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CONTENTS.

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The Helicopter: is it worth a Prize?

JULES VERNE is responsible for the idea of the helicopter, and as a writer of works of imagination he invented devices with ease. The aeronautical engineer asked to produce a helicopter must recognise some limitations of his powers, and one is led to wonder whether the author of "The Clipper of the Clouds" could have solved the problems associated with the materialisation of his ideas. Press comments on the official conditions for the test of a helicopter, and the wording of the rules by the Air Ministry, raise the principle involved in this idea in a form of considerable interest to men of science. In the *Times* of May 11 appeared the following paragraph:

> "Still, the Air Ministry cannot afford to neglect the possibility that some practical helicopter may suddenly be evolved, and by their action they have made reasonably sure that any such development will come before their notice."

To guard against the possibility of ignorance in this particular direction, prizes to the total value of 50,000*l.* have been offered; the cost of the aeronautical research at the National Physical Laboratory is about 23,000*l.* per annum. The construction of the Brennan helicopter by the Air Ministry at Farnborough is variously estimated to have cost from 60,000*l.* to 100,000*l.*; lack of separate accounts for research and *ad hoc* experiments make it difficult to estimate the cost of scientific research at Farnborough, but it is probably of the same order as that at the National Physical Laboratory. It is believed to be inadequate for systematic progress on the full scale, with the result that Britain is far less active than America.[1]

Is the Air Ministry in danger of losing the substance for the shadow in giving prominence to a policy based on accidental strokes of genius rather than on patient and certain inquiry? Scientific workers at least will realise how foreign such a policy is to their own work.

Leaving this issue, which needs no elaboration in the columns of NATURE, it is interesting to examine the prize scheme on technical grounds. A passage which crystallises the underlying idea says: ". . . . a successful helicopter—that is, a machine capable of rising vertically from the ground under its own power, . . ." thereby indicating the property to which chief importance is attached as that which allows an aircraft to leave the ground and return to it without the high forward velocities of 50-60 miles per hour normal to the aeroplane. Such a property added to an aeroplane would be welcomed by all

[1] See the Wilbur Wright memorial lecture before the Royal Aeronautical Society by Dr. Ames, Chairman of the Executive Committee of the American National Advisory Committee for Aeronautics (1923).

interested in flying, but technical opinion, as voiced in public discussions, considers that in attaining this feature by the helicopter almost every other desirable quality of a flying machine is sacrificed.

Criticism has turned largely on the lack of efficiency and safety in the helicopter. The airscrew is not a new device and the principles of its operation are well established; efficiencies of 75 per cent. can be reached and utilised in the aeroplane *because it is an aeroplane*. This point is of some interest and merits further study; all heavier-than-aircraft are supported during flight on the sacrificial principle, that is, something else is driven down to keep the aeroplane from falling under the influence of gravity. In the aeroplane the utilisation of power in producing lift is indirect, for the airscrew is made to overcome the resistance of the aeroplane, whilst the wings produce the down current, and by reaction, the lift. This lift may be nine times as great as the thrust of the screw, and is rarely less than three times its amount.

The arrangement is efficient because the wings are large organs; it is the momentum generated per second which produces lift, whilst the power required is roughly measured by the energy thrown away in the downwardly moving air. The loss of energy for a given lift decreases progressively as the area of the downward stream is increased, and hence the efficiency of the aeroplane follows, in part, from the use of large wings. If the helicopter is to compete with the aeroplane on the score of efficiency its lifting screws must be large.

As the extreme case of large size, consider two aeroplanes flying in a circle and connected by some framework at present undefined, except that it supports a car at its centre. A first problem is immediately indicated—means must be provided for keeping the car free from rotation. If the aeroplanes are far enough apart their efficiency will remain as before, and as supporters of weight are fully effective. As a means of getting from place to place the combination is, of course, useless; modification of the problem still leaves us with the obvious conclusion that, whereas the wings of an aeroplane travel directly from point to point, those of the helicopter follow sinuous and longer paths. The argument seems to be fundamental and to exclude the helicopter from the degree of efficiency as a means of transport which can be reached with a good aeroplane.

Returning to our example, it will be found that a new factor enters into the problem as the two aeroplanes fly in smaller and smaller circles; each passes through the downwash produced by the other and by itself on previous passages. If near enough, this interference becomes very important, and it constitutes the only real difference between the helicopter as hitherto projected and the airscrew as commonly used. In looping, pilots frequently feel a bump on closing the loop, although some fifteen seconds has elapsed since the first passage and the distance travelled has been about 1000 ft. A further illustration explained on this principle arises from the observation that an increase of thrust arises from the sideways moving of a stationary airscrew, and therefore may be expected in a helicopter when used for transport.

All this is known, and the principles were laid down many years ago by the late Lord Rayleigh and others. Combined with modern data, it is possible to use existing knowledge to predict the limits of efficiency of a helicopter and to rely on the results. The design of the structure which holds the wings together presents greater difficulties, and attempts to build helicopters now may react favourably on structural design, but probably at a cost far in excess of that required to produce the same results by research.

Most of the attempts at helicopter design have led to screws some 40 to 60 ft. in diameter moving on the periphery at speeds of 70 to 100 m.p.h. Devices produced in more than one country have lifted themselves into the air, but little has been attempted in free flight. The Air Ministry has announced the development of the Brennan helicopter to the stage of lifting itself, and only ten per cent. of the prize money is allocated to the extension of this performance from a few feet to vertical flight up to 2000 ft. in a light breeze.

The rest of the competition relates to transport and control. One particularly hazardous requirement is that the helicopter "... must descend vertically from a height of not less than 500 ft. without engine. ..." It is a crucial test which, I believe, would involve certain death to the pilot who attempted it in the helicopters so far devised. In the case of engine failure, the helicopter at best is less effective than a parachute having an area equal to its blade surface, and is quite unable to provide an adequately small rate of descent. At its worst it is far inferior to this. In all circumstances the aircraft will require control, and the solutions hitherto proposed do not inspire confidence. It is evident that even the essential principles of a happy solution depend on that stroke of genius for which the Air Ministry is appealing and which it appears to think only needs a monetary stimulus to become operative.

Unlike the helicopter, the aeroplane does not lose its lift when the engine fails. It must perforce descend, but all its controls remain intact and danger comes only if the available alighting ground is unsuitable. Safety in aeroplanes is a subject for insistent inquiry, but marked improvement appears to be near realisation. Safety in a helicopter presents unsolved difficulties.

What, then, is the purpose of the helicopter? Presumably the use is to be military and secret. Outside opinion has not made any satisfying guess, and in these circumstances men of science, as well as aeronautical engineers, are disturbed by the evidence which this prize scheme gives as to the direction of Air Ministry policy. It is not expected that any appreciable part of the fund will be called on, and the whole sum would not be grudged to the producers of a new and useful type of aircraft. The fear is that, in following a "will of the wisp," insufficient attention will be given to systematic research on which, in the past, British constructors have been able to maintain a high quality for their productions. L. BAIRSTOW.

Life of a Naturalist and Teacher.

The Days of a Man: being Memories of a Naturalist, Teacher, and Minor Prophet of Democracy. By David Starr Jordan. Vol. 1: 1851–1899. Pp. xxix+710+56 plates. Vol. 2: 1900–1921. Pp. xxi+906+56 plates. (Yonkers-on-Hudson, N.Y.: World Book Co.; London: G. G. Harrap and Co., Ltd., 1922.) 15 dollars.

"THE Days of a Man" is the title chosen by Dr. David Starr Jordan for his autobiography. Dr. Jordan, who was born in 1851, has been for many years the leading ichthyologist in America, and is the author of a large number of memoirs on fishes, generally written in collaboration with his pupils. Of these the best known is the monumental "Fishes of North America" (1896–1900) by Jordan and Evermann, but perhaps his work on the Fishes of Japan marks the greatest advance, for these had been comparatively little studied until his collecting expedition in 1900.

Dr. Jordan's early tastes were for botany, in which he was so well-versed that even as a student at Cornell he was teaching this subject. He was first led to study fishes by attending a vacation course for science teachers organised by Louis Agassiz, and for many years afterwards he generally spent his vacations in collecting and reporting on the fishes of some region, at first on his own account and afterwards for the American Government, which ultimately sent him so far afield as the Sandwich Islands. It is perhaps worth mention that he invented the name "Rainbow Trout" in 1878.

Notwithstanding his distinction as an ichthyologist, we are inclined to think that Dr. Jordan's best work has been educational; and this applies even to ichthyology, since nearly all American ichthyologists were taught by him. In 1879, at the early age of 28, he became professor of natural history in the University of Indiana, and did so well that in 1885 he was elected president. He had now an opportunity to show his genius for organisation and to put his educational ideas into practice. There were many difficulties, but he overcame them. In his own words:

"In 1886 I made some sweeping changes, doing away with the fixed curriculum and adjusting the work so that practically all the subjects hitherto taught in the University, being elementary in their nature, were relegated to the first two years. Further than this, we instituted a 'major subject' system, by which each junior or third-year student was required to choose a speciality or 'major,' and to work under the immediate advice of his 'major professor,' whose counsel in details he was obliged to secure. An individual course of study was thus framed for each one. This system, which has now stood the test of more than thirty years in Indiana, Stanford, and elsewhere, was originally developed by a committee consisting of Dr. Hans C. G. von Jagemann, Dr. William Lowe Bryan, and myself. Its purpose was to enable every one to make the most of his four college years, by seeking the best teachers and the subjects best suited to his tastes and capacity."

