropriate section, with a short abstract, not later than October 15, for submission to the Sectional Publication Committees; not more than ten minutes will be allowed for the reading of any paper. The local secretaries for meeting will be Prof. G. R. Paranjape, professor of physics, Royal Institute of Science, and Principal A. J. Turner, Victoria Jubilee Technical Institute, P.O. Matunga, Bombay, to whom all inquiries as to accommodation should be addressed.

THE Soviet of Commissars of the U.S.S.R. decided on July 28 that, for all foreign visitors invited to the celebration of the bicentenary of the Russian Academy of Sciences, arrangements should be made for free travel on all the railways and waterways of the Union, for sleeping-cars on the direct communication routes, for seats, and for first-class cabin accommodation on all the sea and river steamers from August 15 until October 1. These facilities will depend on the production of a foreign passport, with the visa of the plenipotentiary representatives of the Union abroad, or of the general consulates of the U.S.S.R., with the inscription, "For the celebration of the Academy of Sciences." Besides free travel facilities, the production of a passport and visa thus inscribed will also obtain, without waiting, reserved seats in express trains, and luggage transport. These passports will thus be considered in the present case equal to the yearly certificates of members of the Central Executive Committee of the U.S.S.R. Special Reception Committees at the frontier stations (including Odessa) will meet foreign guests proceeding to the celebration as soon as they disembark, and assist in getting the necessary tickets or reserved seats without delay.

THE death on July 29, at the age of eighty-seven years, is announced of Prof. H. Hildebrand Hildebrandsson, the distinguished meteorologist who was formerly Director of the Meteorological Observatory at the University of Upsala.

WE much regret to announce the death on August 20, at the age of seventy-nine years, of the Right Hon. Sir George D. Taubman Goldie, K.C.M.G., F.R.S., who may be rightly regarded as the founder of Nigeria. When quite a young man, Goldie travelled extensively in Africa, and in 1877 visited the middle and lower Niger, where British traders had already secured a somewhat precarious foothold, depending on the caprice of the river chieftains. Goldie realised quickly the potential value of the region, and set to work to develop a system of government which would afford peace and security for both natives and traders, consideration of native rights being prominent, as in all Goldie's dealings with the negroes. By 1879 he had amalgamated the trading companies on the Niger into a single company, and two years later he applied unsuccessfully to the British Government for a charter which would have given the company practically sovereign powers. Goldie pursued his course in spite of this set-back, buying out in 1884 some French companies which had established themselves on the Niger. His efforts were rewarded in 1886, when the Niger Company was established, with Lord Aberdare as governor and Goldie as vice-governor, after some four hundred political treaties with native chieftains had been concluded. Goldie's schemes were opposed to the aims of the German Colonial Society, backed by Prince Bismarck; but

British interests prevailed, and in 1898 Nigeria was secured to Britain. In 1900 the administration was taken over from the Niger Company by the Imperial Government, and Sir George Goldie took no further share in the administration of the country. Sir George was president of the Royal Geographical Society from 1905 until 1908, and was elected a fellow of the Royal Society in 1902.

THE June issue of the Journal of the American Museum of Natural History, New York, affords a good example of the means by which the Museum keeps in touch with its 8000 members, who receive the Journal bi-monthly as one of their privileges of membership. Of the nine articles, each of about ten or twelve pages, we have space to refer only to three or four. Prof. Ulric Dahlgren describes in clear, non-technical language the "ear" of a katydid situated in the tibia of the front leg, the structure of the tympana on which the sound waves impinge, and the nervous elements by which the impression is transmitted towards the brain. An article by the glass modeller of the Museum, H. O. Mueller, gives the reader a fair idea of the stages in the preparation of models of rotifers and Utricularia which are excellent examples of his technique. Dr. E. W. Gudger brings together a number of instances of spiders attacking and feeding upon fishes, frogs, lizards, birds, and small mammals, and Dr. W. G. van Name in "an instance where evolution has turned backward" gives a readable account of ascidians. The illustrations are, as is usual in the Journal, beautifully reproduced, and include a series by Dr. R. W. Miner representing some of the groups of invertebrates exhibited in the Darwin Hall of the Museum, *e.g.*, as seen on the sea bottom in Vineyard Sound, in a tide pool, on wharf piles, and in sand.

THE Geological Survey of the Union of South Africa has just issued Memoir No. 19 on the Inland Coalfields of Natal, by W. J. Wybergh. This memoir describes the three important coalfields of Natal, the Klip River coalfield, the Vryheid coalfield, and the Utrecht coalfield, giving descriptions in each case of the general surface contours, of the geology of the field, the general analyses and commercial qualities of the coal of the various seams, and finally an attempt to estimate in each case the available coal reserves. The available information concerning the three fields differs considerably, the first named having been quite largely worked and relatively well explored, whilst very little has as yet been done upon the last of the three, although this may well prove to be the most extensive of any. The memoir is illustrated by sketch sections and maps, and constitutes the most complete source of information respecting Natal coalfields which has hitherto been published.

THE Report of the Survey of India for 1923–24 records a considerable increase in the topographical survey of the year, 65,673 square miles being surveyed, an increase of some four thousand square miles compared with the previous year. About 41 per cent. of the whole topographical survey has now been completed. Aero-photo surveys were undertaken in the Irawadi delta and in Waziristan. During the year, 187 one-inch topographical sheets were published, and it has now been decided to treat this series as the tactical map of India, in place of the half-inch series. One new sheet of the international "one million" map was published, making 13 sheets now available. Of the useful maps of India and adjacent countries on the one-million scale, no new sheets were published during the year. Two new sheets have appeared in the Southern Asia series, on a scale of one to two million. The report contains full indexes to all the survey maps.

THE British Museum has recently issued a guide (price 1*s.*) to the collection of fossil plants in Gallery X in the Department of Geology and Palæontology. This guide, which was originally drawn up by Mr. H. Hamshaw Thomas just before the War, has now been revised by Mr. W. N. Edwards, assistant in the Museum, and with its 6 plates, folding-chart of geological strata, and 70 pages of letterpress with 40 text figures, must be regarded as very good value. The guide is simply and concisely written, and concentrates attention mainly upon features which can be seen in plant impressions and without reference to the microscope, though important efforts at reconstruction of long extinct plant types from the scattered material in the rocks are elucidated with the aid of diagrams, some new, some already well known to the student. It may be hoped that this guide will make more accessible, and therefore better known, the palæobotanical resources of the Museum, which include more than 5500 microscope slides from the historic collections of two English investigators, W. C. Williamson and Dr. D. H. Scott.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned: Secretary to the Medical Society of London—The Acting Secretary to the Society, 11 Chandos Street, W.1 (September 4). Inspectors under the Ministry of Agriculture and Fisheries for the purposes of the Diseases of Animals Acts, 1894 to 1922—The Secretary, Ministry of Agriculture and Fisheries, 10 Whitehall Place, S.W.1 (September 7). Two analysts for the building research station of the Department of Scientific and Industrial Research—The Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (September 14). A junior assistant physicist at the building research station of the Department of Scientific and Industrial Research—The Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (September 14). A preparer in the herbarium of the Royal Botanic Gardens, Kew—The Secretary, Ministry of Agriculture and Fisheries, 10 Whitehall Place, S.W.1. A pathological laboratory assistant in the Agricultural Department of the Government of Kenya—The Crown Agents for the Colonies, 4 Millbank, S.W.1 (quoting M/13369). A lecturer in entomology, botany, etc., at the Royal Agricultural College, Cirencester—The Secretary.

Research Items.

A MAGDALENIAN STATION IN SWITZERLAND.—Dr. Fritz Sarasin and Dr. H. G. Stehlen describe in the *Denkschriften der Schweizerischen Naturforschenden Gesellschaft*, Bd. 61, the results of explorations of a Magdalenian rock shelter at Ettingen near Basel, undertaken in 1918, 1919 and 1922. The latter deals with the animal remains, the former gives an account of the excavations and describes the archæological finds. The uppermost stratum consisted of 1·20 to 1·40 metres of brown earth in which were fragments of human bones, bones of recent animals and potsherds belonging to recent, Roman and neolithic times, but no flint implements. The stratum immediately beneath contained no traces of human occupation, but remains of Magdalenian type were found in the two strata below, the first flint implements occurring in the upper of these two strata at depths of 2·50 to 2·70 metres. The implementiferous deposit continued into the lower stratum, the total depth of the deposit being about 50 cm. at its maximum. The implements found included a number of knives and spear-heads of flint, a doubtful implement of limestone, and an implement made from a long bone, 50 mm. long with a spatulate-shaped end.

THE AGE OF THE PADMA.—Vol. 20, No. 1 of the Journal of the Asiatic Society of Bengal contains an interesting note by Bisvesvar Bhattacharyya on the date at which the waters of the Ganges, which it is known originally flowed to the sea through the channel now indicated by the Bhāgirathi, the Hoogly and the Tolly's nulla, were diverted eastward into what is now the Padma. It is usually assumed that this was caused by a diversion in the course of some northern rivers which took place about the sixteenth century. References in Bengal literature, however, support an earlier date. Thus a copper plate inscription of Srichandra Deva from South Faridpur recording a grant of land shows that in the tenth-eleventh centuries the Padma flowed through that district but not as a considerable stream, while from a poem by Dhoyi, who flourished in the twelfth century, it may be inferred that the Bhāghirati was then a mighty river. In a poem believed to be of the fifteenth century—the Rāmāyaṅa of Kṛttivasa—there is a legend recording that a sacred goddess was taken away through the Padma and brought back through the Bhāgirati, which may be a traditional reference to the diversion of the waters of the sacred stream. The Vaiṣṇava literature shows that by the end of the fifteenth century the position of the Bhāgirati as an important river had gone. It would appear, therefore, that the diversion of the waters to the Padma must have taken place in the fourteenth if not in the thirteenth century.

GROWTH AND SPAWNING OF SALMON.—Mr. W. L. Calderwood has given data on the growth of the salmon (Proc. R. Soc., Edin., vol. 45, No. 13, 1925). He emphasises the great amount of growth which takes place during the first summer of sea-feeding, often continued during the second summer in the sea. Two years commonly elapse before the first seaward migration of the smolt, and such a fish, after spending a year and a varying number of months in the sea, has grown to about three times what its length was when a smolt, and now as a grilse it returns to the river. Other fish have spent two or three years in the sea; these, with two years of early life in the river, are therefore five years old; and still others have spent a further year in the sea, and, not having lost weight by leaving their feeding grounds and spawning, they are of great size. Mr. Calderwood states that all fish more than 50 lb. weight are males, and that during his twenty-five years' experience of Scottish salmon fisheries, he has known only two cases of females more than 40 lb. in weight, and both fish came from the river Lochy; one weighed 43 lb. and the other 48 lb. He asks why it is that the salmon which enter the streams of outlying islands, *e.g.* Lewis, Mull, Skye, and those of small and rocky catchment areas on the mainland are always small, and suggests that it is because of the poor river-feeding for the parr and smolts in those barren grounds. Another feature of the salmon of these small Highland streams is that they return to spawn more frequently than do the fish of the larger rivers. In the river Add in Argyll, fish have been found with three and four spawning marks, and one kelt showed four spawning marks and therefore had spawned five times, which appears to be a unique case. Of all the salmon scales examined by various investigators, only eight which show four spawning marks are recorded—two from the St. Lawrence, four from the Add, one from the Conon, and one from Loch Maree.

CLYDE PLANKTON.—Miss S. M. Marshall has studied the plankton of the Clyde for the years 1923 and 1924, and has summarised the principal results (Proc. R. Soc., Edin., vol. 45, No. 12, 1925). The general course of events was the same in both years and is similar to that found at other stations. There is a winter minimum followed in early spring by a large increase in the number of diatoms and of larval forms, *e.g* of copepods, cirripedes, and molluscs. This is followed in May and June by a period poor in diatoms but rich in crustacea. July, August, and September are the months richest in variety—diatoms are abundant, peridinians reach their maximum, larvæ of all kinds are numerous, as are also medusæ and sagitta. The autumnal diatom maximum is in August or September, after which the number and variety of planktonic organisms decrease. The first part of the paper deals with the organisms in systematic sequence, noting their relative abundance at various seasons, while the second part is a summary of the plankton month by month in 1923.

THE SANTA BARBARA EARTHQUAKE.—A short article on the Santa Barbara earthquake by Dr. Bailey Willis, the well-known student of Californian earthquakes, is published in *Science* for July 10. Dr. Willis was in Santa Barbara when the earthquake occurred, and states that it was a moderately severe, but not a very severe, earthquake. That it was much slighter than the Montana earthquake which occurred thirty-six hours earlier is clear from the fact that it was felt in only four counties in California, while the Montana earthquake disturbed four States. The Santa Barbara earthquake, Dr. Willis considers, was due to a movement of a fault that runs along the Santa Inez range of mountains, the movement being from south to north. As each of the four great faults of southern California has produced an earthquake during the last seven years, and as the last great earthquake of the Santa Barbara region occurred in 1857, an earthquake there was expected by American seismologists, and the prevailing feeling seems to be one of relief that it was not more serious. It was known that a strong pressure is being exerted against the Santa Inez range from the south, as Gaviota Peak, a triangulation point of the U.S. Coast and Geodetic Survey, has been thrust 24 feet northward in thirty years.

RIVER GAUGING.—A pamphlet entitled "River Gauging" has recently been issued by the Department of Scientific and Industrial Research, being a Report by Dr. M. A. Hogan on methods and appliances for use in Great Britain (London: H.M. Stationery Office, 1925, 2*s*. 6*d*. net.). As a review of the present state of knowledge on a complex and difficult operation, the publication is an exceedingly interesting and serviceable compilation. It was prepared for the Committee on Gauging of Rivers and Tidal Currents, and the conclusions arrived at are endorsed by them and embodied in their report. Very briefly, the general conclusion is that methods and instruments for gauging are available and adequate for the needs of a hydrometric survey. In detail, for gauging small streams, some form of measuring weir is suggested with an automatic recorder. For large streams with natural flow, the discharge can be expressed as a function of the water level, provided the bed of the river does not alter its character; the curve representing this function in any given case can be drawn from measurements of the discharge by a current meter—this is known as the "stage-discharge" curve. For large streams artificially regulated, the stage-discharge method is useless, but measurements can be made by calibrating a weir by a combination of model experiments and current meter measurements. The most generally useful type of meter on the market is stated to be the small Price meter, as used in the United States. This meter has proved reliable and convenient where the velocity of flow is not less than half a foot per second and there is no undue turbulence. "Where turbulence exists," it is advisable to take readings both by the Price and screw type meters. "Under turbulent conditions," a propeller meter with a guard ring, such as the Stoppani, should be used, as this type is subject only to small error when measuring oblique velocities.