Whilst carrying out these and other reforms Dr. Jordan undertook propaganda work, giving lectures that made the aims and purposes of the university understood in the State of Indiana. At the same time he showed wise judgment in making new appointments, Campbell, the botanist, and Branner, the geologist, being two of his early choices.

Jordan's success at Indiana was so great that in 1891 he was the obvious man to select as president of the newly established Stanford University. Here he had a congenial task, to plan out from the beginning the lines on which a university should be run and to select what men he liked to help him in the work. At first all went well, but in 1893 Stanford's death led to unexpected legal difficulties with regard to his estate, which seriously hampered the university, and after this matter had been satisfactorily disposed of came the earthquake of 1906, which wrecked a great part of the university buildings. On the morning of the earthquake Dr. Jordan received an invitation to become secretary of the Smithsonian Institution; in other circumstances he would probably have accepted, but he felt that it was his duty to stay at Stanford, and he did so, becoming Chancellor of the University in 1913, and finally retiring in 1916, at the age of sixty-five. He has good reason to be proud of the flourishing condition and the high reputation of Stanford, and of the success of its graduates.

Dr. Jordan is a man with high ideals and strong convictions, and he is a keen observer who has travelled in many lands. His views on men and matters are full of interest and demand attention. He is strongly opposed to the use of alcohol and tobacco, and he regards war as an out-of-date and anti-democratic method of settling disputes. At one period he gave much attention to the reform of the American civil service, and in recent years he has devoted a great deal of his time to lectures in America, Europe, and Japan in the cause of international peace, a subject on which he has written several books. When a man's life has been so strenuous and so varied the writing of an autobiography is a task of some magnitude. But it was well worth doing, and it has been well done. We congratulate Dr. Jordan and we thank him.

C. T. R.

The Structure of the Atom.

(1) *The Structure of Atoms.* By Prof. Dr. Alfred Stock. Translated from the Second German edition by S. Sugden. Revised and enlarged. Pp. viii+88. (London: Methuen and Co., Ltd., 1923.) 6*s.* net.

(2) *La Théorie des quanta et l'atome de Bohr.* Par Léon Brillouin. (Recueil des Conférences-Rapports de Documentation sur la Physique. Vol. 2, 1re Série, Conférences 4, 5, 6. Édité par la Société *Journal de Physique.*) Pp. 181. (Paris: Les Presses universitaires de France, 1922.) 15 francs.

(3) *Institut International de Physique Solvay.* Atomes et électrons. Rapports et discussions du Conseil de Physique tenu à Bruxelles du 1er au 6 avril 1921 sous les auspices de l'Institut International de Physique Solvay. Pp. vii+272. (Paris: Gauthier-Villars et Cie, 1923.) 20 francs.

THE problem of the structure of the atom is one which for many years has exercised a fascination for the scientific mind. Its solution demands the correlation of phenomena from many branches of physics and chemistry, and the repercussion of the current ideas on the subject makes itself felt over a correspondingly wide field. It is a subject on which no worker in physics or chemistry dare allow his knowledge to become out-of-date, and in which other scientific workers take an interest which is by no means entirely extraneous. Owing partly perhaps to the distinction and lucidity of some of its famous exponents, it has also aroused the interest of a wider non-scientific circle and has won for itself a distinctly "good press." In the circumstances it is not surprising that books on the subject, addressed to one or other of these numerous classes of potential readers, should appear at frequent intervals.

(1) Prof. Stock's little volume is addressed to the chemist, and contains a resumé of a series of lectures delivered by him to the works chemists of a well-known German manufactory. He attempts to remove what he describes as the "thorns of theoretical physics and mathematics" which beset the tender feet of the chemist who would wander in the "Wonder-garden" of atomic structure. He has, in fact, pruned so remorselessly that the book resembles rather a sketch plan than a garden, showing little more than the direction of the main paths and the openings into some of the principal alleys. To abandon the metaphor which Prof. Stock himself suggests in his preface, the book contains a fairly complete, but very brief, summary of the various phenomena which have a bearing on the problems of atomic structure; and a still briefer exposition of some of the current theories. A very interesting volume could be written around the synopsis thus provided. The fact that positive rays and the quantum theory occupy little more than half a page each, while the theory of relativity is consigned to a footnote, indicates the extreme condensation which has necessarily been employed to compress so vast a subject into so narrow a space. The reader will, however, learn from its pages how much there is to be learnt, and a brief bibliography points out the principal sources from which the English reader can obtain further information.

(2) M. Léon Brillouin's book "La Théorie des quanta et l'atome de Bohr" is addressed to the serious student of the subject. It forms the second volume of the series of reports which the Society *Journal de Physique* is publishing on various aspects of modern physics, and maintains the high standard which was set by M. de Broglie in his initial volume, "Les Rayons X." Probably no student of physics is entirely ignorant of Planck's quantum theory, and its application to thermal radiations, or of Bohr's daring and brilliant extension of the quantum principle to the nuclear atom of Sir Ernest Rutherford which resulted in the calculation of the hydrogen spectrum, and the evaluation of Rydberg's constant; certainly one of the greatest achievements of theoretical physics in modern times.

The later developments of the theory are far less known, nor has it been, up to the present, at all an easy matter to become acquainted with them. The original memoirs of Bohr and other distinguished workers on the same problem are scattered through the pages of many periodicals in many languages. Moreover, as was inevitable in a problem so complex as that of the motion not of three only but of many attracting and repelling particles, there have been numerous false starts and incorrect conclusions, and it has not infrequently happened that, after mastering with some difficulty one of these essays, the student has found to his chagrin that it has been superseded by later work. It must be confessed, too, that the pioneers of the theory, in their preoccupation with the extension of the subject, have not had too much pity on their weaker brethren, and it has not always been easy to discover either the exact nature or the physical basis of some of the principles to which they appeal. M. Brillouin's lucid and authoritative survey of the whole subject is, therefore, particularly welcome and valuable.

It was a happy inspiration on the part of M. Brillouin to preface his main thesis with two preliminary chapters on the quantum theory of radiation. It is a subject on which the author has himself done much valuable work, and his excellent, though brief, account provides a firm basis for the developments which follow. The succeeding chapters on the theory of Bohr, on its applications to atomic structure, and in particular the account of the principles of selection and correspondence, are equally illuminating.

It is not to be expected, from the very nature of the subject, that the volume should be easy reading. The author has not shirked the very considerable mathematical difficulties which are involved in the theory. He has, however, minimised them as far as is consistent with a proper understanding of the argument. Though it cannot be promised that the average student of physics will find his progress through the volume an easy one, he may be assured that his labours will be rewarded by a completer knowledge and a deeper appreciation of this important subject.

(3) It is in no way derogatory to M. Brillouin's excellent treatise to say that it is surpassed in interest by the report of the proceedings of the council of distinguished physicists who assembled in Brussels in 1921 under the presidency of Prof. Lorentz and under the auspices of the Solvay Institute. The number and distinction of the participants, each a master in his own particular branch, and the variety and importance of the subjects considered would in themselves suffice to raise high expectations. It may be said at once that, in the main, these expectations are fully realised by the volume which is now to hand.

Each of the twelve closely related subjects chosen for discussion was introduced at the Conference by a report on the actual position of the subject, and these reports make up the main part of the text. Thus Sir Ernest Rutherford reports on the structure of the atom, M. de Broglie on the quantum relation in the photoelectric effect, Prof. Kamerlingh Onnes contributes an account of his work on paramagnetism at low temperatures and on the super-conductivity of certain metals at low temperatures. Prof. Bohr gives an account of the application of the theory of quanta to atomic problems, which is supplemented by a report from Prof. Ehrenfest on the principle of correspondence.

It is natural that the different authors should develop their subjects in slightly different ways, and should assume slightly different degrees of previous knowledge amongst their distinguished colleagues, or perhaps we should rather say among the wider circle of readers for whom the reports were ultimately destined. In most cases, however, the reports are so well conceived and so lucidly expressed that the reader with only an elementary knowledge of the subject will have little difficulty in following a very considerable part of them. It is, in fact, an open question whether such a reader, at the expense of a little judicious "skipping" of the more recondite portions, would not attain a better appreciation of the present position of atomic physics from this volume than from many of the works ostensibly written for his special benefit. This, of course, does not apply to the one or two reports of a mathematical character, such as the profound suggestions of the president, Prof. Lorentz, in his notes on the theory of electrons which opens the volume.

In addition to their expository value, these reports have the great merit of opening up new avenues for discussion and experiment. In dwelling on the very considerable achievements which have been brought about, partly by the application of quantum theories to atomic problems, it is apt to be overlooked that these theories present formidable difficulties in addition to the fundamental one of explaining themselves. These difficulties are clearly raised in the discussions which follow the reports, and perhaps in none of them more clearly than in Prof. Barkla's discussion of M. de Broglie's report on the photoelectric effect. The discussions, which are excellently reported, are full not only of scientific but also of human interest. To the physicist, whether mathematical or experimental, in need of a subject for research they offer an ample choice of problems of fundamental importance.

It is to be regretted that so long an interval has been allowed to elapse between the meetings of the council and the publication of its report. It was not to be expected that the members of the council would allow two years to elapse before attempting the solution of some of the problems raised, and still less to be expected that their attempts should be entirely without success. In some particulars, therefore, the subject has advanced beyond the stage indicated in the reports. In the main, however, this applies only to minor problems. If it is true that intellectual satisfaction results from the discovery rather than from the knowledge of truth, a perusal of this volume will convince the reader that in this portion of physics he may confidently expect to find intellectual satisfaction for many years to come.

J. A. C.

The Ascent of Sap.

The Physiology of the Ascent of Sap. By Sir Jagadis Chunder Bose. (Cossimbazar Endowment Publication.) Pp. xv+277. (London: Longmans, Green and Co., 1923.) 16*s*. net.