ATMOSPHERIC POLLUTION.—The tenth report of the Advisory Committee on Atmospheric Pollution which has recently been issued by the Meteorological Office, Air Ministry, shows continued activity on the part of this body during the financial year 1923–24. The report is divided into eight sections, three of which deal with methods of measurement of atmospheric pollution which have now become well established. These are: (1) the standard collecting gauge which measures the impurities brought down by rain, (2) the automatic filter which gives a semi-continuous record of the amount of impurity in the air, and (3) the dust counter. The remaining five sections are devoted to more recent developments of the work. Of these, the research into the effect of atmospheric pollution upon visibility is drawing to a close. A close connexion has been found between the amount of impurity as measured either by the automatic filter or by the dust counter and the percentage transmission of light through 50 feet of air. It is probable that the relationship would be even closer were it not for the presence of small water drops in the air in foggy weather. These drops affect the visibility but not the pollution measurements, and no satisfactory means of measuring their number has yet been found. Some useful measurements of dust in the upper atmosphere taken on aeroplanes are recorded from America, but it has not yet been found possible to obtain records in Great Britain, though it is hoped the difficulties in the way may be surmounted shortly. In two other sections a new dust counter for use in exceptionally dusty atmospheres is described, and the darkness of January 23, 1924, in London, when a high fog of unusual intensity prevailed, is discussed in some detail. It is noted that records from one or two additional standard collecting gauges are still needed in country districts, though urban areas are well represented. It may be hoped that this need will soon be met.

WEATHER AT FALMOUTH.—Meteorological notes and tables for the year 1924 prepared by Mr. J. B. Phillips, superintendent of the Falmouth Observatory, have just been issued. Many features of general interest have been brought out in the notes by the author. Temperature comparisons are made with other stations reporting to the Air Ministry which show Falmouth to enjoy a generally mild winter. The mean air temperature for the year was 51°·2 F., which is 0°·5 warmer than the normal for 50 years; the coldest month was February with a mean 41°·5; the warmest, July with 59°·5. The absolutely highest temperature was 69° in August, and the lowest 27° in February. The duration of bright sunshine in 1924 was 1597 hours, which is 156 hours less than the normal for 40 years; the brightest month was July with 208 hours, and the months with least sunshine were January and December with 59 and 60 hours respectively. There was a great preponderance of winds from south and west, these directions occurring on 238 days, while north and east winds blew only on 128 days. The total rainfall for the year was 58·08 inches.

CINEMATOGRAPHY IN COLOURS.—The Keller-Dorian method of cinematography in colours is described by M. A. Troller in *La Nature* of August 1. A colour filter is inserted between the components of the lens, which is divided into two equal segments with a parallel-sided strip between them, each of the three spaces thus provided being coloured with one of the three primary colours. The film has impressed upon the back of it closely packed lens-like projections, at the rate of about thirty to forty to the mm., and this side is turned towards the lens, so that each of the lenticular projections on the film gives a minute image of the tricoloured filter on the sensitive surface. For projection the arrangement is the same, but the direction of the light is reversed. To produce the projections on the back of the film, a skilled engraver working under a microscope cuts an original, and from this a suitable steel roller is prepared, which is mounted with an ebonite roller, so that the film may be passed between them. The steel roller is electrically heated to 100° C. to soften the base of the film, and enable it to take the impression.

XENON HYDRATE.—A hydrate of argon was discovered by P. Villard in 1896, and M. R. de Forcrand announces in *C.R. Acad. Sci.*, Paris, July 6, that he has prepared xenon hydrate by compressing the gas, with a trace of water, in a Cailletet apparatus. He had already found a crystalline hydrate of krypton, with the probable formula $Kr + 5H_2O$, in 1923; but the xenon hydrate is produced much more easily, only a few atmospheres being required to coat the walls of the tube with a kind of hoar frost, without the application of ice. At temperatures in the neighbourhood of 0° C., this remains intact when the pressure is only a little above that of the atmosphere. A table gives the heat of formation, starting with liquid water, at a series of temperatures and pressures ranging from 1·4° C. and 1·45 atm. up to 23·5° and 17·00 atm., the mean value being 18·266. At and above 24° C. the hydrate is not formed even with very high pressure; the corresponding temperature for krypton is 13°. It is found graphically that the dissociation pressure of one atmosphere corresponds to a temperature of −0·13°. The calculated number of molecules of water to one atom of xenon is 6·6; that is to say, that there are 6 or 7 molecules of water in the hydrate. The dissociation pressures at 0° C. are 1·15 atm. for xenon, 14·5 for krypton, and 98·5 for argon; a hydrate of neon has not been obtained even with 260 atm. at 0° C. Thus the stability of the hydrate increases with the molecular weight of the gas, and this is also shown by the heats of formation of the hydrates.

Carnot's Cycle and Efficiency of Heat-Engines.[1]

CARNOT laid down the great and incontrovertible principle that if, when we have obtained motive power by the application of heat, we inquire whether we have obtained the maximum of motive power from this application, we can answer this question by ascertaining whether by applying the same amount of motive power in reversing the process of expansion, or expansion and contraction, in the course of which we have obtained motive power, we can bring the working substance back to its starting-point. When the process is reversible in this manner, we have obtained the maximum possible output in motive power, whatever be the nature of the working substance, gaseous, liquid, or solid.

Carnot thus furnished a criterion by applying which we could judge of the efficiency of a heat-engine. Unfortunately, however, he failed in applying that criterion correctly. His unsuccessful attempt was, however, a great one, since it has continued to mislead scientific men, and confuse engineers, for now more than a century. Carnot invented the famous Carnot cycle, the bugbear of generations of students, and with it an argument to the effect that it is the most efficient cycle possible in the mode of action of a heat-engine.

It is evident that in the cycle described by Carnot, much of the heat taken up from the source in the second stage (isothermal expansion) is thrown away into the condenser in the fourth stage (isothermal compression). This is apparently a waste of heat energy. It is only in the second and third stages of the cycle (namely, isothermal expansion and adiabatic expansion) that work is done on the engine, or motive power is, to quote Carnot's expression, gained. It is, therefore, at the end of stage three that we must apply Carnot's test. When we do so, and simply re-compress the air to its starting volume, we find that much more work has to be done on the air than was done by it during the second and third stages of the cycle. We have, therefore, in stages two and three of the Carnot cycle expended heat which could have been converted more completely into mechanical energy if we had employed adiabatic expansion; and this waste has evidently occurred in the isothermal stage of expansion, since the third stage is in each case adiabatic.

We thus see that the Carnot cycle is radically inefficient. A great deal of heat is transferred quite uselessly from the source to the condenser, and thus wasted. To obtain from the heat communicated to the air in the cylinder the maximum of work on the engine during the expansion, we must quite evidently make the whole expansion adiabatic, while to reduce to a minimum the corresponding work done by the engine in the compression stage, we must make the whole of the compression isothermal, thus throwing away as much heat as we can with the condenser at its existing temperature.

It is evident that by eliminating altogether the effects of atmospheric pressure, we could at once obtain fifty per cent. efficiency in the cycle of an ideal heat-engine. This is accomplished in the ideal cycle of a steam-engine working with complete adiabatic expansion of the steam down to the pressure of the aqueous vapour in the condenser. In this case the cylinder would be enclosed above, and would contain at the start nothing but aqueous vapour at the pressure corresponding to atmospheric temperature, except for a little water in the space below the piston. In stage 1 the water would be evaporated before the piston was allowed to move. In stage 2 the steam would expand adiabatically, doing work on the engine, until it reached the pressure of the aqueous vapour above the piston. In stage 3 the piston would return to its original position without any net work being done by or on the engine, and the steam not already condensed would condense again to water. Half the heat applied would be spent almost entirely on the engine during expansion, and the other half would pass into the condenser as the piston returned. The efficiency would thus be practically fifty per cent.

We can see now that the percentage efficiency of a heat-engine, or at any rate of a steam-engine, provided that the expansion is adiabatic and complete, and the compression isothermal, does not depend at all on the difference between the initial and final temperature during the expansion. We can quite evidently obtain just the same percentage efficiency with a small as with a great difference of temperature. On this point we are running counter to cherished academic doctrines and to authority which has been generally accepted for more than seventy years; but that authority rests upon the quite mistaken conclusion that the Carnot cycle is one of maximum efficiency within a given interval of temperature.

Let us now look more carefully, and at the same time from a wider point of view, at the reason why more than fifty per cent. efficiency is impossible in a heat-engine. In the case of the air-engine starting from atmospheric pressure and temperature, it is the atmospheric pressure which limits the stage of expansion. The air can no longer expand and do external work after its pressure has fallen to that of the atmosphere pressing on the upper side of the piston. Now the pressure of the expanding air falls in accordance with Boyle's law in proportion to its relative increase of volume; but the work done during adiabatic expansion, and consequently the fall in absolute temperature of the expanding gas, depends also on the pressure, and therefore proceeds also in proportion to the relative increase in volume. The air in the cylinder can only exist in the expanded state at the existing pressure in virtue of an increase of absolute temperature proportional to the increased volume. This follows from Charles's law. Hence, assuming Charles's law, for every degree of temperature lost by the air in expansion, the air in the cylinder must be a corresponding degree above the atmospheric temperature which it had before heat was applied to it. When the temperature of the expanding gas has fallen by half the amount to which it had been raised, this condition is no longer possible, and the air can no longer expand against the atmospheric pressure. Half the heat has gone in external work, and half remains in the expanded air, and must be thrown away if the air is to be brought back to its original state with the help of atmospheric pressure alone.

The conception of the Carnot cycle, with its extraordinary peculiarities, was quite evidently based, not on the study of actual heat-engines, but on Carnot's ideas, derived from the caloric theory, of how a heat-engine works. These ideas led him to the conclusion that in the working of a heat-engine, any change of temperature in the working substance, unless the change is accompanied by change in volume, is a waste of heat. Hence the strange feature of the Carnot cycle that in it there is no change of temperature without change of volume.

As we have already seen, the whole of the expansion and none of the compression must be adiabatic

[1] Abstract o a paper on "The Maximum Efficiency of Heat-Engines and the Future of Coal and Steam as Motive Agents," read before the Institution of Mining Engineers on June 16 by Dr. J. S. Haldane, F.R.S.

in a heat-engine working with maximum efficiency. There must also be one and only one stage in which abrupt change of temperature occurs without change of volume. In the steam-engine with maximum expansion of the steam, there is abrupt rise of temperature at the beginning of the cycle. If, as in the Watt-Newcomen engine, there is also abrupt fall of temperature before expansion is complete, loss of efficiency is a necessary result.

At the present time steam-engines and oil-engines are running a neck-to-neck race as regards many employments, while elsewhere the oil-engine is everywhere being applied for quite new purposes, where no heat-engine had previously been applied. In the opinion of many persons the steam-engine is bound to be displaced more and more by the internal-combustion engine. This opinion is largely based on the current academic doctrine that the efficiency of a heat-engine depends on the absolute temperature reached in the engine. In the present paper the academic teaching has been thrown to the winds, backed though it be by the names of men to whom the whole world has good reason to be grateful. A step further may also now be taken. We suggest that the development of the steam-engine has been very greatly hindered by the fallacious teaching associated with Carnot's cycle. Engineers have been prevented from seeing clearly what the maximum efficiency of a heat-engine is, where that efficiency is being needlessly lost, and how the steam-engine can be modified to suit varying circumstances without loss, or with minimum loss, in efficiency.

We still use furnaces and boilers which waste much heat whenever an engine is temporarily out of action or doing only light duty, even though they may be so designed as to cause very little waste, during continuous full duty of the engine. It seems probable that the furnaces and boilers of the future will be gas fed, the gas being formed in a heat-insulated producer or carburettor, and only made and burnt as the steam is required, the whole regulation being mechanical and the heat of the waste gases being nearly all returned to the furnace and boiler. Another alternative presenting similar advantages is the use of pulverised fuel. The boiler and furnace can then be made much smaller than is now usually the case.

As regards modifications of the steam-engine to suit varying circumstances, it seems that small engines, working at very high pressures, and with correspondingly small tubular boilers, will come more and more into use. A steam pressure of 100 atmospheres, with a corresponding temperature of 600° F., seems well within reach. At such a pressure the percentage loss of efficiency, owing to either the discarding of a condenser or condensation at or even somewhat above boiling-point, would not be too large. The bulky apparatus required for complete expansion can thus be dispensed with, reducing the engine to extremely compact proportions and very small weight. By these means the steam-engine can be rendered far more compact and adaptable to varying conditions under which only internal-combustion engines, or steam-engines without a condenser, are now used.

Perhaps too sanguine a view is taken of the future of the steam-engine; but it seems that in every case where either fuel economy or size of engine is of predominating importance, the steam-engine and coal will in the future displace the internal-combustion engine and oil. Even where oil or gas is alone desirable or available as fuel, it will probably turn out to be cheaper, where fuel economy and weight of engine are important, to use them as fuels for steam-engines. The latter will probably take the place of internal-combustion engines in even motor vehicles and aeroplanes. With the further development of electrical transmission of power obtained from coal and steam, the steam-engine and coal will also come more and more to the fore.

The Motion of Whales during Swimming.

By Dr. C. G. JOH. PETERSEN, Director of the Danish Biological Station, Copenhagen.

IN our two well-known Danish zoological handbooks it is stated regarding the swimming of whales, in one that "It is the screwing actions of the hind part of the body (the tail) which force the whale through the water, the tail fin acting only to balance up and down," in the other that "The whales move in the manner of fish by flapping the tail from side to side"; according to a verbal statement, this was observed by the author himself on porpoises in a tank in the Zoological Garden. In the foreign literature I have found information[1] that whales, when swimming rapidly, move the tail fin up and down; when they swim slowly, on the other hand, they perform screw-like motions. Porpoises have been observed in tanks in England to swim by moving the tail fin up and down with slight undulations to each side.

Thus there seem to be greatly divergent opinions as to the manner in which whales effect their swimming movements. I have myself seen dolphins following, *e.g.*, the steamship of the Biological Station, and I have spoken with many others who have seen the same; we are agreed that it is impossible to see how they swim; they only tremble, but follow, apparently with ease, the largest steamship going at full speed.

In the spring of 1924 I was by chance present at a catch of porpoises in the Bramsnæs Vig (by Holbæk), and there I bought the tail of a porpoise just caught. Dr. Blegvad, the assistant of the station, and I dissected it; Fig. 1 is a sketch of the result. At the base the tail fin is very flexible, so long as it is in a fresh condition, similar to the carpus of the hand of man. The vertebræ here are very flexible in relation to each other, and the vertebral column extends right out to the posterior edge of the fin. No muscles are found in the tail fin itself, only four strong tendons extending right out to the extreme vertebræ; these tendons may move the horizontal fin up and down, but scarcely with any force, and doubtfully sideways. The flukes of the tail fin consist only of epidermis and fibrous tissue; they are somewhat elastic for movements up and down. Of other muscles in the tail (hind part of the body), there are two for lateral motions and two for vertical motions; they terminate with strong tendons some distance from the root of the tail fin.

The tail fin with its vertebræ may thus be moved up and down by bending at the root; but these movements do not seem to produce force enough for powerful swimming, because, amongst other reasons, the flukes will impede the speed considerably when in their extreme positions. One can well imagine that quick movements of the flukes towards the horizontal position may give a small speed, as when a rudder is moved in a little boat; this produces a slight speed, if the motions towards the central

[1] Beddard, "A Book of Whales," London, 1900; Murie, "On the Anatomy of a Fin-Whale," Proc. Zool. Soc., 1865; T. Bell Pettigrew, "Animal Locomotion," London, third edition, 1883.

position are the strongest. But if we imagine that the extreme part of the tail (the hind part of the body) itself is moved up and down, even if these movements are only slight, the elastic fin would be enabled to take up suitable inclined positions for up-and-down movements and thus give effective power during the full extent of the motion (Fig. 2).