THE author supplies in this book further ingenious experimental devices in which use is made of automatic recording methods and of various methods of magnifying small movements. The rate of ascent of sap is measured by a mechanical method recording the re-erection of a drooping tissue as sap enters it, and by an electrical method in which a quadrant electrometer is used to determine change of electromotive force between two points, one of which changes in turgor. By placing one electrode, carefully insulated save at the point, upon a graduated micrometer screw movement, the instrument becomes an electric probe by which the most vigorous changes in turgor are traced in the Dicotyledon stem to the living tissues in the region between inner cortex and vascular tissue.

The usual simple potometer experiment is modified into a recording potograph, whilst an ingenious bubbling method is introduced to measure the absorption of water by a cut shoot, and thus indirectly its transpiration, under varying conditions.

Many interesting observations are recorded in this account of work in the Indian climate, notably the report upon the exudation of sugar solution from cut surfaces in the stem apex or the inflorescence of the palm. This exudation is shown to be quite independent of any direct supply of sap from the absorbing system of the root.

The author's attempt to reinterpret the phenomena of the ascent of sap in the light of his new experiments is not convincing. As the result of a discussion of earlier work, mainly based apparently upon the English translations of the text-books of Haberlandt, Jost and Pfeffer, it is concluded that transpiration from the leaf and exudation from the root do not provide an adequate mechanism for the ascent of sap, whilst the rôle of osmosis is dismissed in two paragraphs. As opposed to this inadequate mechanism is advanced "a theory of cellular pulsation according to which the liquid is injected by the living cells into the wood-vascular tissue."

Later, the role of the xylem vessel seems practically to disappear—"The uni-directional propulsion of sap depends upon a sequence of pulsation from cell to cell. The sap expelled during the contraction of any one cell is absorbed by a cell higher up during its phase of expansion. There is then a propagation of a wave of contraction, preceded by one of expansion, in consequence of which the sap is, as it were, squeezed forward. A succession of such waves maintain the continuous ascent of sap." Though this may be clear to the author, the reviewer feels himself no nearer an understanding of the actual movement of sap in the plant. The demonstration of this mechanism rests upon experimental evidence that temperature, poisons, and various other external factors affect similarly sap movement and the pulsating mechanism, and upon a demonstration of electro-motive forces in tissues which are assumed to be manifestations of changes in cell turgor.

The experimental evidence is, however, not employed critically; thus it is argued that transpiration is not essential to the ascent of sap because the author's mechanical method shows a rapid rise of sap in a partially wilted chrysanthemum shoot when the cut end is placed in water, although the surface, both stem and leaf, had previously been coated with vaseline.

W. J.

A Metric Campaign.

World Metric Standardisation: An Urgent Issue. A Volume of Testimony urging World-wide Adoption of the Metric Units of Weights and Measures—Meter-Liter-Gram. Compiled by Aubrey Drury. Pp. 524. (San Francisco: World Metric Standardisation Council, 1922.) 5 dollars.

FOR several years an intensive propaganda has been carried on by the "World Metric Standardisation Council" on both sides of the Atlantic in furtherance of the objects indicated in the title of this book. Apparently self-appointed, its executive includes a number of men prominent in politics, commerce, and engineering, mainly resident in the United States, but representing also Canada and Great Britain, and the council has members and correspondents in almost all countries. It is under the direction of this body that the volume before us has been compiled, bringing together a vast amount of information and data regarding the "master standards" of the world, and aiming, of course, to promote their adoption in the United States and the British Empire for all commercial transactions. It is pointed out in the introduction that far less opposition has been raised to the adoption of the litre and gram than to the metre, which is very much more closely related to industrial processes than the units of mass and volume; but on the other hand, it is not proposed to impose the use of metric measures upon production—only upon distribution.

A large proportion of the work consists of quotations from the reports of committees which have investigated the subject at various times, the writings and speeches of individuals, and Bills which have been introduced into Congress and Parliament, as well as resolutions recorded by public bodies in favour of the metric movement; there are also lengthy lists of municipal authorities, commercial associations, and manufacturing companies which have definitely adhered to the proposed reform. The rest of the work is devoted mainly to the history of metric legislation in the United States and the British Empire, selected articles on the metric system, and a comprehensive bibliography.

From what has been said, it will be seen that the contents of the book are somewhat heterogeneous, and in parts reminiscent of a collection of press cuttings; it necessarily presents only one aspect of the question, being propagandist in the extreme. We cannot conceive of any reader faithfully perusing its pages from cover to cover, any more than he would an encyclopædia, but as a storehouse of opinion, anecdote, and similar material for the apostle of metric weights and measures to draw upon it will exercise considerable influence upon the rate of progress towards "world metric standardisation." A good index facilitates reference to the principal topics and authorities dealt with in the book, which is dedicated to James Watt as the originator of the decimal method of measurement, and contains many portraits of its advocates.

In Great Britain there is at present little evidence of a popular demand for the compulsory adoption of the metric system, though Chambers of Commerce and the Trade Union Congress annually pass resolutions advocating the reform; the Decimal Association, whilst continuing its metric propaganda, is devoting attention mainly to the decimalisation of the coinage, with the adoption of the "high-value penny" (one-tenth of a shilling, the latter retaining its present value) as the principal item in its programme. In the United States, where the benefits of decimal coinage are already enjoyed, strong efforts are being put forth to add thereto the advantages of decimalised weights and measures, and a Bill is now before Congress for that purpose. The energy devoted to the campaign in that country, of which the volume under review affords striking evidence, commands our admiration; but it must be admitted that the opposition to the movement in certain quarters is both bitter and powerful.

A. H. A.

Our Bookshelf.

Catalogue of Scientific Papers. Compiled by the Royal Society of London. Fourth Series (1884-1900). Vol. 18: Q-S. Pp. iv+1067. (Cambridge: At the University Press, 1923.) 9*l.* net.

FROM the outset this monumental work has occupied a very high position as a trustworthy work of bibliographical reference—due to the judicious extension of its range, the faultless accuracy of its entries, and the critical examination to which its author headings have been subjected. It is international in scope and appeal, but of purely British manufacture, and is now nearing the completion of the first century of its labours, for the final volume of the present series is promised next year. At first sight it might appear a tolerably simple matter to assign to their proper author headings a collection of carefully prepared transcripts of the titles of papers; but this view would not be confirmed by any cataloguer or indexer of experience. Initials of the forenames of writers have to be expanded, entries under writers of the same name and forenames to be distinguished, pseudonyms to be unmasked, and changes of name accounted for. With the spread of Western science to the East, the difficulties of accurate editing have multiplied. Nevertheless the standard of sound workmanship set by the editors of the earlier volumes has been maintained.

No great loss, we think, has resulted from the partial elimination in the present series of references to serials containing reprints, abstracts or translations of original papers. The retention of these references in the case of papers written in the less familiar languages serves most practical purposes of research. We trust that in the concluding volume Dr. Forster Morley will furnish us with complete statistics of the number of papers and their authors for the period 1800-1900, together with a chronological table or graph showing the rate of growth of scientific periodical literature for the same period.

Handbook for Electrical Engineers: a Reference Book for Practising Engineers and Students of Engineering. Compiled by a Staff of Specialists. Edited by H. Pender and W. A. Del Mar. Pp. xxiii+2263. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1922.) 30*s.* net.

THE many engineering researches both theoretical and experimental which have been carried out in recent years have created a demand for handbooks which will give the practical results obtained in a way that can be readily understood. The principal articles in this work under notice are written by well-known engineers and professors. The arrangement is excellent and there is practically no overlapping. It contains more theory than is usually found in similar works. The mathematical symbols are very clearly printed, the diagrams are excellent, and the index is very complete and well arranged. Although there are many references to radio communication, "wireless" is not mentioned. We are pleased to see that both "ground" and "earth" are given. The word "hydrology" is used to denote the "science of water." In water power engineering, for example, hydrological data such as the rainfall, natural drainage, and the velocity of the stream are required.

The Evolution of the Conscious Faculties. By Dr. J. Varendonck. Pp. 259. (London: G. Allen and Unwin, Ltd.; New York: The Macmillan Co., 1923.) 12*s.* 6*d.* net.

THIS book contains much valuable matter in the shape of introspective analysis, experimental investigation, and critical examination of theories, of the mental faculties. Dr. Varendonck leaves the impression of an enthusiastic and competent student of conscious processes. He takes Bergson and Freud as his directors. He follows Bergson in distinguishing two kinds of memory, but he names them reduplicative (Bergson's pure memory, the integral record of the past) and synthetic (Bergson's habit-memory). He also follows Bergson in the view that memory is an essential factor of perception. His method, on the other hand, closely follows the kind of analysis with which Freud has familiarised us in the "Traumdeutung," but unlike Freud he lays no emphasis on the sex motive, nor is he in any way obsessed with the idea of symbolism. It is a sane and useful discussion of the nature and origin of intelligence.

The Principles of Geography, Physical and Human. By Dr. E. G. Skeat (Mrs. Woods). Pp. 432. (Oxford: Clarendon Press; London: Oxford University Press, 1923.) 6*s.* 6*d.* net.

DR. SKEAT has produced an attractive book, fresh in outlook, inspiring and thoroughly readable. We miss with gratitude the wearisome reiterations of the ordinary run of text-books and find the author continually turning to original sources and taking new points of view. Both matter and style commend the book and give it a place by itself. The greater part treats of the physiographical side of geography, but the concluding section gives an excellent introduction to human geography. There are many well-selected diagrams, sketch-maps, and illustrations, and a copious bibliography. The book is too advanced for most school work, but should prove valuable to teachers of geography. Its careful use could not fail to improve the teaching of the subject.

The Contact between Minds: a Metaphysical Hypothesis. By C. Delisle Burns. Pp. x+138. (London: Macmillan and Co., Ltd., 1923.) 7*s.* 6*d.* net.

MR. BURNS has produced a very clear argument. It avoids the epistemological problem of intercourse, and the psychological problem of the genesis of knowledge, and narrows itself to the discussion of the nature of our knowledge of other minds. The traditional view that the existence of other minds is an inference is rejected, and it is held that the knowledge of them is "enjoyment" in the technical philosophical meaning of the term. Mr. Burns conceives knowledge realistically as the contemplation of objects compresent with the mind which knows itself in the contemplating. Other minds are known, he thinks, not as objects contemplated, but as our own mind contemplating. It is a thoughtful essay on a problem of deep interest.

Readable School Chemistry: a Book for Beginners. By J. A. Cochrane. (Bell's Natural Science Series.) Pp. x+84+8 plates. (London: G. Bell and Sons, Ltd., 1923.) 2*s.*

MR. COCHRANE'S book deals historically, and to a certain extent popularly, with the ground usually covered in a first year's course of chemistry. It contains interesting biographical details of the great founders of the science, and deals with their important researches. These are supplemented by brief notes on modern chemistry, and the book is well illustrated with portraits. Mr. Cochrane's book should be very useful and interesting to beginners in chemistry, and its very moderate price brings it within the reach of all students. On p. 30 the name should be "Brand," and on p. 64 "Warltire."

An Introduction to Theoretical and Applied Colloid Chemistry: "The World of Neglected Dimensions." By Prof. Wo. Ostwald. Authorised Translation from the Eighth German edition by Prof. M. H. Fischer. Second and enlarged American edition. Pp. xiii+266. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1922.) 12*s.* 6*d.* net.

THE new American edition of Wo. Ostwald's book on colloid chemistry is a translation from the eighth German edition. The author's lecturing tour in America appears to have taught him how to present the difficult subject of colloids in its simplest and most dramatic form. The great success of the book is a tribute to the completeness of the education thus received.

A Text-book of Inorganic Chemistry. By G. S. Newth. New and enlarged edition. Pp. xiii+772. (London: Longmans, Green and Co., 1923.) 8*s.*

NEWTH'S text-book has been found useful for so long that it needs no description. The new edition has been revised and brought up-to-date, and will be found as clear and accurate as former editions. The sections on modern advances are very readable, and this side of the subject has not been overdone. In one or two instances the revision has perhaps not been so complete as it might have been: the long descriptions of the Leblanc process and the chamber process seem out of proportion in comparison with the very short sections on the ammonia-soda and contact processes.

Electrical Horology. By H. R. Langmand and A. Ball. (Lockwood's Technical Manuals.) Pp. xi+164. (London: Crosby Lockwood and Son, 1923.) 7*s.* 6*d.* net.

THERE are scarcely any books which give an accurate account of the progress that has been made in recent years in applying electric currents to horology. The explanations given in this work are confined mainly to the essential parts of the mechanism and the electrical and mechanical principles which they illustrate. Inventors of electric clocks who, as a rule, have only a hazy knowledge of what has been done previously, will find this book helpful.

The Phase Rule and the Study of Heterogeneous Equilibria: an Introductory Study. By Prof. A. C. D. Rivett. Pp. 204. (Oxford: Clarendon Press; London: Oxford University Press, 1923.) 10*s.* 6*d.* net.

PROF. RIVETT'S little book on the Phase Rule deals mainly with theory, the various types of equilibrium being set out under the headings of one, two, three and four-component systems. It is a useful type of book for a worker who wishes to make use of the Phase Rule in his own work, although less attractive to a general reader than a book dealing mainly with examples.

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.*]

Breeding Experiments on the Inheritance of Acquired Characters.

[AT the request of the Editor of NATURE, and of Dr. Kammerer, I have translated this letter from the original German into English. Dr. Kammerer has also sent me the typewritten script of a reply to Mr. Cunningham, but in an accompanying letter he tells me that he considers it superfluous to publish this now, as he is quite satisfied with the reply which I made to Mr. Cunningham in my letter to NATURE published on June 23. E. W. MACBRIDE.]

To begin with, may I remark that I have not seen Mr. Bateson's first criticisms of my work (NATURE, July 3, 1919, p. 344) which he cites in the course of his recent letter. Whilst I was in England, my colleagues informed me of the contents of Mr. Bateson's letter of 1919, but I had unfortunately no opportunity of referring to this letter myself. I regret this all the more, since if what I had been informed of its contents was actually in the letter, it would not have been possible for me to enter into any discussion of the subject with Mr. Bateson himself. I must therefore for the present confine myself to his most recent letter (NATURE, June 2, p. 738) and the remarks which he made on the discussion which followed my lecture to the Linnean Society,[1] in which he expressly apologised to me in case I had considered his previous attacks too rude.

It is indeed remarkable that Mr. Bateson on that occasion (May 10) did not produce a single one of the many objections which are contained in his printed letter of June 2. The general impression which I gained at the meeting was that he could not think of any further objection to raise. The "vague diagrams" which he complained of appear not to be derived from my original paper (1909, *Archiv für Ent. Mech.*, vol. 28, Plate 16, Figs. 25 and 26), but—if I am not mistaken—from Plate ("Selektionsprinzip," 4th edition, p. 469, Fig. 95) in which my simple figures have been rather strongly altered and exaggerated.

Mr. Bateson must, therefore, have discovered by subsequent reflection all that during my demonstration and lecture he *did not* see. Otherwise it might have been possible for me to make him to see what he did not wish to see; I would certainly, for his benefit, have removed the Alytes specimen from the jar and he would have been able to view it—without obscuration by glass or background—from all sides under the lens: I treated it in this way during my stay in England for many colleagues (as, for example, for Mr. E. C. Boulenger and Sir Sidney Harmer).

On the occasion of the meeting of the Cambridge Natural History Society, I had at my disposal a Zeiss binocular microscope. Every unprejudiced observer could convince himself by its aid that the skin-area under discussion was of the nature of a nuptial pad—an area which according to Mr. Bateson was merely "a piece of thickened blackish-brown skin."

Numerous are the reasons which Mr. Bateson has given in order to be "absolved from basing broad conclusions on his testimony"; in a word, in order to deny the existence of the nuptial pads. First he questioned the existence of the pad; then he suggested it was merely a black patch of pigment; then, that it was present in only one specimen—consequently an accidental monstrosity; then he asserted that it was a shadow which appeared in the photograph; then, even that it had been produced by artificial retouching "in the wrong place," that is to say, on the outermost smallest finger, where in my untouched photograph (1919) some dirt had accidentally remained adhering. The microtome-sections of the pad-tissue, Mr. Bateson suggested, had been taken from another type of Anuran; then, since it appeared that homologous tissues of other species of Anura were of a different character, that these sections did not show genuine pad-tissue.

The most recent communication in which Mr. Bateson gives the impression which he received from the specimen which I demonstrated at the Linnean Society is capable of only two explanations, namely, either that Mr. Bateson is not an acute observer or that his theoretical views have affected his vision. In neither case can he escape the criticism that in describing "Dr. Kammerer's Alytes" he proceeded with a rashness unusual in a scientific man, especially when he makes slightly veiled accusations of "correcting Nature" against conscientious observers. We may now enumerate the points on which Mr. Bateson's "doubtful memory" has led him astray, namely:

(1) It is incorrect to say that my preparation of Alytes prevented a view of the dorsal aspect of the hand and only showed the palmar aspect—to make such a preparation it would have been necessary to fasten each finger flat against the substratum.

(2) It is incorrect to say that the black colour is restricted to the palmar aspect. (Why should Mr. Bateson assert this when he had not seen the dorsal aspect?) Actually the pads extend to the dorsal aspect and are therefore not "in the wrong place." It is curious to find Mr. Bateson prescribing to Nature the "right" place—Nature which has produced much more "astounding" and "curious creatures" (cf. Trichobatrachus) than my modest cultures of Alytes.

(3) It is incorrect to say "The right hand showed nothing special." On the inner side of the wrist-joint, on the insertion of the ball of the "thumb," there has been regenerated[2] a distinct dark pad—of course, not so large as that on the left hand.

(4) It is incorrect to say that the pad presents only "a dark uniform surface but no papillary or thorny structures." I send herewith an enlarged photograph in which "rugosities" can be seen on the edge of the pad with the naked eye. [I have verified this, but doubt very much whether the rugosities would appear in a print reproduced in NATURE.—E. W. M.] Unfortunately this photograph is taken from the palmar aspect; it was not foreseen that Mr. Bateson would criticise this, the most advantageous, position, in order to deny the presence of the pad on the dorsal surface, and to call in question the pad-nature of the whole structure. It is probable that the majority of my English colleagues have no idea how difficult it is to obtain a satisfactory photograph in our impoverished Austria. Of course, at the very first opportunity I shall have the upper side photographed; perhaps Mr. Bateson in his desire for truth will provide the necessary camera and photographic materials.

Dozens of scientific men have seen the pads and are now convinced; only Mr. Bateson has seen nothing. Unfamiliar as he is with this special department, he expects to see the same as can be seen in

[1] NATURE, May 12, 1923, p. 639, column 2, line 10, should read "macroscopic observation," not "microscopic."

[2] Dr. Kammerer stated at the meeting of the Linnean Society that the original pad on the right hand had been removed for the purpose of making microtome sections.—E. W. M.