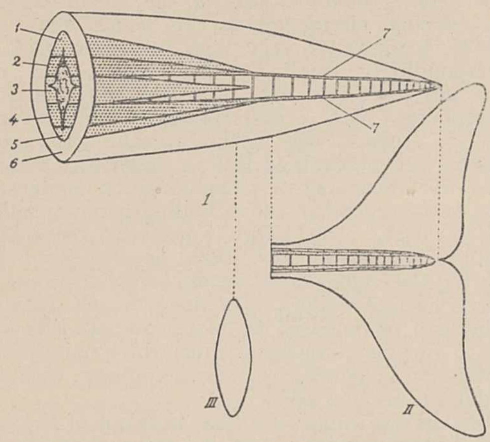

FIG. 1.—Combination of a vertical, transverse section and a vertical, longitudinal section through the tail of the porpoise. 1, Dorsal muscle; 2, the two upper tail fin muscles; 3, the two lateral muscles; 4, the two lower tail fin muscles; 5, ventral muscle; 6, layer of blubber; 7, left upper and lower tail fin tendon. II. The tail fin seen from above, with its two upper tendons and the vertebræ denuded. III. Transverse section through the tail.

In order to try this, I had a thin steel plate made, shaped like the tail fin of a porpoise, and attached it to a vertical stick; when this stick was moved up and down in the water at a suitable speed (rhythm) the plate produced a powerful current rearward, simultaneously forcing the stick forward, against the edge by which I supported it. The steel plate I employed was too thin and flexible for a continuation of these experiments; for I could only "swim slowly" with it, and to procure a stronger one took so long, that I was not able to proceed further; but the experiment had proved, without doubt, that by means of small movements up and down of the terminal part of the tail, the tail fin of the dolphin may be employed as an excellent means of propulsion, inasmuch as its muscles (tendons) may give it the correct rigidness, corresponding with the varying speed through the water; in this the operations of the four named muscles and tendons surely may be sought. When the dolphin starts swimming, large movements are required to move a sufficiently large quantity of water, but, when speed is once gained, the water will be felt hard, and then only small but quick motions up and down, with more force and more rigidity in the tail for each stroke, are required. Dolphins are said to be able to follow destroyers up to a rate of about 30 knots, *i.e.* at the same speed as fast trains go between Copenhagen and Korsør.

It is the great drawback in all steamship propellers that their mould cannot conform with the variation in speed, and that they are quite without elasticity; they yield, therefore, only a comparatively small effective power. Mr. Vogt, an engineer, has endeavoured with the pendulum propeller to produce a variable pitch by means of a complicated system of springs (metal springs), and he really succeeded in this; but the construction seems to have been too expensive to make use of practically.

By means of the elastic and flexible structures of which the tail fin and the tail of the porpoise are made it is, on the other hand, possible to obtain an enormous effective power by comparatively few and small movements; thus there is no need for astonishment that this little fin is really able to give such a high speed to the big animal. Mr. Vogt, with whom I have debated this matter, agreed fully with me on this point, as well as, on the whole, with my views upon this matter.

The objection may be raised to this illustration of the swimming movements of the whale, that the movements up and down of the tail itself must evidently impede the speed through the water; but the tail of the whale is, as a rule, so compressed in the terminal part that the resistance offered is considerably diminished, and, furthermore, it refers only to small, vertical movements.

As is well known, many fishes swim by performing lateral movements with the tail, because the fin is set vertically, *i.e.* on the same principle as the motions of whales, which only move the fin up and down, because this is situated horizontally; that fish in addition to these movements may also perform screw-like motions, is also well known from seeing goldfishes in aquaria. But they do this only when swimming slowly; if speed is desired, it is gained by means of strokes from side to side, analogous to the up-and-down strokes of the whales.

It is now easily understood why many people, including myself, who have observed dolphins following steamships during speed, have seen nothing but a trembling of their bodies, because the movements of the tail and the fin are up and down and comparatively slight, and vertical movements are not easily observed from above. Had there been sideways or screw-like motions, they could not have escaped the observer; that such movements also may be performed by whales, I do not doubt, but they occur only during quite slow movement, when the whale feeds, or when for some other reason it is in no hurry.

When, especially from observations of porpoises in tanks, lateral motions of the tail are mentioned, or

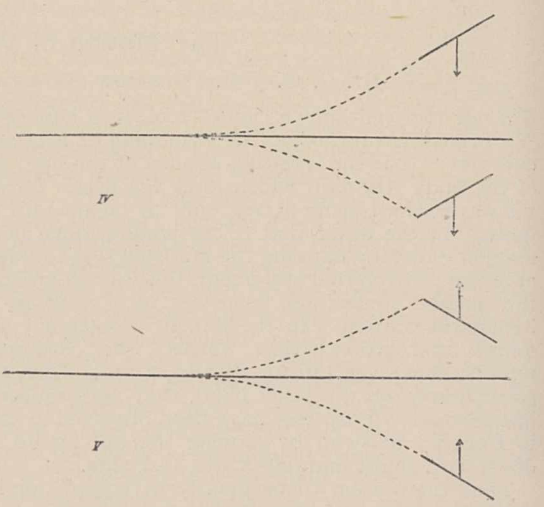

FIG. 2.—The positions of the tail fin (IV.) during downward movement of the tail, (V.) during upward movement of the tail.

that the tail is used in a fish-like manner by strokes from side to side, this evidently arises from the fact that here the animal the whole time had to steer in order to avoid running against the sides of the tank. The observations themselves undoubtedly are correct. But statements to the effect that the tail fin is exclusively used for steering up or down are false; it may be used for this, and certainly also for steering sideways, but the flukes of the tail fin are the proper organs for propulsion of the whale, as the propellers are in a ship, and the importance of the tail (hind part of the body) corresponds to that of the ship's engine which moves the propeller.

If we compare the size of the propeller of a steamship with the size of the ship, the propeller seems small, and still it may, in spite of its slight effective power, propel the ship; the tail fin of a dolphin or a whale is not smaller in comparison with the size of these animals than the propeller of the steamship, but larger, if anything. Thus, bearing in mind the obviously far greater effective power of the fins of the whales, it is not to be wondered at that these animals may follow the biggest steamships with ease, and even follow our quick destroyers; in fact, a harpooned whale may carry away a steamship with great velocity through the water, in spite of the steamer backing full speed with its propeller.

I have presumed that the anatomy of the tail and the tail fin is mainly the same in the porpoise as in the other whales; this, however, as well as so many other things concerning this matter, I must leave to others, who may get an opportunity to examine it more closely.

Physics in Radiology.

SEVERAL notable papers were read before the Physics Section of the International Congress of Radiology, which was held at the Central Hall, Westminster, on June 30-July 4. The work of the Congress began with a joint discussion, in which the Physics and Radiology Sections met for a full day's consideration of the difficult problem of X-ray measurement. This discussion was opened at 10 A.M. on July 1 before a large attendance, by Sir William Bragg and Dr. Beclére, the president (Dr. T. Holland) occupying the chair. The importance of such a discussion, in which representative men from practically all over the world took part, is obvious, and it is satisfactory to be able to report that the practical outcome has been a definite proposal as to the mode of initiating the formation of an International Committee to deal with the matter.

Sir William Bragg dealt generally with the importance of physical measurements and referred to the difficulties already met with in determining the brightness of light. He pointed out that the X-ray problem has special added difficulties of its own. First comes the question of a unit, and then the production of standards to be expressed in terms of the agreed unit, and finally it remains to ascertain what biological effects are associated with certain rays, or groups of rays, so measured. He was hopeful that a successful issue will ultimately result from the efforts now being made throughout the world towards setting up a suitable system of X-ray measurement, but he warned his hearers that the question of an X-ray unit is beset with more difficulties than have ever been met with in the case of any other unit which science has been called upon to devise. Finally, he directed attention to the principles which must underlie such a system, and set the problem clearly before the meeting.

Dr. Beclére, of Paris, spoke more in detail with reference to the conditions which the medical radiologist has to face, referring to the pioneer work of Villard, and discussing the actual methods of measurement suggested by Solomon, Krönig and Friederich, Seit and Wintz, and others. He made an eloquent appeal for international unity in regard to the question of X-ray measurement.

On the conclusion of the formal opening of the discussion, the chairman of the Physics Section (Major C. E. S. Phillips) presided for the rest of the day. In the course of his remarks, Dr. Beclére strongly urged the setting up of an International Committee to deal with X-ray measurements, and Dr. Finzi, who spoke later, also directed attention to the matter and seconded Dr. Beclére's proposal, which on being put to the meeting was carried with enthusiasm.

Dr. Beclére was followed by Dr. Solomon (France), Dr. Behnken (Germany), Prof. Grebe (Germany), Dr. Altschul (Czechoslovakia), Dr. Shaxby (Cardiff), who read a communication from Dr. A. Dauvillier (France), Dr. Finzi (London), Dr. Moore (London), Prof. Wintz (Germany), Dr. Reyjeski (on behalf of Prof. Dessauer), Dr. Glasser (U.S.A.), Prof. Friederich (Germany), Dr. Mallet (France), Dr. Holdfelder (Germany), Prof. Holthusen, Dr. Coliez, Prof. Crowther (Reading), Prof. Russ (London), and Dr. Ernst (U.S.A.). The chairman directed attention, at the conclusion of the discussion, to the principal points raised, and emphasised the desirability of taking steps towards the establishment of an International Committee to pursue the subject.

On Wednesday evening the Silvanus Thompson Memorial Lecture (inaugurated by the Röntgen Society) was delivered (in English) by the Duc de Broglie, and attracted an enthusiastic audience. The nature of the secondary radiations set up by X- and gamma rays, and attempts to understand the process by which they are initiated, are matters of great importance and interest to radiologists generally, and especially to those searching for clues as to a biophysical explanation of the effects of radiations upon tissues. The Duc de Broglie eloquently summarised our present knowledge of this subject, and gave a valuable account of some recent researches by French physicists who have been extending the work begun by Rutherford, C. T. R. Wilson, Ellis, and others, relating to the problem. At the conclusion of the lecture the Silvanus Thompson Memorial Medal was handed to the Duc de Broglie by the president.

On Thursday morning an interesting paper on the radiography of coal was read by Mr. Norman Kemp, and Dr. Bouers then described a new metal X-ray tube (Metalix) for use in radiography and X-ray therapy. This was followed by an important paper by Prof. Friederich (Freiburg) in which some new results were described. The last paper of the morning was read by Dr. Koopman, of Amsterdam, who showed a novel type of Potter-Bucky diaphragm. The variety and originality of these papers were striking, and interesting discussions followed each one of them.

In the afternoon the Section did not meet, on account of the visit to the National Physical Laboratory, which had been arranged for that day in response to the kind invitation of the Director.

The Section again met on Friday morning at 10 A.M. for a discussion of methods of protection, opened by Dr. G. W. C. Kaye, of the National Physical Laboratory. An animated debate followed, to which M. Pilon (Paris) sent a written contribution (read by Mr. Gough), and the following took part: Dr. Ferreaux (Paris), Mr. Pullin (London), Dr. Pirie (Montreal), Dr. Shaxby (Cardiff), and Dr. Moore (London). Dr. Kaye, in his reply, directed attention to the need of standardising the scheme of protection, and proposed the following resolution, which was seconded by Mr. Pullin and unanimously agreed to:

" That the Physics Section of the first International

Congress of Radiology wishes to place on record the desirability of adopting a standard scheme of X-ray and radium protection throughout the world."

The morning session was brought to a close with a valuable paper by Prof. F. L. Hopwood, who dealt in detail with the organisation of a hospital radium service. Considerable discussion ensued, in which Dr. Ferreaux, of the Radium Institute, Paris, and Dr. Failla, of the Memorial Hospital, New York, took part.

The afternoon session was opened with a paper (read in title only) by Dr. George Clark (U.S.A.), which was followed by an interesting contribution by Dr. Lewis Simons (London), entitled "The Basis of the Selective Chemical Action of X-rays and Light," and the work of the Section was brought to a close by a discussion dealing with modes of producing currents at constant high potential. This discussion was opened by the chairman (Maj. C. E. S. Phillips), who gave a general survey of the subject. Many speakers stated their views, and Prof. Dessauer described his new methods now in use in Germany. Dr. Moore, Mr. Gunstone, and others contributed to the discussion in which all were agreed as to the desirability of adopting constant high-tension apparatus for accurate physical or therapeutic work.

It is clear from the work of the Congress that physics is playing an important part in the progress of medical radiology, and that the scope of its usefulness is ever widening. The study of X-ray spectroscopy, for example (to mention only one aspect of it), has already lead to the design of wave-length measuring instruments for use in the ordinary routine work of a medical X-ray department, as well as furnishing a knowledge of organic structures unobtainable by other means. A well-organised exhibition of apparatus held in conjunction with the Congress also testified to the many practical applications that have arisen from work in radiation physics, which has been carried out in many parts of the world during recent years, as well as to the ingenuity of those who provide appliances for medical radiologists.

The truly international character of the Congress was very striking. There were representatives from India and Iceland, from Sweden, Russia, Czechoslovakia, France, Belgium, Germany, Italy, U.S.A., Canada, and so forth; and it was a remarkable fact that this great medical meeting had been made possible by the researches of a physicist whose rare distinction it was to have given to the world a discovery of such far-reaching possibilities for the good of mankind. It was generally acknowledged that the Congress had proved a success; it had, in fact, brought together representative men from many parts of the world, whose enthusiasm was tempered only by a desire to advance cautiously in a field of medical work which is admittedly still imperfectly understood.

C. E. S. PHILLIPS.

Industrial Water Supply.

THE subject of industrial water supply and stream pollution was discussed at the joint meeting of the Institution of Chemical Engineers and the American Institute of Chemical Engineers, which was held on July 17, in Leeds. Messrs. F. P. Veitch and L. C. Benedict, of the Bureau of Chemistry (U.S.A.), contributed a valuable paper on the composition and disposal of wool-scouring waste liquors, in which they described current methods of recovering wool-grease and fertilising material from them, as well as recent work done by the Bureau which indicates the superior advantages of extracting with naphtha and subsequent scouring with soap and water. They estimate that the wool-scouring liquors annually produced in the United States contain, in millions of pounds weight, grease 60-70, potash salts 40-48, nitrogenous matter 15, and dirt 60-90, the total value of which is about 5 million dollars. The authors are convinced that wholesale economic recovery of the valuable ingredients is possible.

Mr. W. L. Stevenson, chief engineer to the Department of Health, Commonwealth of Pennsylvania, criticised most legislative efforts to control pollution of streams as being too peremptory and too punitive, and he advocated the policy of scientific and friendly co-operation between municipality and manufacturer; such a policy is successfully pursued by the Sanitary Water Board of Pennsylvania, which, *inter alia*, has re-classified the waters of that State on the principles of conservation and controlled utilisation. The nature of the restrictive and penalising legislation passed by most States was well shown by Mr. E. B. Besselievre, of New York, whose paper included a summary of the rules upon which the decisions of courts of justice have been based. Mr. H. C. Parker, of Pennsylvania, described recent developments and improvements in the apparatus used for determining hydrogen-ion concentration in industrial effluents and sewage liquors.