Rana agilis. His assertion that the pads of *Alytes obstetricans* are not pads because they have a different appearance from those of *Rana agilis* is as unreasonable as it would be to maintain that *Alytes obstetricans* is not a Batrachian because it does not look like *Rana agilis*.

Lastly, a few words on the question of adaptation. In my lecture I avoided speaking of adaptation because this term involves a hypothetical and teleological element: I feared that to use it might lead to endless unfruitful discussion. Unfortunately, I was unable to prevent this; Mr. Cunningham discussed his own theory of adaptation in a way that had little to do with the facts which I had cited. I definitely declined to enter into this subject in my reply, simply because it is not usual for the discussion to wander so far from the subject of the lecture. So far as the nuptial pads are concerned, may I refresh Mr. Bateson's memory so far as to remind him that not only my Alytes but also other Batrachians, and especially the Discoglossidæ (to which Alytes belongs), have pads on places which never come into contact with the female? *Bombinator pachypus*, for example, develops pads on two or three toes of the *hind* foot (cf. Schreiber, "Herpetologia Europæa," 1912, p. 175). Are these "in the wrong place" or "retouched" by Nature?

I willingly admit that the traditional explanation of the pads, namely, that they are produced by friction with the skin of the female, may possibly be a fable: for that reason I have referred to this view with reserve and scepticism in my paper (1919, pp. 331, 339, 353). It is true that the spread of the thickening to regions of the skin which in the copulatory act do not undergo friction, is no valid ground for rejecting the theory. Mr. Bateson has doubtless himself observed that pressure thickenings and blisters often extend beyond the original zone of irritation. But it is by no means impossible, although of course not proved (Kammerer, 1919, p. 340), that life in water produces the pads; if this were so we should have a case of direct passive production but not of active adaptation. The correctness of my observations and their relevance to the theory of heredity, is not affected whichever of the explanations is adopted. PAUL KAMMERER.

DR. BATESON, in a letter to NATURE of June 2, raises the very interesting point as to whether the appearances alleged to be "nuptial pads" in *Alytes obstetricans* are really such. Whatever their nature, they are undoubtedly organised structures; and if they should prove not to be "nuptial pads," they will have to be regarded as a new and arbitrary feature which has appeared after subjection to an experimentally altered environment for two or three generations, and which persists for at least a few generations after a return to normal conditions. In other words, it would seem that Dr. Kammerer has had success in an experiment which is almost analogous to those ancient researches in which was attempted the reproduction by hereditary means of a surgically impressed modification.

However, Dr. Kammerer has clearly stated that in his opinion the only feature of the experiment which in any way justifies such a view is that the excrescences in question are not dependent for their development on the presence of a testis, and in this differ from the nuptial pads of the better known Amphibia Anura.

Dr. Bateson points to two details which make "the appearance quite unlike that of any natural *Brunftschwielen*": first, that in Alytes there is a "dark uniform surface . . . without the dotting or stippling so obvious in true *Brunftschwielen*"; secondly, that their position does not correspond to that of the nuptial pads in *Rana agilis*.

Lataste's excellent drawings (*Ann. Sci. Nat.* (6), tom. 3, pl. 11, 1876) show that a uniform blackness of the outer layer of the pad is a characteristic feature of the Discoglossidæ (to which Alytes belongs) and distinguishes them from other Anura. The fully developed pads of *Bufo vulgaris* are also uniformly black, and I have recently found that when such full hypertrophy of the outer epithelium is inhibited, as occasionally happens from obscure causes, it may be induced by making the male maintain a sexual embrace for a week or two. The same effect may be produced in the summer condition of the pad, and I have found that the hypertrophy takes place even when the male maintains his tonic embrace on thin air.[1]

The pad of the Alytes "water-breed" also resembles that of the Discoglossid Bombinator in having a complete layer of black pigment in the cutis vera which would further contribute to the uniform dark appearance which Alytes so well and characteristically shows. Photographs show another interesting point. Very distinct connective-tissue papillæ are developed from the cutis vera in association with the epidermal spines. Such papillæ are but very slightly developed in the Discoglossidæ, though Lataste's picture of Discoglossus shows traces, whilst they are a characteristic feature of the pads of many other Batrachians.

The epidermal spines are very obvious in the intact specimen, as I have repeatedly seen both with lens and binocular microscope, and as many others have witnessed in my presence. Of course, they are practically impossible to photograph on account of the glistening of a wet specimen, but a photograph at least makes clear what areas of skin are affected. These include nearly the whole of the palm, the radial surface of the inner metacarpal and part of the first phalangeal joint of the thumb, and more or less of the ventral and radial surfaces of the forearm, passing over the dorso-radial margin of the inner carpal tubercle. The Discoglossidæ are remarkable for the very various positions in which the histological features of *Brunftschwielen* may manifest themselves, on the chin, belly, thighs, toes of the feet even; in other words, they are not necessarily dependent on contact with the female for their development. Dr. H. Gadow has shown me his sketch of the nuptial pad in *Alytes cisternasii*, Bosca., where it is developed on the tip of the thumb, extending on the palmar surface. Even in the common toad I have frequently observed the nuptial rugosity extending on to the palmar surface of the inner carpal tubercle.

Questionable as it is to draw conclusions on anatomical points by analogy from other animals, it is even more unsafe to do so as regards their habits and postures; Alytes does not belong even to the same suborder as *Rana agilis*. De l'Isle (*Ann. Sci. Nat.* (6), tom. 3, p. 18), in his account of the cervical clasp of Alytes, says with regard to "les paumes," "les applique contre le cou de la femelle." Moreover, although he gives no definite description of the attitude of the hands during the inguinal clasp, he describes how, with the fingers interlaced, the two backwardly directed internal digits participate in the well-known chafing of the cloaca, which seems to me anatomically impossible if the hands are so much everted that the palms do not come in contact with the pubic region, the groins, or at least the thighs of the female. MICHAEL PERKINS.

Trinity College, Cambridge,
June 16.

[1] The surgical details of this experiment are of no importance in the present connexion.

Light-Quanta and Interference.

IN a very important and stimulating paper on the scattering of X-rays by light elements (*Phys. Review*, May 1923), Prof. A. H. Compton suggests that a study of the problem of scattering by atoms with tightly bound electrons and by groups of atoms may shed some light upon the difficult question of the relation between interference and the quantum theory.

In an investigation of this kind it may be useful to keep in mind an important difference between an electron and a light-quantum, which depends on the fact that generally most of the electron's energy is unavailable, while the whole energy $h\nu$ of a light-quantum seems to be available. This indicates, of course, that a light-quantum is a simpler form of matter than an electron or proton.

Roughly speaking, a light-quantum possesses a large amount of available energy and a small momentum, while a moving electron generally possesses a small amount of available energy and a comparatively large momentum. As a rule, then, we cannot expect a free or lightly bound electron to absorb the whole energy of a light-quantum. It is indeed possible, according to the theory of Compton and Debye, for an electron which encounters a light-quantum $h\nu$ to move away with a kinetic energy equal to $h\nu$ if the electron has an initial kinetic energy nearly equal to $h\nu$, but this case is not of much physical interest. When, however, an electron is tightly bound to an atom, so that some of the energy of an impinging quantum may be transformed into potential energy, there is a possibility that the whole energy of the quantum may be absorbed in a single impact.

If we admit that the energy of a quantum can be absorbed bit by bit, it does not follow that the type of absorption considered by Compton is the only one which can occur. Let us suppose that a quantum $h\nu$ after encountering an atom is transformed into a quantum $h(\nu - d\nu)$ travelling in the same direction as the original quantum. Assuming that the atom (of mass m) acquires the energy $hd\nu$ and momentum $hd\nu/c$ lost by the quantum, the centre of mass of the atom may be supposed to move forward with velocity $hd\nu/mc$ and a kinetic energy $h^2(d\nu)^2/2mc^2$, which is generally negligibly small in comparison with $hd\nu$. The acquired energy $hd\nu$ may therefore be energy of small oscillations about a state of steady motion. To ascertain the nature of these oscillations we represent the incident quantum by a field of type

$$E_x = H_x = 0, \qquad E_y = H_z = \frac{\partial\Omega}{\partial y} f\left(t - \frac{x}{c}\right),$$

$$E_z = -H_y = \frac{\partial\Omega}{\partial z} f\left(t - \frac{x}{c}\right),$$

where $$f(t) = \int_0^{2\pi\nu} \cos(pt + \alpha)dp.$$

(See NATURE, April 28, p. 567.)

The emergent quantum may be represented by a field of the same type with $\nu - d\nu$ instead of ν, while the field which is really effective in producing the oscillations is the difference of these two, and is of the same type with

$$f(t) = \int_{2\pi(\nu - d\nu)}^{2\pi\nu} \cos(pt + \alpha)dp.$$

When $d\nu$ is very small, this represents approximately a homogeneous train of waves of frequency ν. The small oscillations set up in the atom are thus specified approximately by a trigonometrical function of type $2\pi d\nu \cos(2\pi\nu t + \alpha)$ and are practically undamped and of frequency ν. The phenomenon of interference may, then, be quite compatible with quantum theory, for it may depend really on an interference of small oscillations produced in the atoms by the quanta. If a number of quanta in phase strike the same atom, the small oscillation may become large and eventually result in a quantum jump, but the growth of an oscillation may depend, of course, on the phenomenon of resonance.

Since we have endowed a quantum with a field, a single quantum may produce small oscillations in a large number of atoms in accordance with Compton's idea, and so a second difficulty in the theory of interference may not be so great as it seems at first sight.

H. BATEMAN.

Institute of Technology,
Pasadena, California.

A Mountain Mirage.

As part of a magnificent view from Ben More of Mull on July 13, my sister and I saw a striking mirage on the Coolins of Skye. To begin with, Skye and all the Highlands to the eastward of it were covered by a level sheet of white cloud, with the highest peaks just showing clear and sharp above it. Then, starting from the sea, this cloud gradually melted away, and revealed a magnificent prospect extending far past the Coolins into the mountains of Ross. But as the cloud first melted it left the Coolins strangely transformed, each of their jagged crests drawn up into a fantastic spire. In the course of a very few minutes this effect died away and the Coolins took on their natural outline.

This was about 6.30 P.M., summer time. Presumably the mirage had some connexion with the cloud sheet; at one stage of its absorption the sheet must have been represented by a refracting layer, which would be very nearly at our eye-level. The air was remarkably clear, not only to the north but also to seaward. For some time a long line of the Outer Hebrides, from about South Uist to Barra Head, was visible, pale but perfectly clear-cut.

E. LEONARD GILL.

Royal Scottish Museum, Edinburgh,
July 18.

Probable Aeolian Origin of Greywether Sandstone.

ON reading Mr. C. Carus-Wilson's note (NATURE, March 3, p. 292) referring to the long tubular holes seen in sarsen stones, which he says suggest "the work of marine annelids, anterior to the consolidation of the rock," it struck me that some important light may be thrown on this subject by observations made on this side of the globe. First of all one might suggest that if these were annelid burrows they would have an average diameter, and there seems to be no evidence that the greywether sandstone, with its once softer siliceous matrix, was of marine origin. In Australia we have a great extent of country along the coast and inland, covered with dune formation, and these deposits enclose enormous quantities of vegetation. Plants that are growing on or near these dune areas, sometimes under swampy conditions, are covered over with sand, which is being blown about the stems of such grasses, reeds, and shrubs so as to completely enclose them. When the dune rock, some of which dates back to the early Pleistocene, has consolidated, a fracture reveals tubular holes which might suggest worms, but from their positions, at all angles, as well as vertical, and from their varied diameter and outline, are easily traced back to plant origin.

From many years' observations upon our Australian dunes, I cannot help thinking that here we have a similar process going on, which obtained during the arid interludes of the Eocene in the south of England.

Evidence of cross-bedding, which is inseparable from this type of rock, would be easily lost, since the greywethers are secondarily silicified or "concretionary." From conversation with the late Prof. Rupert Jones, than whom I knew no keener observer, I gathered that he firmly believed in the rootlet and stem structure of these perforations (see *Geol. Mag.*, 1901, pp. 54-59 and 115-125). Another recorded instance of enclosed rootlets is given by Wm. Carruthers (*Geol. Mag.*, 1885, p. 361), who found in a weathered sarsen stone from Abury a root with rootlets, which he doubtfully ascribes to a palm, and in the position of growth.

It would be interesting to discover any positive evidence of cross-bedding in these white Tertiary sandstones. The Bagshot sands, by the way, both in Surrey and Kent, are often strikingly and steeply cross-bedded, and this, from a study of our dune rock in Victoria, points to aeolian formation rather than to marine current action. FREDK. CHAPMAN.

National Museum, Melbourne,
June 15.

Barometric Pressure in High Latitudes.

I AM much obliged to Mr. L. C. W. Bonacina (NATURE, July 21, p. 100) for pointing out a clerical error in my statement concerning the winter and summer Arctic pressures. The correction gives greater emphasis to my contentions.

My point is that in the Arctic regions, even during the winter when the sun's light does not reach the area to any extent, the pressure is low, indicating a sufficiently warm stratosphere able more than to counterbalance the effect of the cold lower troposphere.

The lower troposphere over the polar areas is undoubtedly very cold, and this cold air often flows outwards from the poles for some distance. I am not aware that my views on this point are in conflict in any way with those of Dr. G. C. Simpson, Prof. Mohn, or Prof. Bjerknes, except on very minor points. What I have attempted to explain is not why these northerly Arctic winds exist, but rather why they do not blow from the poles to the equator. The real difficulty, to my mind, is to account for the westerly poleward winds of middle latitudes.

Mr. Bonacina says "there must, on the average, be a relatively high surface pressure about the poles." But all the charts show a relatively low pressure. However, an outflow of cold air from the poles will occur if the density of the *lower* troposphere decreases with sufficient rapidity as we move towards lower latitudes; and this is what actually often occurs, for the temperature rises as we move from the poles.

R. M. DEELEY.

Tintagil, Kew Gardens Road,
Kew, Surrey,
July 20.

Phototropic Compounds of Mercury.

IN NATURE of June 9, p. 775, Messrs. Venkataramaiah and Rao describe "A New Phototropic Compound of Mercury" of the composition $Hg<^{HS}_{CNS}$, which they regard as "the most phototropic compound as yet known"; or that this compound shows appreciable change in colour on exposure to light in less time than that required by any other known phototropic compound. In 1917, while working in the College of Science, Calcutta, in an attempt to prepare $(SHgI)_2$, described by Ray (Trans. Chem. Soc., 111, 109), without using any organic compound, I obtained $2HgS.HgI_2$, which showed phototropy to a remarkable degree. The orange yellow powder turned black very quickly on exposure to sunlight, but only gradually in diffused daylight. On keeping the black powder in the dark, the reverse change took place. At room temperature, it took several hours to recover, but at higher temperatures the change of colour was quicker; at about 85° C., for example, only a few seconds. Both varieties had the same chemical composition. This substance was exhibited before the Indian Science Convention of that year, and a preliminary note was published in the Report of the Indian Association for the Cultivation of Science, 1917. Since then I have found that phototropy is exhibited more or less by all the complex sulphides of mercury of the general formula $HgS.HgX_2$ or $2HgS.HgX_2$, where X is a halogen or a monovalent acid radicle, including CNS, of which $2HgS.HgI_2$ is the most sensitive.

The sensitiveness to light depends to some extent, as might be expected, on the nature and area of the surface exposed. I have found that paper coated with an emulsion of $2HgS.HgI_2$ in gelatin is much more sensitive to light than the powder. In fact, it turns black more quickly on exposure to light than the ordinary gelatino-chloride paper used in photography. But it is very curious that in this case the reverse change of colour does not take place on keeping in the dark or heating. Evidently the gelatin somehow prevents the reversal. A detailed report on these inorganic phototropic compounds will be published in due course. M. L. DEY.

Central Chemical Laboratory,
Kirkee, India, July 5.

Melanism in the Lepidoptera and its Possible Induction.

BELIEVING that light can be thrown on some of the problems of evolution by an experimental investigation of the development of melanism in lepidoptera, we have been studying the influence of the food plants growing in critical areas, and also of inorganic substances likely to occur in or on the plants of such regions, on races of moths imported from non-melanic districts. Our cultures have been reared at two centres; some at Birtley (Durham), an area producing a very large number of melanic species, and others at Hexham (Northumberland), where melanism is much less prevalent, although not absent. The work is not finished, but certain facts seem worth publishing at once, particularly in view of the recent controversy as to the value of Kammerer's experiments.

We began with Kentish races of *Tephrosia crepuscularia* Hb., and Kent and Hampshire strains of *T. bistortata* Goeze, rearing them on hawthorn gathered by the roadside at Birtley, and in the third generation of *T. crepuscularia*, a species in which we have proved melanism to be a Mendelian dominant, obtained one black female in a brood of 23 insects. *T. bistortata*, on the other hand, showed no change in the fourth generation, at which stage the eggs from one pairing were sent to Hexham and others reared at Birtley, where in the next (fifth) generation one black female was obtained from about 90 pupæ. The eggs at Hexham, cousins to those at Birtley, were divided into four batches, the larvæ in one case being fed on local hawthorn and in the others on hawthorn impregnated with a metallic salt. In each culture one or two black moths appeared, the broods averaging two dozen in number.

In 1918 pupæ of *Selenia bilunaria* Esp. were obtained from Kent, and broods resulting from these reared at Birtley on hawthorn from the roadside. In the following year the spring brood, the second lot fed at Birtley, gave a batch of moths containing a large number of typical insects, several melanochroic forms together with two insects uniformly leaden black. A black female was paired with an unrelated typical male, and F_1 and F_2 generations secured; the results suggested that the melanism was recessive, as in the allied moth *Ennomos quercinaria* Hufn. Another batch of ova was obtained from a typical wild Abbot's Wood (Sussex) female in July 1921, and after two generations had been reared at Birtley, eggs were sent to Hexham. Some of the larvæ were fed on prepared hawthorn, the salts used being lead nitrate and manganese sulphate. The moths emerging in the spring of 1923 showed no particular variation, but were paired, and the treatment continued. The summer brood proved extremely interesting. The controls began to show the effects of inbreeding, only 12 moths resulting from 60 eggs, and 3 of these were dwarfs; but there was no melanism. From one batch of larvæ fed on hawthorn containing lead nitrate 12 males and 15 females were bred; all were of normal size, but 1 male was practically black. Another such batch gave 20 males and 11 females, 1 male again being melanic. A fourth section, reared on hawthorn charged with a manganese salt, yielded 11 males and 9 females; these displayed both melanism and melanochroism, 6 males and 2 females being of the black type, whilst insects absolutely typical were practically absent. All of these melanic forms are fairly uniform in colour, showing no markings except an almost white line such as is so common a feature of melanic lepidoptera.