Of the papers presented by British workers, that by Dr. T. Lewis Bailey, of the Ministry of Health, on effluents from ammonia plants of coke-oven and gas-works, was of outstanding importance. Such effluents, it is well known, are the source of much trouble at sewage-disposal works, and Dr. Bailey has for years past been investigating methods of prevention and cure. He described the probable origins of, and the possible ways of eliminating, the harmful ingredients (chiefly ammonium thiocyanate, ammonium thiosulphate, phenol, organic bases and higher tar-acids), but holding that prevention is better than cure, he indicated how relatively clean ammoniacal liquors can be produced by minimising the time of contact between tar and liquor, and by rapidly cooling the crude gas in water-cooled systems, together with rigid exclusion of "adventitious" air. Bad effluents from ammonia plants can be successfully purified in percolating filters, given proper dilution and adequate regulation, although this method is seldom practicable at gas-works owing to lack of the necessary ground space.

Mr. R. D. Littlefield, also of the Ministry of Health, retold the interesting tale of how the Royal Commission on Sewage Disposal solved the problem of purifying the effluents from Scottish distilleries. Here again the percolating filter did what was required, after suitable inoculation.

Water-softening by the base-exchange method was the subject of two contributions. Dr. E. B. Higgins and Mr. J. P. O'Callaghan summarised the advantages which this method has over the older lime-soda process, and described in outline the preparation of "Permutit," both the artificial material (made from sodium silicate and sodium aluminate) and the natural material, which is prepared from greensand or glauconite. In their opinion, natural zeolite is the better owing to its rapidity of action and of regeneration with sodium chloride solution, as well as on account of its superior mechanical and chemical stability. On the other hand, Dr. T. P. Hilditch and Mr. H. J. Wheaton claimed that the water-softener "Doucil" is practically free from the defects which the previous authors held to be inherent in all such artificial base-exchange materials.

Societies and Academies.

Edinburgh.

Royal Society, July 6.—G. Leslie **Purser**: *Calamoichthys calabaricus* Smith. Pt. i. The alimentary and respiratory systems. Calamoichthys is the less known of the two genera of the Polypterini. The histology of the alimentary tract is not so complex as the anatomy would lead one to expect, as the intestinal epithelium is practically the same throughout its length; and as a whole the digestive tract is of a simple piscine type. Gills are well developed, but in addition there is, opening into the pharynx by a median ventral glottis, a pair of lungs, the minute structure and the vascular connexions of which show how well the pulmonary respiratory mechanism is developed.—W. W. **Taylor**: The precipitation of sols by polyvalent ions. With the alkali salts of methanetrisulphonic acid and naphthalenetrisulphonic acid, which are neutral, there is only one zone of precipitation of ferric hydroxide sol, which commences abruptly at about 0·0002 *N* and extends up to the saturated solution. It is not followed by a zone of no-precipitation. The range investigated was from 7×10^{-8} *N* to nearly 1·5 *N*. They thus fall in line with the neutral chloride and sulphate solutions. The two zones of precipitation, separated by a zone of no-precipitation ("reversal") obtained with sodium phosphate, which contains OH′ and no trivalent anion, is ascribed to the OH′. If this be the case, the analogous behaviour of negative sols with ferric and aluminium salts will be due to their hydrolysis. Whether the presence of a polyvalent ion is also necessary is not certain. With the neutral anions, more or less periodic variations in the rate of precipitation were observed; these are not due to errors in procedure. The valency rule does not hold in the case of the above trivalent anions.—E. **Neaverson**: Ammonites from the Upper Kimmeridge Clay. The Upper Kimmeridge Clay includes a variable series of clays and sands lying between the Gravesia zones of the Lower Kimmeridgian and the base of the Portland Stone Series. The zonal sequence is here tabulated with equivalent stratigraphical terms:

5. pallasioides zone 4. rotundum zone	Hartwell Clay.
3. pectinatus zone	Swindon Sands; Oil Shale of Kimmeridge.
2. nodiferous zone 1. Wheatleyensis zone	Kimmeridge Clay (in part).

The ammonites have hitherto been grouped under the name *Ammonites biplex* which, as Lamplugh pointed out thirty years ago, is useless for stratigraphical purposes. Though the forms found in the Hartwell Clay are familiar (but undescribed), those in the lower two zones are practically unknown in literature, and none has previously been described or figured. Some of these ammonites have been recognised in the Upper Kimmeridge Clay (*sensu anglico*) of Boulogne, but their identity with Russian forms (suggested by Pavlov and others) is not accepted. Indeed, palæogeographical considerations seem to indicate that the British and Russian areas were not in direct communication during the period when these ammonites flourished.—Prof. A. A. **Lawson**: A contribution to the life-history of Bowenia.—J. E. **Nichols**: Meteorological factors affecting fertility in sheep. The association of climatic conditions at times of service and lambing in a Cheviot and a Blackface flock, kept under the same conditions of pasturage, altitude and management for fourteen years, and data of fertility are examined. Significant evidence of differential responses of the two breeds are presented, and of the meteorological factors considered, the mean temperature at time of service is shown to exert the greatest influence.

Paris.

Academy of Sciences, July 15.—G. **Bigourdan**: The mean errors of the various modes of observation of the time signals. Over their longest paths, the perturbations of Hertzian waves have no influence on the time of transmission exceeding 0·01 sec. The error due to the mode of reception of the waves is of the same order of magnitude.—René **Lagrange**: The uniform deformation of a beam and the equation $\frac{\partial^4 F}{\partial x^4} + 2\frac{\partial^4 F}{\partial x^2 \partial y^2} + \frac{\partial^4 F}{\partial x^4} = 0$.— — **Eydoux**: The graphical determination of the meridian lines of turbine blades.—P. **Choux**: The Cupanieæ of Madagascar.—A. **Tronchet**: Vascular acceleration in schizocotyly.—Alexandre **Lipschutz**: Unilateral phenomena resulting from castration.—Henri **Pottevin** and Robert **Faillie**: Work during walking.

Cape Town.

Royal Society of South Africa, June 17.—A. W. **Roberts**: A statistical inquiry into the population problem in South Africa. The rate of increase of the white population in the Cape Colony is subject to a cyclical variation completed in 170 years. The rate of increase has been decreasing during the past twenty years. In Natal, exact statistics go back to 1860, and again there is evidence of cyclical variation. The rate of increase has been steadily decreasing during the past ten or fifteen years. This condition is also found in the Orange Free State and the Transvaal. Early enumerations of the native population are not available. Those taken in recent years indicate a declining rate in every instance but one, Zululand. The rate is increasing here, but very slowly.—W. J. **Copenhagen**: A note on Azotobacter in some South African soils. Soils from a number of localities in the Cape Province were examined and records made of the hydrogen-ion concentration, moisture, amount of organic matter, nitrogen per gram, characters of cultures, and nitrogen fixed per culture.—J. **Moir**: Colour and chemical constitution, Pt. xx.: Some residual problems.

Rome.

Royal Academy of the Lincei, June 5.—P. **Burgatti**: Conditions of validity of Lagrange's equations.—U. **Cisotti**: Fundamental equations of potential laminary motions on any surface.—G. **Armellini**: A theorem on the problem of two bodies of increasing masses.—N. **Parravano** and G. **Malquori**: Reactivity of silver with oxygen.—C. F. **Parona**: New observations on the chalks with *Heterodiceras Luci* of the Parenzo coast in Istria.—Gaetano **Rovereto**: New observations on the crystalline mass of Savona.—E. **Carano**: Detailed development of the female gametophyte of *Euphorbia dulcis L.*—Fil. **Bottazzi** and L. De **Caro**: Further results on the variations in the electrical resistance of muscles caused by solutions having different P_H values.—A. L. **Herrera**: Imitation of the smallest details of the Microsporidia by means of calcium fluosilicate.—Gianna **Calzolari**: Totality of analytical functions.—Mineo **Chini**: Determination of the geodetics of certain surfaces.—Gaetano **Scorza**: Complex algebraics connected with groups of infinite order.—Vasco **Ronchi**: A new stellar interferometer.—A. **Ferrari**: Crystalline lattices and isomorphism of lithium and magnesium fluorides. The structure of magnesium fluoride is of the rutile type, and the volumes of the elementary cells, containing four molecules in the case of lithium fluoride and two in that of magnesium fluoride, are practically equal.—G. Canneri and L. Fernandes: Contribution to the study of certain minerals containing thallium: thermal analysis of the systems, $Tl_2S-As_2S_3$ and Tl_2S-PbS.—G. Scagliarini: Complexes of quinquevalent molybdenum.—Ardito Desio: The geological constitution of some of the smaller islands of the Dodecanese.—C. Jucci: Races of silkworms with three or four mutations: Study of crosses.

Official Publications Received.

Journal of the College of Agriculture, Hokkaido Imperial University, Sapporo, Japan. Vol. 12, Part 3: Some Studies on a Japanese Apple Canker and its Causal Fungus, *Valsa Mali*. By Kogo Togashi. Pp. 265-324+plates 27-30. Vol. 15, Part 4: On the *Platypodidae* of Formosa; Supplementary Notes on "The *Platypodidae* of Formosa," by Jozo Murayama; Notes on the Japanese *Mantispidae*, with Special Reference to the Morphological Characters. By Satoru Kuwayama. Pp. 197-267+plates 12-16. (Sapporo.)

Proceedings of the Cambridge Philosophical Society. Vol. 22, Part 5, July. Pp. 601-812. (Cambridge: At the University Press.) 10*s*. net.

Union of South Africa: Department of Agriculture. Science Bulletin No. 39: Streak Disease of Sugar-Cane. By H. H. Storey. Pp. 30. (Pretoria: Government Printing and Stationery Office.) 3*d*.

Meddelanden fran Statens Skogsförsöksanstalt. Häfte 22, No. 1: Grundvattenrörelser och Försumpningsprocesser belysta genom Bestämningar av Grundvattnets syrehalt i Nordsvenska Moräner: Grundwasserbewegungen und Versumpfungsprozesse, durch Sauerstoffanalysen des Grundwassers nordschweidischer Moränen erläutert. Av Olof Tamm. Pp. 44. Häfte 22, No. 2: Vaxttidsundersökningar å tall och gran: Recherches sur la marche de l'accroissement chez le pin et l'épicéa durant la période de végétation. Av Lars-Gunnar Romell. Pp. 45-124. (Stockholm.)

The Journal of the Institute of Metals. Vol. 33. Edited by G. Shaw Scott. Pp. xii+710+15 plates. (London: 36 Victoria Street.) 31*s*. 6*d*. net.

Eugenics in Relation to the New Family and the Law on Racial Integrity: including a Paper read before the American Public Health Association. Second edition. Pp. 32. (Richmond, Va.: Bureau of Vital Statistics, State Board of Health.)

University of California Publications in American Archaeology and Ethnology. Vol. 22, No. 1: Wiyot Grammar and Texts. By Gladys A. Reichard. Pp. 215. (Berkeley, Cal.) 2.75 dollars.

Aeronautical Research Committee. Reports and Memoranda, No. 963 (Ae. 179): Notes on Stalled Flying. By Squadron Leader R. M. Hill and H. L. Stevens. (A.2.b. Stability-Full Scale Experiments, 22—T. 1757.) Pp. 9+1 plate. 6*d*. net. Reports and Memoranda, No. 964 (Ae. 180): The Control of a Stalled Aeroplane as affected by the Use of Differential Ailerons. By H. L. Stevens. (A.2.a. Stability Calculations and Model Experiments, 88—T. 1986.) Pp. 5+2 plates. 6*d*. net. Reports and Memoranda, No. 965 (Ae. 181): Pitching and Yawing Moments with Sideslip on a Model Aeroplane with Zero Stagger. By F. B. Bradfield. (A.2.a. Stability Calculations and Model Experiments, 91—T. 2021.) Pp. 14+5 plates. 1*s*. net. Reports and Memoranda, No. 970: Report of the Airworthiness of Airships Panel. (D.1. Special Technical Questions, 115—T. 1944.) Pp. 19. 9*d*. net. (London: H.M. Stationery Office.)

The National Physical Laboratory. Watch and Chronometer Trials, 1923-24. Pp. 7. (London: H.M. Stationery Office.) 6*d*. net.

Imperial Department of Agriculture for the West Indies. Report on the Agricultural Department, Montserrat, 1922-23 and 1923-24. Pp. iv+50. (Barbados.) 6*d*.

Otago University Museum and Hocken Library. Annual Reports for the Year 1924. Pp. 16. (Dunedin, New Zealand.)

Society of Chemical Industry: Chemical Engineering Group. Proceedings, Vols. 5 and 6a, 1923-1924. Pp. x+130. (London: Abbey House, Victoria Street.) 10*s*. 6*d*.

Empire Cotton Growing Corporation. Report on the Cotton-Growing Industry in Uganda, Kenya and the Mwanza District of Tanganyika; with Map of the Eastern Province of Uganda. By Col. C. N. French. Appendices 1 and 2 by W. C. Jackson. Pp. 44. (London: Empire Cotton Growing Corporation.) 1*s*. 3*d*.

The Indian Forest Records. (Silviculture Series), Vol. 11, Part 7: Volume Tables for *Tectona grandis* (*Teak*) and *Shorea robusta* (*Sal*) for the Central Provinces. By V. K. Maitland. Pp. 8+4 plates. 9 annas; 11*d*. (Entomology Series), Vol. 11, Part 8: The Economic Importance and Control of the *Sal* Heartwood Borer (*Hoplocerambyx spinicornis* Newm., fam. *Cerambycidae*). By C. F. C. Beeson and N. C. Chatterjee. Pp. iv+47+8 plates. 1.4 rupees; 2*s*. 3*d*. (Calcutta: Government of India Central Publication Branch.)

Forest Bulletin No. 59 (Economy Series): Summary of Results of Treated and Untreated Experimental Sleepers laid in the various Railway Systems of India, brought up to date. By J. H. Warr. Pp. 34+4 plates. 1.14 rupees; 3*s*. 3*d*. Forest Bulletin No. 61 (Botany Series): Eucalyptus in the Plains of North West India. By R. N. Parker. Pp. 34. 5 annas; 6*d*. (Calcutta: Government of India Central Publication Branch.)

Empire Cotton Growing Corporation. Reports received from Experiment Stations for the Seasons 1923, 1924 and 1925 (South Africa only). Pp. 48+9 plates. (London: Empire Cotton Growing Corporation.)

Department of the Interior: Bureau of Education. Bulletin, 1924, No. 39: Visual Education and the St. Louis School Museum. By Carl G. Rathman. Pp. iv+36. Bulletin, 1925, No. 2: Important State Laws relating to Education enacted in 1922 and 1923. Compiled by William R. Hood. Pp. iv+82. (Washington: Government Printing Office.) 10 cents each.

State of Connecticut. Public Document No. 24: Forty-seventh Annual Report of Connecticut Agricultural Experiment Station; being the Annual Report for the Year ended October 31, 1923. Pp. viii+534+xlviii+26 plates. (New Haven, Conn.)

Department of Commerce: Bureau of Standards. Technologic Papers of the Bureau of Standards, No. 284: A Study of the Seasonal Variation of Radio-frequency Phase Difference of Laminated Phenolic Insulating Materials. By J. L. Preston and E. L. Hall. Pp. 223-234. (Washington: Government Printing Office.) 5 cents.

Agricultural Experiment Station: Michigan Agricultural College. Special Bulletin No. 143: Winter Pruning the Black Raspberry. By Stanley Johnston. Pp. 22. Special Bulletin No. 145: Christmas Tree Plantations. By A. K. Chittenden. Pp. 9. Special Bulletin No. 146: Air-Cooled Storage for Apples. By Roy E. Marshall. Pp. 54. Special Bulletin No. 147: Cherry Leaf-Spot; Residual Effects and Control. By W. C. Dutton and H. M. Wells. Pp. 15. (East Lansing, Mich.)

Annual Report of the Board of Regents of the Smithsonian Institution showing the Operations, Expenditures and Condition of the Institution for the Year ending June 30, 1923. (Publication 2758.) Pp. xii+578+100 plates. (Washington: Government Printing Office.) 2 dollars.

The Institution of Civil Engineers. Engineering Abstracts prepared from the Current Periodical Literature of Engineering and Applied Science, published outside the United Kingdom. Supplement to the Minutes of Proceedings of the Institution. Edited by W. F. Spear. New Series, No. 23, April. Pp. 203. (London: The Institution of Civil Engineers.)

Smithsonian Miscellaneous Collections. Vol. 77, No. 5: Solar Variation and Forecasting. By C. G. Abbot. (Publication 2825.) Pp. 27. Vol. 77, No. 6: Solar Radiation and Weather, or Forecasting Weather from Observations of the Sun. By H. H. Clayton. (Publication 2826.) Pp. 64. Vol. 77, No. 7: Solar Radiation and the Weekly Weather Forecast of the Argentine Meteorological Service. By Guillermo Hoxmark. (Publication 2827.) Pp. 23. (Washington: Smithsonian Institution.)

Ministry of Public Works, Egypt: Zoological Service. Publication No. 38: Report on the Zoological Service for the Year 1923, in which is included the 25th Annual Report of the Giza Zoological Gardens. By Major S. S. Flower. Pp. iii+20. (Cairo: Government Publications Office.) 5 P.T.

Diary of Societies.

SATURDAY, August 29.

British Association for the Advancement of Science (at Southampton), at 3.—Dr. F. A. Dixey: Mimicry in relation to Geographical Distribution (Lecture for Young People).—At 8.—Prof. E. V. Appleton: The Rôle of the Atmosphere in Wireless Telegraphy (Citizens' Lecture).

MONDAY, August 31.

British Association for the Advancement of Science (at Southampton), at 10 a.m.—Prof. C. H. Desch: The Chemistry of Solids (Presidential Address to Section B).—Prof. A. V. Hill: The Physiological Basis of Athletic Records (Presidential Address to Section I).—Dr. J. B. Orr: The Inorganic Elements in Animal Nutrition (Presidential Address to Section M).—At 3.—W. H. Barker: The Development of Southampton in relation to World Commerce (Lecture for Young People).—At 5 (Section K).—Dr. D. H. Scott: Some Points in the Geological History of Plants (Lecture).—At 8.—Capt. P. P. Eckersley: Some Technical Problems of Broadcasting (Citizens' Lecture).

TUESDAY, September 1.

British Association for the Advancement of Science (at Southampton), at 3.—Prof. W. J. Dakin: Whaling in the Southern Ocean (Lecture for Young People).—At 8.—C. J. P. Cave: The Highway of the Air (Citizens' Lecture).

Institute of Metals (Autumn Meeting, Glasgow), at 8 p.m.—Sir John Dewrance: Education, Research, and Standardisation (Lecture).

WEDNESDAY, September 2.

British Association for the Advancement of Science (at Southampton).

Institute of Metals (Autumn Meeting, Glasgow), at 10 a.m.—A selection from the following papers:—R. J. Anderson and E. G. Fahlman: The Effect of Low-Temperature Heating on the Release of Internal Stress in Brass Tubes.—Prof. J. H. Andrew and R. Hay: Colloidal Separations in Alloys.—J. S. Brown: The Influence of the Time Factor on Tensile Tests conducted at Elevated Temperatures.—L. H. Callendar: Passification and Scale Resistance in relation to the Corrosion of Aluminium Alloys.—R. B. Deeley: Zinc-Cadmium Alloys. A Note on their Shear Strengths as Solders.—J. W. Donaldson: Thermal Conductivities of Industrial Non-Ferrous Alloys.—Prof. O. W. Ellis: The Influence of Pouring Temperature and Mould Temperature on the Properties of a Lead-Base Anti-Friction Alloy.—Dr. Marie L. V. Gayler: On the Constitution of Zinc-Copper Alloys containing 45 to 65 per cent. of Copper.—Dr. R. H. Greaves and J. A. Jones: The Effect of Temperature on the Behaviour of Metals and Alloys in the Notched-Bar Impact Test.—Dr. D. Hanson and Dr. Marie L. V. Gayler: On the Constitution of Alloys of Aluminium, Copper, and Zinc.—Dr. J. L. Haughton and W. T. Griffiths: The β Transformations in Copper-Zinc Alloys.—Dr. H. Hyman: The Properties of some Aluminium Alloys.—D. H. Ingall: The High Temperature-Tensile Curve. (*a*) Effect of Rate of Heating; (*b*) Tensile Curves of some Brasses.—C. H. M. Jenkins: The Physical Properties of the Copper-Cadmium Alloys Rich in Cadmium.—G. B. Phillips: The Primitive Copper Industry of America.—D. Stockdale: The Alpha-Phase Boundary in the Copper-Tin System.

THURSDAY, September 3.

Institute of Metals (Autumn Meeting, Glasgow), at 10 a.m.—A selection from the papers given above.

Supplement to NATURE

No. 2913 AUGUST 29, 1925

The Figure and Constitution of the Earth.[1]

By Prof. HORACE LAMB, Sc.D., LL.D., F.R.S., President of the British Association.

WHEN one is confronted, as on this occasion, with the British Association in plenary session, it is permissible, I hope, to indulge in a few reflections on the nature and purpose of science in general. The theme is no new one and has never been discussed so frequently as in our time, but the very range of our activities entitles us to consider it from our own point of view. The subjects treated at these meetings range, according to the titles of our Sections, from the most abstract points of mathematical philosophy to the processes of agriculture. Between these limits we have the newest speculations of astronomy and physics, the whole field of the biological sciences, the problems of engineering, not to speak of other matters equally diverse. These subjects, again, have become so subdivided and specialised that workers in adjacent fields have often a difficulty in appreciating each other's ideas, or even understanding each other's language. What then is the real purpose of science in the comprehensive sense; what is the common inspiration, the common ambition, behind such enthusiastic and sustained effort in so many directions?

The question may seem idle, for a sort of official answer has often been given. It was deemed sufficient to point to the material gains, the enlarged powers, which have come to us through science, and have so transformed the external part of our lives. The general aim was summed up in an almost consecrated formula: "to subdue the forces of Nature to the service of man"; and since it was impossible to foresee what abstract research might or might not provide a clue to something useful, the more speculative branches of science were not only to be tolerated, but also to be encouraged within limits, as ancillary to the supreme end. And, it must be said, the cultivators of these more abstruse sciences have themselves been willing sometimes to accept this position. The apologists of pure mathematics, for example, have been wont to appeal to the case of the conic sections, which from the time of Apollonius onwards had been an entirely detached study, but was destined after some 2000 years to guide Kepler and Newton in formulating the laws of the planetary motions, and so ultimately to find its justification in the Nautical Almanac.

I will not stop to examine this illustration, which I personally think rather strained. We may recognise that practical utility has been a conscious though not the sole aim in much scientific work, and sometimes perhaps its main justification; but we can scarcely admit that any such formula as I have quoted worthily conveys what has been the real inspiration of discovery through the ages. If we may go back to Apollonius and the conic sections, we cannot suppose that he was thinking of posterity at all; he was engaged in a study which he no doubt held to be legitimate and respectable in itself. Or, to take a very recent instance, when Faraday and Maxwell were feeling their way towards an electric theory of light, they could scarcely have dreamed of wireless telegraphy, though, as we now know, this was no remote development. The primary aim of science as we understand it is to explore the facts of Nature, to ascertain their mutual relations, and to arrange them so far as possible into a consistent and intelligible scheme. It is this endeavour which is the true inspiration of scientific work, as success in it is the appropriate reward. The material effects come later, if at all, and often by a very indirect path.

We may, I think, claim for this constructive task something of an æsthetic character. The provinces of art and science are often held to be alien and even antagonistic, but in the higher processes of scientific thought it is often possible to trace an affinity. The mathematician, at all events, is at no loss for illustrations of this artistic faculty. A well-ordered piece of algebraical analysis has sometimes been compared to a musical composition. This may seem fantastic to those whose only impression is that of a mass of curious symbols; but these bear no more resemblance to the ideas which lie behind them than the equally weird notation of a symphony bears to the sounds which it connotes or the emotions which these evoke. It is no misplaced analogy which has led enthusiasts to speak of the poetical charm of Lagrange's work, of the massive architecture of Gauss's memoirs, of the classic perfection of Maxwell's expositions. The devotees of other

[1] Inaugural address delivered to the British Association at Southampton on August 26.

sciences will be at no loss for similar illustrations. Is it not the case, for example, that the widespread interest excited by the latest achievements of physical science is due not to the hope of future profit, though this will doubtless come, but to the intrinsic beauty as well as the novelty of the visions which they unfold?

It is possible, I trust, to insist on these aspects of the scientific temperament without wishing to draw a sharp and even mischievous antithesis between pure and applied science. Not to speak of the enormous importance in our present civilisation of the material advantages which have come in the train of discovery, it would be disloyal to science itself to affect to depreciate them. For the most severely utilitarian result comes often as the result of a long and patient process of study and experiment, conducted on strictly scientific methods. We must recognise also the debts which pure science in its turn owes to industry, the impulse derived from the suggestion of new problems, and not least the extended scale on which experiment becomes possible. Reference may appropriately be made here to the National Physical Laboratory, initiated mainly in the higher interests of industry, which by the mere pressure of the matters submitted to it is becoming a great institute of theoretical as well as applied science, informed throughout by the true spirit of research.

But perhaps the most momentous consequences of the increased scientific activities of our time have been on the intellectual side. How profound these have been in one direction we have recently been reminded by the centenary of Huxley. Authority and science were at one time in conflict over matters entirely within the province of the latter. The weapons were keen and the strife bitter. We may rejoice that these antagonisms are now almost obsolete; one side has become more tolerant, the other less aggressive, and there is a disposition on both sides to respect each other's territories. The change is even reflected in the sermons delivered before the British Association. The quarters where we may look for suspicion and dislike are now different; they are political rather than ecclesiastical. The habit of sober and accurate analysis which scientific pursuits tend to promote is not always favourable to social and economic theories, which rest mainly on an emotional if very natural basis. Some of us, for example, may remember Huxley's merciless dissection of the theory of the social contract. There is hence to be traced, I think, a certain dumb hostility which, without venturing on open attack, looks coldly on scientific work except so far as it is directed to purposes of obvious and immediate practical utility.

There is a more open kind of criticism to which we are exposed, which we cannot altogether ignore, though it again rests on a misconception of the true function of science. It is to be met with in quarters where we might fairly look for countenance and sympathy, and is expressed sometimes with great force, and even eloquence. The burden is one of disappointment and disillusion; we even hear of the "bankruptcy of science." It seems to be suggested that science has at one time or other held out promises which it has been impotent to fulfil; that vague but alluring hopes which it has inspired have proved delusive. It may be admitted that extravagant and impossible claims have sometimes been made on behalf of science, but never, I think, by the real leaders, who have always been most modest in their claims and guarded in their forecasts. It is true, again, that in the enthusiasm which attended the first sensational developments of modern industry, hopes were conceived of a new era where prosperity would ever increase, poverty would be at least mitigated and refined, national antipathies would be reconciled. When these dreams did not swiftly come true there was the inevitable reaction; the idols were cast down, and science in general has rather unreasonably come in for its share of depreciation. The attitude which I have been trying to describe is put very forcibly in a quotation from President Wilson which I saw not long ago, though its date is not very recent:

"Science has bred in us a spirit of experiment and a contempt for the past. It made us credulous of quick improvement, hopeful of discovering panaceas, confident of success in every new thing. . . . I should fear nothing better than utter destruction from a revolution conceived and led in the scientific spirit. Science has not changed the laws of social growth or betterment. Science has not changed the nature of society, has not made history a whit easier to understand, human nature a whit easier to reform. It has won for us a great liberty in the physical world, a liberty from superstitious fear and from disease, a freedom to use nature as a familiar servant; but it has not freed us from ourselves."

The tone is one of bitter disillusion, but we may ask why should science, as we understand it, be held responsible for the failure of hopes which it can never have authorised? Its province, as I have tried to define it, is vast, but has its limits. It can have no pretensions to improve human nature; it may alter the environment, multiply the resources, widen the intellectual prospect, but it cannot fairly be asked to bear the responsibility for the use which is made of these gifts. That must be determined by other and, let us admit it, higher considerations. Medical science, for example, has given us longer and healthier lives; it is not responsible for the use which we make of those lives. It may give increased vitality to the wicked as well as the just, but we would not, on that account, close our hospitals or condemn our doctors.

In spite of the criticisms I have referred to, we may still hold up our heads, let us hope without arrogance, but with the confidence that our efforts have their place, not a mean one, in human activities, and that they tend, if often in unimagined ways, to increase the intellectual and the material and even the æsthetic possessions of the world. In that assurance, we may rejoice that science has never been so widely and so enthusiastically cultivated as at the present time, with so complete sincerity, or (we may claim) with more brilliant success, or even with less of international jealousy.

Passing from these reflections, which are, I hope, not altogether inopportune, it is expected that the president of the British Association should deal with some subject in which he has himself been interested. For a mathematician this obligation is a specially difficult one, if he is not to overstrain the patience of his audience. I propose to speak briefly, and mainly from the mathematical and physical point of view, about some branches of geophysics, and in particular those relating to the constitution of the earth. It is a subject which in the past has often engaged the attention of the Association. I need only recall the names of Kelvin and George Darwin, and the controversies with which they are associated. Historically, it is of special interest to the mathematician and the physicist, for it was in his researches on the figure of the earth that Laplace initiated the theory of its potential, with its characteristic equation, and so prepared the way for Poisson, Green, Cauchy, and a host of followers, who developed the theory of electricity and ultimately that of light. To go further back, it was in this connexion that Newton found an important verification of his law of gravity. Quite recently, the whole subject has been reviewed in a valuable treatise by Dr. Jeffreys, who arrives at conclusions which are at all events definite, and maintained with great ability.

I do not propose to deal with the fascinating speculations as to the past history of the earth and its reputed child, the moon, which will be more or less familiar. I must confine myself to a rapid survey of the information as to its present constitution, which can be gathered from observations made in our own time, and capable of repetition at will. This, though less exciting, is at all events a region in which imagination is more subject to control.