In partnership with Mrs. Garrett, one of us recently directed attention in these columns to the effect of lead on *Smerinthus ocellatus*, and the same workers have now tried it with *Amorpha populi*, the eggs originating with a wild Hexham female. The larvæ again fed up more rapidly, but whereas the *S. ocellatus* pupæ were heavier, those of *A. populi* were about 15 per cent. lighter than those of the controls. They were perfectly healthy, however, and moths were obtained from every pupa save one. Though there was no definite melanism, there was a tendency towards it, the colours being more intense and the markings more clearly defined; the difference was sufficiently great to enable one of us, who had not seen the moths before, to sort them correctly without any clue as to their history.

As the investigation is being continued, and the study of the inheritance of the induced melanism well in hand, we content ourselves with a mere statement of the facts; next summer we hope to be able to publish fuller details.

F. C. GARRETT.
J. W. HESLOP HARRISON.
Armstrong College, Newcastle-upon-Tyne,
July 27.

The Reported Meteorite at Quetta.

THE issue of NATURE of May 26, p. 704, contains a short communication from my Department correcting a report concerning the fall of a meteorite at Quetta. Further inquiries make it desirable that the opinion in that letter should be modified. Though no traces of a meteorite can be identified in the material collected, it does not necessarily follow that a meteorite did not fall.

During a storm at Quetta on the afternoon of January 25 last, a large ball of fire is reported to have fallen and struck a stack of baled *bhoosa* (chopped straw) in the Military Grass Farm Stack-yard. The stack, composed of 12,800 bales, was for the most part consumed by fire, and amongst the ashes were found some three tons of a hard dark stone. Portions of this stone were forwarded to the laboratory of the Geological Survey and found to consist of slag, parts of which showed a ropy structure and slightly scoriaceous texture. As we were informed that no one had actually seen the fireball strike the stack, it was at first thought that the latter was ignited by a simple flash of lightning. Later information, however, makes it possible that a meteorite did actually fall into the *bhoosa* stack. Not only was the "ball of fire" witnessed by several people, but the men who were set to work on top of the stack extinguishing the fire immediately after its outbreak reported a hole in the stack 18 inches wide, and their observation was confirmed by Conductor Trewhella, who noticed that the hole led towards the centre of the stack.

The possible sequence of events may be reconstructed as follows: The *bhoosa* was struck and ignited either by a meteorite which burned its way to the base of the stack, or by a simple flash of lightning. The intense heat fused the iron bands binding the bales of *bhoosa*, and this iron combined with the silica in the *bhoosa* itself or with any mud roofing which may have been present. Mr. A. J. Gibson, of the Punjab Forest Service, has reminded me that the tissues of the Gramineæ contain an unusually large percentage of silica, and 12,000 bales would probably supply sufficient to form most of the three tons of slag, consisting of silicate of iron, free iron, and impurities.

The meteorite, if there were one, was itself probably of iron, and would have mixed with and become part of the fused slag. Unmelted fragments of the iron bands of the *bhoosa* bales were found in the cooler portions of the melt. In such circumstances it is of course impossible to identify any remains of a meteorite in the slag.

E. H. PASCOE (Director).
Geological Survey of India,
Simla, July 9.

Scientific Names of Greek Derivation.

IN NATURE for July 7, p. 10, Prof. Cole criticises "American authors" for using the term dinosaur, instead of clinging as he does to "deinosaur." In a previous number of NATURE (July 1, 1922, p. 21) the reviewer of an article on the Deinodontidæ takes the authors to task for not using "what is now considered the more correct rendering of the Greek, as Dinodontidæ." What can a poor American author do to be saved?

In fact, the usual custom among American and Canadian palæontologists has been to follow the rules of the International Code for names of genera and families, and otherwise adhere to the original spelling of scientific names, although some of us have had sufficient classical training to dislike having to use badly composed or wrongly transliterated names. Dinosauria was Owen's spelling of the word and Deinodontidæ is formed according to the rule from the radical of Leidy's genus as originally proposed.

While the rules and recommendations of the Code are a sufficient guide for future coining of names, its retroactive applications are not altogether clear, and it does not provide any definite guide for the spelling of the larger group names or other scientific terminology. Is there any scientific dictionary to which one could refer as internationally authoritative? Or could the matter be taken up by the next international congresses of zoology and geology?

W. D. MATTHEW.
American Museum of Natural History,
New York, July 17.

Hardness Tests.

EVERY one has a general idea of what is meant by hardness—that the diamond is harder than steel, and steel harder than copper. The workman judges of hardness as the resistance of a material to the action of his cutting-tools or files. But there is as yet no rational definition of hardness. A property connected with hardness is resistance to abrasion or wear. As Sir Robert Hadfield has said, rails are demanded which will not wear out quickly and tyres which will not need renewing every few months. It was entirely for these reasons that modern qualities of steel were produced. To some extent hardness is opposed to ductility or toughness. Very hard materials are generally brittle. The engineer requires a material in which hardness is obtained without too great a sacrifice of toughness.

The earliest scale of hardness is that proposed by Moh. He selected ten minerals arranged in order such that each would scratch the one next below it in order and be scratched by the one above it in order. On this scale talc has a hardness 1 and diamond a hardness 10; iron has a hardness of 4·5. But the scale is qualitative only and arbitrary. Prof. Turner has used a balanced lever turning on a knife-edge. The free end carries a diamond. The surface to be tested is polished. The hardness is taken to be the weight in grams on the diamond necessary to produce a definite scratch. The method is useful, but there are practical difficulties in applying it. Recently Mr. Hankins, at the National Physical Laboratory, has modified this test. He uses a diamond shaped so as to produce an indentation furrow rather than a scratch.

The diamond is loaded with weights and drawn over the surface to be tested. The widths of the scratches with different weights is measured, and it is found that the square of the widths plotted against the weights fall on a straight line passing nearly through the origin. Hence Mr. Hankins takes as the hardness number the quantity

$$k=\frac{P-p}{w^2-q},$$

where P is the load on the diamond, w the width of scratch, and p and q small constants not depending on the material tested.

Various investigators have used an indentation method for determining hardness. Such a test is very suitable for ductile metals, but how far it is applicable to brittle materials is uncertain, though this is not of practical importance. The indenting tool has been a knife-edge, ball, cone, or pyramid.

In 1895 and 1900 Lieutenant-Colonel Martel communicated two very interesting papers to the Paris Congress on Testing Materials. He used chiefly a falling monkey with various forms of indenting points and various heights of fall. He concluded that (1) for a given material the work of indentation is proportional to the volume of the indentation and independent (within limits) of the form of indenting tool; (2) that the pressure causing indentation is at each instant proportional to the area of the indentation normal to the pressure. If V is the volume of the indentation, P the weight of the monkey, and h the height of fall, then Martel's hardness number is

$$D=\frac{Ph}{V}$$

in kilogram-millimetre units.

About 1900 Brinell introduced the indentation test, which has been most widely used. A very hard steel ball 10 mm. in diameter indents the material by a gradually applied load of 3000 kilograms, which rests on the ball for some seconds until the indentation is complete. The radius of the indentation is measured by a microscope. If P is the load, a is the radius of the indentation, and r the radius of the ball, then Brinell's hardness number is

$$H=\frac{P}{2\pi r(r-\sqrt{r^2-a^2})}.$$

The quantity in the denominator is the spherical surface of the indentation; and the units are kilograms and millimetres. In practice it is necessary to use a smaller load for soft materials and sometimes to use a smaller ball. Then the hardness number obtained is not the same unless the load P_1 and the ball radius r_1 satisfy the condition

$$\frac{P}{r^2}=\frac{P_1}{r_1^2}.$$

This is Meyer's law confirmed by Mr. Batson, of the National Physical Laboratory. If the law is complied with the indentations are geometrically similar.

Prof. Ludwik uses a right-angled cone instead of a ball, so that the radius and depth of the indentation are equal and the indentations for different loads are similar. He also takes the hardness number to be the load divided by the conical area of the indentation.

Prof. Föppl placed two cylinders of the material to be tested at right angles and pressed them together in a testing machine. The pressure per unit of flattened surface is taken as the hardness number. Prof. Henderson, of Greenwich, has introduced a similar test, the material being in the form of square prisms.

For ordinary materials of construction, Brinell's test has proved most useful. It rather fails for very hard materials from the smallness of the indentation and the distortion of the ball, and efforts have been made to find another test or to revive the scratch test for such cases.

A new instrument which appears to be very sensitive has been introduced recently by Messrs. E. G. Herbert, Ltd., of Manchester (see NATURE, April 28, p. 583). This consists of an arched pendulum weighing 2 or 4 kilograms. At its centre is a ball 1 mm. diameter of ruby or steel. By adjusting screws the centre of gravity of the instrument can be made to coincide with the centre of the ball. A weight over the ball can be adjusted to lower the centre of gravity of the instrument to 0·1 mm. below the centre of the ball when the time of swing on a very hard surface is 10 sec. A level tube over the ball is graduated from zero at one end to 100 at the other. Two scales of hardness are proposed: (1) Inclined to zero and left, the reading of the level bubble at the end of the first swing is taken as the hardness number. The softer the material, when the indentation due to the weight of the instrument is deep, the shorter is the swing. (2) The time period of an oscillation is another measure of hardness. The time in making ten swings is taken as the hardness number. Thus the time of ten swings on glass is 100 sec., on hardened steel 50 to 85 sec., on soft steel 20 to 40 sec., on lead 3 sec. The pendulum is set in oscillation through a small arc by the touch of a feather. The sensitiveness of the instrument is very great, and it gives definite indications with the hardest materials.

Dr. Stanton has designed an ingenious instrument in which the deformation of a very hard ball used in the indentation test is substituted for the deformation of the material. This gives a much opener scale for hard materials. But the instrument is one for laboratory rather than workshop use. W. C. U.

Structural Colours in Feathers.[1]

By Prof. WILDER D. BANCROFT.