The accurate investigation of the figure of the earth is intimately connected with the variation of gravity over its surface. In view of the local irregularities, some convention was necessary as to what is meant by the shape of the earth as a whole. The usual definition is that it is a level surface as regards the resultant of true gravity and centrifugal force: often that particular level surface of which the sea forms a part. I need not dwell on the immense amount of theoretical and practical labour which has been devoted in various countries to the determination of the geometrical surface which most nearly satisfies this requirement. Of more recent interest are the irregularities in the intensity of gravity, which have been found to exist over wide areas, by the highly trained Survey of India, by the Coast and Geodetic Survey of the United States, and by various observers on the continent of Europe. Briefly, the general result is this, that in mountainous regions the observed value of gravity is abnormally low, whilst on oceanic islands, and so far as can be ascertained on the sea, it is abnormally large, when all allowance has been made for altitude and the normal variation with latitude. The fact that this has been found to be the case in so many different places, shows that we have here to deal with no casual phenomenon.

The accepted explanation, originated by Archdeacon Pratt, of Calcutta, in 1859, and since developed by Hayford and Bowie, of the U.S. Survey, is that if we imagine a level surface to be drawn at a depth of about 100 kilometres, the stratum of matter above this, though varying in density from point to point, is approximately uniform, in the sense that equal areas of the surface in question bear equal weights. The altitude of the mountains is held to be compensated by the inferior density of the underlying matter, whilst the oceanic hollows are made up for by increased density beneath. Leaving aside the technical evidence on which this hypothesis is based, there are one or two points to be noticed. In the first place it suggests, as is highly plausible on other grounds, that the matter in the interior of the earth, below the stratum referred to, is in a state of purely hydrostatic stress, *i.e.* of pressure uniform in all directions. So far as this stratum is concerned, it might be floating on an internal globe of liquid, although no assertion is really made, or is necessary, to this effect. But in the stratum itself, shearing forces must be present, and it is necessary to consider whether the actual material is strong enough to withstand the weight of continents and mountains, and the lack of lateral support due to the oceanic depressions. The researches of Prof. Love and others show that this question can fairly be answered in the affirmative.

The accurate determination of the acceleration of gravity at any place is, of course, a matter of great delicacy. Not to mention other points, in the pendulum method the yielding of the support due to the reaction of the pendulum as it swings to and fro affects the time of oscillation. It may be recalled that, so far back as 1818, Kater, in his absolute determination of the length of the seconds pendulum in London, was on his guard against this effect, and devised a test to make sure that it was in his case negligible. In a portable apparatus, such as is used for comparative determinations, it is difficult to give sufficient rigidity to the support, and a correction has, in some way, to be applied. Recently, Dr. F. A. V. Meinesz, of the Dutch Survey, who has carried out an extensive gravity survey in Holland, has sought to minimise this effect by the use of pairs of pendulums swinging in opposite phases, and so reacting on the support in opposite senses. This has opened out a prospect of accurate gravity determinations at sea. The use of a pendulum method on a surface vessel is scarcely possible, but a submarine when sufficiently immersed offers comparative tranquillity, and it is hoped that the small residual horizontal motions may be capable of elimination, and the diminished vertical oscillation allowed for. The methods previously employed at sea which could claim any accuracy are those of Hecker. In one method, the pressure of the atmosphere is found in absolute measure from the boiling point of water and compared with the gravitational measure afforded by the barometer. In a more recent method, also devised by Hecker, and followed with some modifications by Duffield, the idea is to carry about a standard atmosphere, *i.e.* a mass of air at constant volume and prescribed temperature, the pressure of which is measured gravitationally by the barometer. Both methods are highly ingenious, but cannot compete as regards accuracy with the pendulum method if this should be found practicable.

It is a matter of regret that the observational side of geophysics has of late been so little cultivated in Great Britain. In India, with its wide opportunities, geodetic and gravitational work has long been carried on with high efficiency, and has furnished essential material for the generalisations I have referred to. But in the Home country, although we have an admirable topographical survey, nothing so far as I know has been done towards a gravity survey since the time of Kater, more than a century ago. Proposals for the establishment of a formal Geodetic Institute, such as existed in some other countries before the War, which should embrace this as well as other subjects, have been urged, but have had to be abandoned owing to the exigencies of the time. It is therefore some satisfaction to record that a modest beginning has been made at Cambridge by the institution of a readership in geodesy, and that, when the requisite pendulum outfit is complete, it is hoped that a gravity survey of the British Isles may be initiated. The physical features are scarcely so rugged that sensational results such as were found in India are to be expected; but it is desirable that the work, which will involve comparatively little labour and expense after the initial steps, should be carried out. The example of Holland shows that in a country which has no outstanding features at all, a survey may reveal peculiarities which are at all events of considerable interest. I may add that it is contemplated that the Cambridge apparatus should also be designed to eliminate the disturbing element I have mentioned, and that it should be available for determinations at sea. It is perhaps not too much to hope that, with the co-operation of the Navy, the gravity chart of the world, which is so far almost a blank as regards the ocean, may in this way be gradually filled in.

The distribution of the intensity of gravity over the surface of the earth gives by itself no positive information as to the distribution of density throughout the interior, though the contrary view has sometimes been held. For example, a spherical globe with a uniform intensity of gravitation over its surface would not necessarily be homogeneous, or even composed of spherical strata each of uniform density, however plausible this might be on other grounds. Consequently, there is room for hypothesis. There are certain tests which any hypothesis has to satisfy. It must account for the observed distribution of gravity, and having regard to the phenomena of precession, it must give the proper relation between the earth's moments of inertia about a polar and an equatorial axis. It may be added that it should be fairly consistent with the ascertained velocities of seismic waves at different depths, and the degree of elasticity which it is allowable to assign to the material. The somewhat artificial laws of density adopted by Laplace and Roche, respectively, mainly on grounds of mathematical convenience, have lost much of their credit. A more natural law, suggested indeed by Thomson and Tait in 1867 in their book on natural philosophy, has since been proposed in a more definite form by Wiechert. On this view, the earth is made up of a central core of about four-fifths the external radius, of high density, about that of iron, surrounded by an envelope of about the density of the surface rocks. This is, of course, only to be taken as a rough picture, but it satisfies the requirements I have mentioned, and is apparently not incompatible with the seismic data.

In all speculations on the present subject, considerations as to the thermal history of the earth and the present distribution of temperature in the interior play an essential part. The apparent inconsistency between the requirements of physics and geology was long a matter of controversy, and has given rise to keen debate at British Association meetings. Lord Kelvin's historic attempts to limit the age of the earth, by consideration of the observed temperature gradient as we go downwards from the surface, lost their basis when it was discovered that the rate of generation of heat in the processes of radioactive change was amply sufficient to account for the present gradient, and would even be far more than sufficient unless the amount of radioactive material concerned were strictly limited. Assuming an average distribution of such material similar to what is found near the surface, a stratum of some 16 kilometres in thickness would provide all that is wanted. Radioactive speculation has gone further. A comparison of the amounts of uranium, and of the end-products associated with it, has led to estimates of the time that has elapsed since the final consolidation of the earth's crust. The conclusion is, that it must lie definitely between 10^9 and 10^{10} years. The figure is necessarily vague owing to the rough value of some of the data, but even the lower of these limits is one which geologists and biologists are, I believe, willing to accept, as giving ample scope for the drama of evolution. We may say that physics has at length amply atoned for the grudging allowance of time which it was once disposed to accord for the processes of geological and biological change.

The radioactive arguments on which these estimates are based are apparently irrefutable; but from the physical point of view there are reasons why one would welcome an extension even of the upper limit of 10^{10} years if this could possibly be stretched. For if this barrier be immovable, we are led to conclusions as to the present internal temperature of the earth which are not quite easy to reconcile with the evidence as to rigidity to be referred to in a moment. In the space of time I have mentioned, enormous as it is, the great mass of the earth could scarcely have cooled very much from the temperature when it was in a state of fusion. The central portion, whatever its nature, and however high its thermal conductivity, is enclosed by a thick envelope of feebly conducting material, just as a steam boiler, for example, may be jacketed with a layer of asbestos. To take a calculable hypothesis, we may assume with Wiechert that we have a central core of three-fourths the earth's radius, with an outer shell of rock. We may give the core any degree of conductivity we like; for mathematical simplicity we may even regard it as infinite. Then, if the outer layer consists of material having some such conductivity as the surface rocks, the internal temperature would take to fall to one-half its original value a period of at least ten times the limit I have named. It is obvious that the details of the assumption may be greatly varied without affecting the general conclusion of a very high internal temperature.

The question as to the degree of rigidity of the earth has so often been dealt with that a brief recapitulation must suffice. It was about the year 1862 that Kelvin first pointed out that if the earth as a whole were only as rigid as a globe of glass or even steel, it would yield so much to the deforming action of the solar and lunar tidal forces as seriously to affect the amplitudes of the oceanic tides, which are a differential effect. Unfortunately, the tides are so much complicated by the irregular distribution of land and sea that a comparison with the actual values of the theoretical amounts which they would have on the hypothesis of absolute rigidity is hopeless. The fortnightly tidal component, due to the changing declination of the moon, is probably an exception, but the difficulty here is to extract this relatively minute component from the observations, and the material is consequently imperfect. The problem was attacked in a different way by G. and H. Darwin in 1881. The horizontal component of the lunar and solar disturbing forces must deflect the apparent vertical, and it was sought to measure this effect by a pendulum. The quantities to be determined are so excessively minute, and the other disturbing forces so difficult to eliminate, that the method was only carried out successfully by Hecker in 1907, and afterwards by Orloff in Russia. The results on the whole were to the effect that the observed deflexions were about three-fifths of what they ought to be if the earth were perfectly unyielding, and were, so far, in accordance with estimates previously made by Darwin and others, from the somewhat imperfect statistics of the fortnightly tide.

There was, however, a discrepancy between the results deduced from the deflexions in the meridian and at right angles to it, which gave rise to much perplexity. The question was finally set at rest by Michelson in 1916. He conceived the idea of measuring the tides produced in two canals (really two pipes half filled with water) of about 500 feet long, extending one N. and S., the other E. and W. These tides are, of course, of a microscopic character, their range is of the order of one-hundredth of a millimetre, and they could only be detected by the refined optical methods which Michelson himself has devised. The observations, when plotted on a magnified scale, exhibit all the usual features of a tide-gauge record: the alternation of spring and neap tides, the diurnal and semi-diurnal lunar tides, and so on. The theoretical tides in the canals can, of course, be calculated with great ease, and the comparison led to the result that the ratio which the observed tides bore to the theoretical was about 0·69, being practically the same in both cases. The whole enterprise was as remarkable for the courage of its inception as for the skill with which it was carried out, and was worthy of the genius which has accomplished so many marvels of celestial and terrestrial measurement. The perplexing discrepancy in the results obtained by Hecker at Potsdam is no doubt to be explained by the attraction of the tidal waters in the not very remote North Sea, and by the deformation due to the alternating load which they impose on the bottom. In Chicago, near the centre of the American continent, these influences were absent.

The question may be asked: What is the precise degree of rigidity which is indicated by these observations, or by others which have been referred to? Various answers have been given, based on observations of the tides, of the lunar deflexion of the vertical, and of the period of the earth's Eulerian nutation, on which I have not touched. The estimates have varied greatly, but they are all high, some of them extremely high. That they should differ among themselves is not surprising. The material is certainly not uniform, either in its elastic properties or the conditions to which it is subject, so that we can only speak of the rigidity of the earth as a whole in some conventional sense. Larmor and Love have shown that all the information that can be gathered, whether from the tides or from the Eulerian nutation, can be condensed into two numerical constants. This leaves a large degree of indeterminateness as to the actual distribution of elasticity within the earth. It is at all events certain that in regard to tidal forces the great bulk of the material must be highly rigid.

In leaving this topic, it may be recalled that it was in this same connexion that Kelvin was led to initiate the method of harmonic analysis as applied to the tides, as well as to accomplish much brilliant mathematical work, the importance of which is by no means limited to the present subject. The whole theory of the tides and cognate cosmical questions afterwards became the special province of George Darwin; but after his death, work on the tides was almost at a standstill until it was resumed by Prof. Proudman and his associate, Dr. Doodson, in the recently established Tidal Institute at Liverpool. They have already arrived at results of great theoretical as well as practical interest.

Within the last twenty years or so, light has come on the elastic properties of the earth from a new and unexpected quarter, namely, from a study of the propagation of earthquake shocks. It is pleasant to recall that this has been largely due to efforts especially fostered, so far as its means allowed, by the British Association. To John Milne, more than to any one else, is due the inception of a system of widely scattered seismological stations. The instruments which he devised have been improved upon by others, notably by Galitzin, but it is mainly to his initiative that we are indebted for such insight as has been gained into the elastic character of the materials of the earth, down, at least, to a depth of half the radius. It may be remarked that the theory of elastic waves, which is here involved, was initiated and developed in quite a different connexion, in the persistent but vain attempts to construct a mechanical representation of the luminiferous ether which exercised the mathematical physicists of a generation or two ago. It has here at length found its natural application.

One of the first problems of seismologists has been to construct, from observation, tables which should give the time which an elastic wave of either of the two cardinal types, namely, of longitudinal and transverse vibration, takes to travel from any one point of the earth's surface to any other. It has been shown by Herglotz and Bateman that if these data were accurately known it should be possible, though naturally by a very indirect process, to deduce the velocities of propagation of the two types throughout the interior. Such tables have been propounded, and are in current use for the purpose of fixing the locality of a distant earthquake when this is not otherwise known. They are, however, admittedly imperfect, owing to the difficulty of allowing for the depth of the focus, which is not always near the surface, and is sometimes deep-seated. This uncertainty affects, of course, the observational material on which the tables are based. Some partial corrections have been made by Prof. Turner, who almost alone in Great Britain, amidst many distractions, keeps the study of seismology alive, but the construction of accurate tables remains the most urgent problem in the subject.

Taking the material, such as it is, however, the late Prof. Knott, a few years ago, undertook the laborious task of carrying out the inverse process of deducing the internal velocities of the two types of waves referred to. Although it is possible that his conclusions may have to be revised in the light of improved data, and, it may be, improved methods of calculation, they appear to afford a fairly accurate estimate of the wave velocities from the surface down to a depth of more than half the earth's radius. Near the surface the two types have velocities of about 7·2 and 4 km. per second, respectively. These velocities increase almost uniformly as we descend, until a depth of one-third the radius is reached, after which, so far as they can be traced, they have constant values of 12·7 and 6·8 km. per second, which, by the way, considerably exceed the corresponding velocities in iron under ordinary conditions. The innermost core of the earth, *i.e.* a region extending from the centre to about one-fourth of the radius, remains somewhat mysterious. It can certainly propagate condensational waves, but the secondary waves are hard to identify beyond a distance of 120° of arc from the source of disturbance. Knott himself inferred that the material of the central core is unable to withstand shearing stress, just as if it were fluid, but this must at present remain, I think, uncertain.

It should be remarked that the wave-velocities by themselves do not furnish any information as to the elasticities or the density of the material, since they involve only the ratios of these quantities. The relation between the two velocities is, however, significant, and it is satisfactory to note that it has much the same value as in ordinary metals or glass.

It is to be regretted that at present so little is being done in the way of interpretation of seismic records. Material support in the way of more and better equipped stations is certainly needed, but what is wanted above all is the co-ordination of such evidence as exists, the construction of more accurate tables, and the comparative study of graphical records. These latter present many features which are at present hard to interpret, and a systematic comparison of records of the same earthquake obtained at different stations, especially if these are equipped with standardised instruments, should lead to results of great theoretical interest. The task will be a difficult one, but until it is accomplished we are in the position of a scholar who can guess a few words in an ancient text, possibly the most significant, but to whom the rest is obscure.

Even on this rapid review of the subject, it should be clear that there is an apparent inconsistency between the results of two lines of argument. On one hand, the thermal evidence points to the existence of a high temperature at a depth which is no great fraction of the earth's radius, so high indeed as to suggest a plastic condition which would readily yield to shearing stress. On the other hand, the tidal arguments, as well as the free propagation of waves of transversal vibration at great depths, indicate with certainty something like perfect elasticity in the mathematical sense. The material with which we are concerned is under conditions far removed from any of which we have experience; the pressures, for example, are enormous; and it is possibly in this direction that the solution of the difficulty is to be sought. We have some experience of substances which are plastic under long-continued stress, but behave as rigid bodies as regards vibrations of short period, although this combination of properties is, I think, only met with at moderate temperatures. It is conceivable that we have here a true analogy, and that the material in question, under its special conditions, though plastic under steady application of force, as for example centrifugal force, may be practically rigid as regards oscillatory forces, even when their period is so long as a day or a fortnight. But beyond that we can scarcely, with confidence, go at present.

I have chosen the preceding subject for this address, partly because it has not recently been reviewed at these meetings, and also for the opportunity it has given of urging one or two special points. It is evidently far from exhausted—the loose ends have indeed been manifest—but this should render it more interesting. It furnishes also an instance, not so familiar as some, of the way in which speculations which appear remote from common interests may ultimately have an important influence on the progress of science. It is true that the secular investigations into the form of the earth's surface have an importance in relation to geodesy, but certainly no one at the time of Laplace's work on this matter would have guessed that he was unwittingly laying the foundation of the whole mathematical theory of electricity. The history of science is indeed full of examples where one branch of science has profited by another in unexpected ways. I would take leave just to mention two, which happen to have specially interested me. It is, I think, not generally understood what an important part the theory of elasticity played in Rayleigh's classical determinations of the relative weights of the gases, where it supplied an important and indeed essential correction. Again, the mathematical theory of hydrodynamics, in spite of some notable successes, has often been classed as a piece of pure mathematics dealing with an ideal and impossible fluid, elegant indeed, but helpless to account for such an everyday matter as the turbulent flow of water through a pipe. Recently, however, at the hands of Prandtl, it has yielded the best available scheme of the forces on an aeroplane, and is even being appealed to to explain the still perplexing problem of the screw-propeller.

To promote this interaction between different branches of science is one of the most important functions of the British Association, and differentiates it from the various sectional congresses which have from time to time been arranged. We may hope that this meeting, equally with former ones, may contribute to this desirable end.

Let me close with a local reference. The last fifty years have seen the institution of local universities and university colleges in many parts of Great Britain and of the Empire at large. Through these agencies the delights of literature, the discipline of science, have been brought within the reach of thousands whose horizons have been enlarged and their whole outlook on life transformed. They have become centres, too, from which valuable original work in scholarship, history, and science, has radiated. The University College of Southampton is now contemplating an increased activity and a fuller development. In this ambition it has, I am sure, the best wishes of us all.

Scientific Problems and Progress.

Summaries of Addresses of Presidents of Sections of the British Association.[1]

The New Ideas in Meteorology.

THERE have been great advances in the science of meteorology during recent years which have completely revolutionised our conception of the structure and mechanism of the atmosphere. Dr. G. C. Simpson devoted his presidential address to Section A (Mathematics and Physics) to a description of the chief of these advances, dividing his address into four parts, each dealing with one of the new ideas on which these advances are based.

(1) *The Thermal Stratification of the Atmosphere.*—By using the idea of entropy, Dr. Simpson showed that the atmosphere can be marked off into nearly horizontal shells which have the peculiar property that air which starts in any one shell cannot be transferred to any other shell and remain there in equilibrium unless heat is added or subtracted. Thus, in all atmospheric motion in which heat is neither added nor extracted, the air must travel along the shell in which it started. These shells act like physical restraints to the air, tending to prevent its moving in any but an almost horizontal direction. Occasionally the air contains sufficient water-vapour to supply, when it condenses, the heat necessary to pierce the thermal stratification, but these occasions are practically confined to thunderstorms and to the rain squalls in the doldrums. The thermal stratification of the atmosphere prohibits the ascent of warm air at the equator and descent of cold air at the poles which has generally been considered to be the cause of the general circulation of the atmosphere, on the analogy of a gigantic hot-water system.

(2) *The Mechanism of the Atmospheric Heat Engine.*—The old idea that the energy received from the sun is converted into the energy of winds by the air near the ground being warmed and rising, like the hot air in a chimney, is obviously unsound. The thermal stratification prevents this action in all but exceptional cases. In place of this mechanism a new one is introduced. Masses of air from equatorial regions and from polar regions are brought side by side in middle latitudes. The cold polar air tends to subside and flow under the warm equatorial air which rises up the flank of the cold wedge which the polar air presents to it. When cold and warm air which were originally side by side react in this way, there is an appreciable lowering of the centre of gravity of the two masses taken together. Thus potential energy is released and appears as the energy of winds.

(3) *The Significance of Surfaces of Discontinuity in the Atmosphere.*—The surfaces at which relatively cold and warm masses of air meet and slide over each other as just described can easily be recognised on meteorological charts and by observations in the upper atmosphere. It is found that nearly all cloud is formed at such surfaces. Dr. Simpson discussed the conditions under which these surfaces of discontinuity can be maintained for long periods, and their significance in weather forecasting.

(4) *The Origin and Structure of Cyclones.*—The recent work of Bjerknes and Exner was described, according to which cyclones are formed where masses of air of polar and equatorial origin are brought together, and readjustment takes place in the manner described above. The old idea of a cyclonic depression being a kind of chimney drawing air in below and delivering it at the top can no longer be held.

These new ideas have had a far-reaching effect on the practical application of meteorology. Instead of the old empirical method of forecasting, the forecaster now has much more knowledge of what may be called the anatomy of a depression. He searches his charts for indications of the surfaces of discontinuity and examines the characteristics of the air masses to see whether they are of polar or equatorial origin. This has all resulted in greater confidence on the part of the forecaster, a confidence which is frequently justified by remarkably accurate forecasts.

[1] The collected presidential addresses delivered at the meeting are published under the title "The Advancement of Science, 1925," at 6*s*., or obtainable at the bookstall at Southampton by members at 4*s*. 6*d*.

The Chemistry of Solids.

In his presidential address to Section B (Chemistry), Prof. C. H. Desch shows that the wonderful progress of physical theory in recent years has brought about a tendency to treat chemistry as a deductive science, the reactions of elements and compounds being deduced from the electronic constitution of their atoms. The chemical hypotheses of atoms, of molecular structure, of the benzene ring, of tetrahedral carbon, and of the periodic classification were devised in order to explain purely chemical observations, without reference to questions of ultimate reality, but modern physical investigations have shown them to represent Nature far more closely than their authors had supposed. This result should encourage chemists to continue on paths which have led to success before, rather than to base further work purely on an application of physical theory. The teaching of chemistry suffers from excessive and premature specialisation.

Attention is directed in particular to a comparatively neglected field of research, that of the chemistry of solids, by which are meant crystals and aggregates of crystals. The X-ray method has demonstrated the arrangement of atoms in crystals, and their mechanical properties have been extensively studied, but the relation between these and their chemical behaviour is obscure. The complication due to the unknown properties of the intercrystalline boundary may be eliminated by the use of single crystals, several of the metals having been prepared in this form. Reactions within a solid require the possibility of diffusion for their completion, and the evidence on this question is reviewed by Prof. Desch, as are the reasons for the variations of habit among crystals. Attempts which have been made to determine the distribution of the solute atoms in a crystalline solid solution by chemical means have lead to the conclusion that isomeric solid solutions are possible. The study of the chemical properties of solids has been carried furthest in metallography, but is of importance also to chemical industry and to petrology.

Cultural Aspects in Geology.

Prof. W. A. Parks, in his presidential address to Section C (Geology), expressed the opinion that it is sometimes thought that the sciences are purely utilitarian and materialistic; they have, however, a high cultural value also in that they induce contemplation and bring their devotees into touch with the infinite. Geology, by reason of its breadth and its historical aspect, is particularly serviceable to this end. In both the organic and the inorganic worlds a tendency to greater and greater complexity is observed—from a universe of hydrogen to a maximum of chemical complexity, from a vibrant particle of protoplasm to man. The great age of the earth, probably 2,000,000,000 years, is a promise of still further duration, and the steady upward tendency of life is a promise of further development in the same direction.

Despite great geological changes, there have always been land and water, due to a marvellous nicety of adjustment between destructive and reconstructive forces. Similarly, although climatic changes have been great, the temperature of the earth as a whole has been such that life has been possible from the earliest geological time to the present.

In the evolution of organisms, approximation to perfect adaptation is the herald of destruction. New races arise from less closely adapted stems, and the "missing links" are necessarily few and, owing to migration, are to be sought in stratigraphically oblique lines. Evolution is not brought about by some mysterious force acting on all organisms. The birth of a new phylum is a distinct event in time, and it does not bring about the extinction of the parent phylum. For example, sponges arose from Protozoa in the pre-Cambrian, and never since have the Protozoa fathered other than unicellular offspring.

Geological conditions govern most human activities, but those with a strong historical setting are particularly cultural. For example, a knowledge of the potential energy of Niagara Falls is not necessarily "culture," but that word may be applied to a recognition of the fact that Niagara Falls exist because some millions of years ago a layer of hard limestone was deposited over soft shales. The great principles of geology have had less effect on literature than might have been expected: this is particularly true of poetry. Among the major poets, Tennyson stands in first place in this respect. Strange to say, the principles of evolution and the great animals of the past seem to have inspired more doggerel verse than true poetry.

Organic Evolution.

In his presidential address to Section D (Zoology), Mr. C. Tate Regan stated that his work on fishes has led him to the conclusion that the first step in the origin of a new species is the formation of a community, either with new habits or in a new or restricted environment. In Nature there is every gradation from morphologically identical communities to others so distinct that every one is agreed that they are well-marked species; thus the morphological discontinuity said to be characteristic of species is seen to be the final term of a habitudinal discontinuity that began with the formation of communities at first structurally similar. These ideas were illustrated by a detailed account of some species and communities of Salmonidæ.

The same principles apply to evolution in general; it has been adaptive; changes of structure have followed changes of habits, and especially changes of food and feeding habits. The origin and evolution of the neopterygian fishes illustrates well how modifications that were originally adaptive become historical; they persist, and become the basis for further adaptive modifications.

The natural selection theory is the only adequate explanation yet given of certain classes of facts; but it is a very unconvincing explanation of other classes, which lead to the conclusion that adaptive responses, repeated generation after generation, are consequently made earlier and more effectively. In the flat-fishes the cartilaginous bar above the eye that is going to migrate begins to be absorbed almost as soon as the fish is hatched, and while the fish is still externally symmetrical this bar becomes reduced to short processes of the otic and ethmoid cartilages, with a wide gap between them;

through this gap the eye migrates, so that when ossification takes place, one frontal bone is on the wrong side of its eye. This developmental history may be interpreted as the end result of a process initiated by the ancestral fish that first formed the habit of lying on one side, and tried to move the eye of the under side into a position where it could be of more use.

Many families of perch-like fishes, not at all closely related, have 24 vertebrae (10 praecaudal and 14 caudal), and there is good evidence that this is a primitive percoid character. Here there is no variation, and therefore no material for selection, nor can any fish alter the number of vertebræ during its life by the way it swims. Yet it seems clear that this fixity has been broken through over and over again, and that the number of vertebræ has increased or decreased from 24 whenever it was necessary. Thus Psettodes, the most primitive flat-fish, structurally an asymmetrical perch, has 24 (10+14) vertebræ; it is piscivorous, and probably lies in wait and makes short dashes after fishes that come near enough. But other flat-fishes, which swim along the bottom with undulating movements, have many more vertebræ; the sole, for example, has about fifty. It seems that the muscular activities of a fish, its efforts to swim in a certain way, may produce a change in the number of muscle segments of its descendants. This may be condemned as a teleological speculation, but it is put forward as a hypothesis that fits the facts, and as preferable to the mutation hypothesis, which in effect states that it is only by accident that a structure has a function.

The Science and Art of Map-making.

After reference to Colonel Clarke as a distinguished citizen of Southampton, whose name is now to be commemorated by a tablet on the house where he lived, the president, Mr. A. R. Hinks, of Section E (Geography), expressed his lasting regret that Clarke's figure of the earth (1880) has not been chosen as standard by the International Conference at Madrid. With a glance at recent improvements in instruments Mr. Hinks discussed the modifications required in geodetic practice to cope with local attraction, referred to the intended reorganisation of time signals, and urged the establishment of British signals through the Imperial wireless chain. Dealing next with air-photographs and stereographic survey, he advocated reliance on ground stations, and an earnest attempt to apply the stereographic method to work on geographical scales. A summary of recent developments in map projections led to discussion of the International Map on 1/1,000,000, with the conclusion that its actual production should have been entrusted to a single establishment; that a smaller scale would have sufficed for much of the world; and that the work of the Permanent Committee on Geographical Names for British Official Use would be incomplete without a British map.

Turning then to the art of map-making, Mr. Hinks discussed the effect of multiple printings in colour, British pre-eminence in layer-colouring, and the need for some improved mechanism for drawing or typing names. There has been a lamentable decline in the craftsmanship of both instruments and maps. The former dates from the application of the telescope, at an epoch when other crafts were at their highest point of artistic merit. The decay in map-drawing came later, and may be repaired by diligent study and adaptation of early styles, rejecting the modern exaggerated use of distinguishing physical features by differences of lettering; but above all, avoiding sham medievalism.

The Meaning of Wages.

In discussing this extremely thorny problem in her presidential address to Section F (Economics), Miss Lynda Grier stated that no satisfactory theory of wages has as yet been formulated. Meanwhile, different interpretations of the word are accepted, varying with the aspects from which wages are considered. Wages are sometimes discussed as normal wages only, *i.e.* wages which represent the value of the work done under conditions of free competition. This value may be low, even when the work done is important and the workers do it competently, if there are many workers competing for a limited number of jobs and incapable of undertaking work of a different kind. When this is the case, the rest of the community gains by cheap services.

Frequently, however, wages are discussed as yielding an income which does or should maintain the worker. Up to a point the normal wage must supply sustenance in order to secure efficient workers. But it is not based on calculations of the length of the worker's life, of the cost of rearing him, of the size of his family, of the possibility of his death leaving a widow and children to be provided for. There is no necessity for employers to consider these things; few workers can afford to consider them. The normal wage takes account of the needs of the worker only when their satisfaction affects directly the supply or efficiency of labour. Beyond this point, needs are a weakness rather than a strength in bargaining.

Wage payments may be raised above the normal rate when demand for the product of labour is inelastic. In general, however, they can only be so raised by limiting the number of workers employed; the normal wage being the price at which all workers belonging to a particular grade can be employed in the occupations to which they are admitted. Attempts, legislative and non-legislative, to stretch wages to cover expenses not reckoned in normal wages are made at the risk of unemployment. Additions to low wages may be made with justice, since cheap labour which is not bad labour may provide cheap goods and since the worker is often not responsible for the cheapness of his labour. Moreover, all admit the necessity for some redistribution of wealth; but redistribution of wealth made in the name of wages may lead to a bad distribution of labour.

Fifty Years' Evolution in Naval Architecture and Marine Engineering.

Sir Archibald Denny, in his address to Section G (Engineering), traced the rise in the steam pressures used in marine engineering, and the passing from the simple to the compound engine, and from that to the triple and quadruple, which were practically universal in 1897. The appearance of the little *Turbinia* at the Spithead review in 1897 heralded a revolution in marine steam practice, which was at once embodied in the order placed by the Admiralty in 1898 for the torpedo-boat destroyer *Viper*, and later in the mercantile marine, by the commissioning of the *King Edward* in 1901.

At first applicable only to the faster vessels, in 1909, after the conversion of the *Vespasian* from triple to geared turbine by Parsons, single gearing widened the scope of the turbine, and later double reduction gearing made it applicable to all types of sea-going vessels.

Dr. Diesel, who began developing the internal combustion engine for marine purposes in 1897, saw the fruits of his labours in trading vessels a few years before the War. Since the War, development has been exceedingly rapid, and indeed some enthusiasts claim that the days of the steam turbine are numbered for marine work. The reply of the steam turbine designer is higher steam pressures with superheat, pre-heating of the air to the furnaces, and stage heating of the feed water, etc.

There has been an enormous development in auxiliary machinery, both in the pursuit of economy and in providing for the greater comfort and convenience of the passenger and personnel. As to main engine power in any one hull, in 1875, 3000 I.H.P. was considered high, whereas now the highest in mercantile practice is 75,000, and in naval vessels 140,000 I.H.P. is found.

In the ship itself the changes in design and the growth in dimensions and draught have been many, while the developments in accommodation for passengers have been such that the third class of to-day travel at speeds and in a comfort which was not available to the first-class passenger of 1875, while now the first class have at their disposal all the comforts and luxury found "at home." Many changes in design were made possible when mild steel supplanted iron in the early 'eighties of last century, and present-day metallurgical researches make further advances probable.

Attention is directed to the various agencies which have assisted in the advances made, especially the influence of technical education, which in 1875, so far as workers in private works were concerned, was provided almost exclusively by evening classes under the guidance of the South Kensington Science and Art Department. The Admiralty, however, had much better provisions in the dockyards for their own students. The Admiralty training and the chairs in naval architecture which were later founded at three of our universities have had important influences on private works.

The regulations of the Board of Trade and the classification societies, and also the private and public research at the universities and at the National Physical Laboratory, especially in the Froude experimental tanks, of which there are now seventeen scattered throughout the world, have exerted important influences on shipbuilding. Finally, there are the technical institutions, such as the Institution of Naval Architects, which have had much to do with the development of design, while the effect of standardisation, under the guidance of the British Engineering Standards Association, is also discussed.

Practical Engineering in Ancient Rome.

Dr. T. Ashby discussed the remains of engineering works in Italy in his presidential address to Section H (Anthropology), and stated that what appealed most of all to those who saw Rome in her prime were the aqueducts, the roads, and the drainage system. The Cloaca Maxima is ascribed by tradition to the Etruscan Tarquins, and (though nothing of the original structure is left) it still performs its functions, its splendid construction bidding defiance to the lapse of time: though, to our modern ideas, the direct discharge of sewage into the river seems dangerous.

Besides the drainage system, much attention was bestowed upon the regulation of the banks of the river and upon the bridges which crossed it. From there we pass naturally to the consideration of the road system, the nucleus of which dates from the beginning of Rome's history—of that wonderful network of roads which extended beyond Italy over the whole Roman Empire. Here, too (confining ourselves to Italy alone), we find a number of interesting and important engineering works. The Via Appia, the Via Traiana, and the Via Flaminia provide us with the best examples for study.

Turning last of all to the aqueducts, we find that the most important for our purpose are the four aqueducts which drew their supplies from the upper valley of the Anio, the Anio Vetus (272–269 B.C.) and the Anio Novus (A.D. 38–52), taking their supplies from the river the name of which they bear, the Aqua Marcia (144–140 B.C.) and the Aqua Claudia (A.D. 38–52), from springs which rise in the floor of the river valley. These aqueducts all required considerable restoration works, at more frequent intervals than one might have thought; and remains of the original channels of the two earlier aqueducts are rare, as indeed is to be expected, for they were built at a time when the danger of their being cut by an invader was still present.

As the course of these four aqueducts is often almost identical, the distinction of their remains was much facilitated by levelling operations carried out in 1915 by the late Prof. V. Reina; while Dr. Esther van Deman's researches on the chronology of the various types of construction employed in them are also of great importance. The remains are worth close study in detail; and the course of the aqueducts, which, when Prof. Lanciani's work was published in 1880, was still undetermined for several miles, has since been followed step by step, largely owing to his help.

These works of practical engineering seem to have been carried out by military engineers, who were at the same time civil architects—all of them Roman citizens, and for the most part Italians, not Greeks. The study of these works shows us that in this sphere, as in others, the Romans added very considerably to the sum of human achievement, and thus contributed in no small measure to make the condition of the human race what it is.

The Physiological Basis of Athletic Records.

In the records of athletics and of the various forms of racing there is a considerable store of accurate information as to the capacity of the human body for muscular effort, and the physiological basis of these achievements form the subject of Prof. A. V. Hill's presidential address to Section I (Physiology). The most complete collection of such information is to be found in the "World's Almanac and Book of Facts," published by the *New York World*; similar, though not so extensive information, is to be found in Whitaker's Almanack. The manner in which athletic records can be explained by, and can be used to illustrate, physiological principles is best shown by plotting graphically the average speed at which a race is run as a function of the total time occupied in the race. In this way, for the various types of muscular effort involved, we may construct curves for the ideal individual, showing how long an effort of any required intensity can be maintained. For the shorter durations of effort, say up to twenty minutes, the form of the curve may be explained simply on the ground of the supply of oxygen, actual or potential, available to the competing individual. The muscular system works like an electrical storage battery in the sense that severe exertion may be undertaken for a time at the expense of oxidation (*i.e.* recharging) occurring afterwards in the recovery process. For anything but the shortest races, however, the amount of oxygen available in the contemporary supply through lungs and circulation is also of importance.

The following cases are considered: running, men and women; swimming, men and women; walking, rowing, bicycling, skating, and horse-running. Of these, running and swimming are almost precisely similar in their general relationships: both represent extremely rapid and violent exertion. Rowing, bicycling, and horse-running are different: the two former certainly, the latter probably, because the same extreme violence of exertion is not possible as in running and swimming. For efforts of greater duration, as in skating, bicycling, and in running and walking long distances, the determining factors are quite different from those concerned with the immediate usage and supply of oxygen. Here other types of fatigue, of a nature less understood at present, are at work.

The importance of skill in movement is discussed, and it is pointed out how the curve relating oxygen requirement to speed of movement gives a full and complete account, for any given individual, of the skill which he exercises in movement at any speed: the greater the oxygen requirement, the less the skill. Given a sufficient oxygen intake and a sufficient capacity for running up an oxygen debt, the chief factor in athletic effort of anything but the shortest duration is the skill and economy with which it is carried out. For the very short effort, economy is of less importance; the essential thing is to attain the greatest possible output of energy. Quite astonishing amounts of power are exerted by athletes in violent efforts of short duration.

Some Issues in the Theory of "G" (including the Law of Diminishing Returns).

In his presidential address to Section J (Psychology), Prof. C. Spearman treated of certain points in a theory which has become known as that of two factors or of "g." According to this, every different ability of any person can be resolved into two factors, of which one is always the same but the other always independent; the factor always the same is intimately connected with what is commonly called "intelligence."

The proof falls into three distinct phases. The first is to ascertain what are the conditions under which the measurements of any ability admit of such division into two factors. The second is to find where, if at all, these conditions are actually fulfilled. The third and last phase is that of supplying the factors with some serviceable explanation; the hypothesis which at present seems most helpful is that the "g" measures some particular form of "energy" derived from the whole cortex of the brain. Recently, the first phase was greatly advanced by discovering a new and much improved criterion of the divisibility called the "tetrad-difference." This has now been applied to the results of an actual experiment which furnished 3003 of these tetrad-differences. The median value of these as predicted by the criterion was 0·061; that actually found came to 0·062.

The second part of Prof. Spearman's address discussed the fact that in some abilities the "g" is predominantly influential, in others the "s." Now, evidence has been brought to show that the more any class of persons is well endowed with "g," the smaller becomes the influence of "g" as compared with "s." It would therefore seem as if the more energy is available already, the less advantage accrues from further increments of it. An interesting parallel to this is the economic law of diminishing returns.

In the third part of his address, Prof. Spearman showed that a great number of abilities, since they are dominated by the influence of "s," vary independently from one individual to another. The inference can be made that in respect of the great bulk of these abilities, every individual will tend to be near the average; a fair number will be distinctly above this, and a fair number below; at the extreme ends of the frequency distribution will lie a very small number of performances for which the individual is, on one side a genius, and on the other an idiot. To find out where the genius of each person lies is a work that seems likely to have extremely important results, educationally, industrially, and even socially.

The Phæophyceæ and their Problems.

The Phæophyceæ or brown algæ present a wide range of plant forms; in regard to external form and structure the higher members are the most highly differentiated of the Thallophyta, while in size they exceed greatly any green or red alga. In their reproductive schemes and life-histories they show striking differences, although the uniformity of their motile reproductive cells, the similarity of the colouring matter, and the products of assimilation indicate their descent from a common stock.

According to the presidential address to Section K (Botany) by Prof. J. Lloyd Williams, interest in the group has been much increased by recent work and also by Dr. Church's memoirs on the marine origin of the land flora. Much work has been done on the various bodies found in the Phæophycean cell, but the disagreement between investigators as to the nature, origin, and even the functions of these bodies, shows the need for further research. A similar state of affairs prevails with regard to our knowledge of the reproductive organs. The group, with its very divergent reproductive methods, is good material for a rediscussion of the theory of "alternation of generations," the various types ranging from Pylaiella, with fluctuating alternations of gametophyte and sporophyte, to Fucus, which is variously described as showing (*a*) alternations with extreme reduction of the gametophyte, (*b*) nuclear alternation of generations, and (*c*) no alternations at all, the plant being a gametophyte.

The address concluded with an appeal for increased study of the physiology and ecology of the brown seaweeds. No survey is available of the marine algæ of Great Britain, and there is also great need of an up-to-date English manual of the group.

The Warp and the Woof in Education.

Education depends on a plan which includes the organisation and so much of the curriculum as is determined by the State, or by any other body in whom power is vested, and on the even more important contributions made by the teachers and by all the influences that surround the growing personality. The former is, according to Dr. W. W. Vaughan in his presidential address to Section L (Education), like the warp, the latter like the woof of the loom on which any fabric is woven.

The warp is at present probably too complicated, certainly too uniform, and it must remain too uniform so long as the State, for what were once quite good reasons, feels bound to define closely the powers of the local authorities, the boundary lines between education at different ages and of different sorts, and the limits of any city's or district's aspirations. What is now needed is that geographical units of reasonable size and homogeneity should be allowed to make real experiments, to set up warps of their own devising, receiving from the State in the way of grant what the State can afford to give and being allowed then to work out for that community a scheme of public education for the child, for the youth, and even for the man or woman.

In order that this may be done, we must get rid of some prejudices and some ideals that have been haunting us or are beginning to haunt us. One is that any extension of the school age must be uniform—applying to all children and to all places—another is that all are equally capable of fruitful education, another is that education cannot be won—and best won for some—by close contact with work that brings a livelihood, another is that education is to enable its recipients to have a happy leisure rather than to find happiness in daily work. The bogies, too, of wasted ability and thwarted genius must not be allowed to terrorise us. By all means do all that is possible—more indeed than is *done* now—to prevent waste, but do not let us be morbid in our fear of waste. Excellence depends on waste. Our careful precautions against waste lead to mediocrity.

The woof at which teacher or parent or employer or public opinion is always working depends on a more understanding co-operation between all those and all citizens too. For their goodwill alone can create the material circumstances in home and street that will prevent the influence of school being nullified by the influences that assail the impressionable mind in the hours of work, of leisure, and of recreation.

It is this co-operation that we teachers must ceaselessly implore and boldly claim.

The Mineral Elements in Animal Nutrition.

In his presidential address to Section M (Agriculture), Dr. J. B. Orr states that during the past half-century an increasing number of workers have become interested in the rôle played by inorganic salts in nutrition. Eight or nine of the mineral elements, *e.g.* calcium, phosphorus, potassium, etc., are known to be essential constituents of living matter. Iodine, manganese, fluorine, copper, zinc, and some others are found in traces. The presence of these was at one time thought to be accidental; it is now believed, however, that most, if not all, are essential constituents of the body.

The beginning of life-processes lies in the action of radiant energy on inorganic salts. The carbon atom is harnessed as the most suitable vehicle for conveying the chemical energy formed. The complex carbon-containing compounds, which have been regarded as the fundamental organic substances, are really secondary developments to secure that degree of stability and complexity required for the evolution of higher forms of life.

In the animal body, changes in the concentration of the inorganic ions in the circulating fluid are correlated with changes in functions of the organs. Thus, all the organs regulated by the central nervous system depend for the integrity of their function upon the maintenance of definite ratios of calcium, potassium, and sodium in the fluids within the nerve tissues. The classical experiments of Ringer on the perfused heart show that minute changes in the concentrations of calcium or potassium in the perfusing fluids have a profound effect on the activity of the heart. It is probable that the function of the bones in regulating the supply of mineral elements to maintain the "physiological balance" of the body fluid is as important as the more obvious one of providing a rigid framework. It is probably more fundamental, for when the available mineral matter is insufficient to maintain both the physiological balance in the blood and the rigidity of the skeleton, it is rigidity which is sacrificed.

When, for prolonged periods, the diet contains deficiencies or excesses of mineral elements greater than can be dealt with by the regulating mechanisms of the body, pathological conditions develop. It has been found that these occur not infrequently under modern conditions of intensive production in animal husbandry. Attempts to adjust the mineral content of diets by the addition of inorganic constituents that appear to be deficient meet, in many cases, with a marked degree of success. In the present stage of our knowledge, perfect adjustment is impossible. We need further information with regard to the amounts of each of the essential mineral elements required under different conditions, and the influence of the factors such as the "balance" of the diet and ultra-violet irradiation on the assimilation of mineral elements.

Valuable results are likely to be yielded by investigations on the interactions of colloids and inorganic ions, on the influence of the electrical charge and chemical characteristics of the ion on these reactions, on the effects of radiant energy on the processes associated with mineral metabolism, and on the relationship of these to both normal and pathological processes in the body. In this region there seems to lie the key to the solution of many obscure problems, both of the normal metabolism of health and of the abnormal metabolism of disease.

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