IN pigment colour we have absorption of light due to the molecular structure of the substance under observation. We speak of structural colours when the observed colour is due to, or is modified strongly by, the physical structure. Typical cases of structural colour are observed with prisms, diffraction gratings, thin films, and turbid media. In the case of feathers we find that the blacks, reds, oranges, yellows, and browns are pigment colours, but that the ordinary blues and greens are not blue and green by transmitted light, and that the so-called metallic or iridescent colours, such as those of the peacock, are structural colours.

Biologists have often talked of prismatic or diffraction colours, apparently because those were the only structural colours that they knew about; but they have never tried to show that any arrangement of prisms or gratings would give the actual colours observed. Since prisms and gratings give no colour in a uniform diffused light, it is only necessary to look at a feather on the north side of a house, preferably on a grey day, and all prismatic or grating colours will disappear. Nothing of the sort happens, except to an almost negligible extent, with some moths.

If we have a turbid medium with fine particles, the scattered light is predominantly blue—Tyndall blue—and the transmitted light is reddish. Familiar examples of this are skimmed milk and cigarette smoke. The blue of the sky is also a Tyndall blue, the scattering being due in large part, however, to the molecules of nitrogen and oxygen, as was shown by the late Lord Rayleigh. In feathers of the non-iridescent type, Haecker showed that we have myriads of tiny bubbles in the horn which scatter the light, and a black backing which cuts off all transmitted light. On filling the bubbles with a liquid having approximately the same index of refraction as the horn, the scattering ceases and the blue colour with it. On putting in carbon bisulphide, which has a much higher index of refraction than the horn, the blue reappears because we again have a turbid medium. The blue of the feathers can be reproduced wonderfully by heating a hard glass tube until it begins to devitrify. The myriads of small crystals which are formed scatter the light, and a beautiful blue is obtained if the inside of the tube is coated with a black varnish to eliminate transmitted light.

In almost all cases of non-iridescent green feathers, there is no green pigment and the effect is due to the superposing of a yellow pigment on a structural blue. This can be shown in a number of ways. If we take a green feather and boil it long enough in alcohol, the yellow pigment dissolves and the feather turns blue. If we expose the green feather long enough to an intense light, the yellow pigment bleaches and the feather becomes blue. If we scrape the surface of the feather with a sharp knife, we can peel off a layer of yellow horn and the feather again turns blue.

The metallic or iridescent colours, such as those of the peacock, were considered by Rayleigh to be the interference colours of thin films like those observed with oil films on the streets, while Michelson believed that they were so-called surface colours from solid pigments. Fuchsine gives a yellow-green surface colour quite different from the magenta colour by transmitted light. Our experiments have satisfied us that Rayleigh was right and Michelson wrong. There are no bright-coloured pigments in peacocks' feathers or in any feathers of that type. In the case of the peacocks there are triple films, but this is not so in the neck feathers of the pigeon.

Nobody has ever extracted any bright-coloured pigment from any iridescent feather, and we have confirmed this, using a large number of organic solvents. The change of colour with the angle of incidence is what it should be for thin films, while magenta shows practically no change of colour with changing angle of incidence if one does not use polarised light. If one swells the feather by exposing it to phenol vapour, the change of colour is what one would predict from a thickening of the film. If one destroys the dark pigment, the colour disappears almost completely, though it can still be seen at certain angles. It can be brought back by staining the feather with a dark pigment. In the white pigeon, the iridescence of the neck feathers is very difficult to see, but it can be brought out vividly by staining the feather. Unfortunately the physical structure of the tail feathers of the white peacock is quite different from that of the ordinary peacock, and consequently staining does not develop brilliant colours.

The average thickness of the films in the iridescent feathers is about 0·5 μ or 1/50,000 inch.

[1] Synopsis of a lecture delivered at University College, London, on June 1, at the University of Aberdeen on June 7, and before the Manchester Literary and Philosophical Society on July 19.

Obituary.

PROF. C. NIVEN, F.R.S.

PROF. CHARLES NIVEN was born in September 1845, and was one of four brothers who achieved the distinction of being wranglers. He entered the University of Aberdeen as a student in 1859, graduated there with first class honours in mathematics and natural philosophy. In 1863 he proceeded to Trinity College, Cambridge, and in 1867 was senior wrangler. In the same year he was elected a fellow of Trinity College and was appointed professor of mathematics at Cork.

It was during the tenure of the professorship at Cork that the greater part of Prof. Niven's contributions to mathematical and physical science was published. Between 1868 and 1880 he produced thirteen papers on various subjects. His first paper, on the application of Lagrange's equations to the solution of questions of impact, was published in the *Messenger of Mathematics* in 1868, and, although the method is implicitly involved in Lagrange's general dynamical scheme, its effectiveness in dealing with problems of impulsive motions had previously not been adequately appreciated. This paper was followed by three papers on the wave surface, a paper on rotatory polarisation in isotropic media published in the *Quarterly Journal of Mathematics*, papers on the mathematical theory of elasticity in the Transactions of the Royal Society of Edinburgh, the *Quarterly Journal of Mathematics*, and the *Philosophical Magazine*, and a paper on a method of finding the parallax of double stars, and on the displacement of the lines in the spectrum of a planet, published in the Monthly Notices of the Royal Astronomical Society. In 1879 he communicated a paper on the conduction of heat in ellipsoids of revolution to the Royal Society, and in 1880 a paper on the induction of electric currents in infinite plates and spherical shells; both papers were published in the Philosophical Transactions. These two papers are the most outstanding of Prof. Niven's writings; the analytical skill exhibited in them is very great, and the results obtained are of importance.

In 1880 Prof. Niven was appointed to the chair of natural philosophy in the University of Aberdeen. The demands made on his time by the duties of his professorship and the development of the department appear to have prevented him from pursuing his researches farther. In 1917, however, he sent to the Admiralty a paper on the theory of the location of sound in water, which was of service in connexion with the campaign against submarines, but the paper was never published. His tenure of the chair at Aberdeen extended from 1880 to 1922, and during that time the department of natural philosophy increased greatly; in 1880 it was housed at King's College with very inadequate laboratory accommodation, but later it was removed to Marischal College, where new and extended accommodation was provided. The provision of the new laboratories and other rooms for the natural philosophy department at Marischal College was very largely due to Prof. Niven's initiative and energy, and their successful completion added greatly to the efficiency of the department. When natural philosophy was taught at King's College, only a small number of the students obtained any training in experimental work; with the extended accommodation it became possible to give experimental training to a larger number of students and to a greater extent. Additional lecture courses for students proceeding to an honours degree were also instituted.

In March 1922, Prof. Niven developed a serious illness from which he never fully recovered. He retired from the professorship at the end of September 1922, and his many friends hoped that he might enjoy a period of well-earned leisure, but after a few months free from work he died on May 11.

MR. E. J. BANFIELD

THE *Melbourne Argus* announces the death, in May or June last, of Mr. E. J. Banfield, at the age of seventy-one. Mr. Banfield was born in Liverpool on September 4, 1852, and was the son of Mr. J. W. Banfield, of Ararat, Victoria. After having been occupied for some years as a journalist, he retired in 1897, with his wife, to Dunk Island, in lat. 17° 55′ S., between the Great Barrier Reef and the Queensland coast. Here he lived the life of a recluse, occupied in cultivating tropical produce, and in observing Nature, but he found time to describe his experiences in three books, "Confessions of a Beachcomber" (1908), "My Tropic Isle" (1911), and "Tropic Days" (1918).

The "Confessions of a Beachcomber" gives an attractive picture of Mr. Banfield's life on Dunk Island. It describes something of his success in adapting himself to his novel surroundings, alone with his wife except for a few natives, and it reveals him as a man of lovable nature, with a pleasant sense of humour, and as an acute observer of Nature. The book is full of the sunshine and luxuriance of the tropics. In vivid word-pictures it describes the birds which visit some gorgeous tree to feed on its honey or its fruit, the productiveness of the banana or the papaw, the habits of stick-insects or leaf-rolling ants, of dugongs, turtles, and sucking-fish, and many more of the charms of the tropics. Wherever Mr. Banfield records his observations he has something instructive to say; and in many cases his narrative is as entertaining as truthful. He tells us that his retirement was prompted by his wish to put into practical operation his regard for the welfare of bird and plant life. "Man destroys birds for sport, or in mere wantonness, and the increasing myriads of insect hosts lay such toll upon his crops and the fruit of the earth which by the exercise of high intelligence and noble perseverance he has improved and made plentiful, that the national loss is to be counted by hundreds of thousands."

Under Mr. Banfield's rule Dunk Island became a sanctuary for birds, many of which became bold and familiar. He did not hesitate to incur financial losses in order to remain true to his principles. A promising attempt at bee-keeping was relinquished because of the depredations of two species of bee-eating birds, which he would not interfere with in order to save his bees. His death, which took place on the island, was reported by a passing steamer, to which his wife had signalled for assistance. His writings are well worth the attention of zoologists, botanists, and ethnologists, who will find them to contain much that is illuminating and interesting.

S. F. H.

Current Topics and Events.

THE text of the twelfth Huxley Memorial Lecture, delivered recently by Sir Arthur Keith, is published supplementarily to this issue. Its title, "The Adaptational Machinery concerned in the Evolution of Man's Body," admirably defines the greatest of present biological problems, "infinite in extent and complexity," and still affording scope for "many centuries of labour." Such phrases measure the magnitude of Darwin's influence, exerted steadily for over sixty years. The Huxley lecturer, speaking from a vast knowledge of evolutionary biology, says that we know of no means by which the machinery of mechanical adaptation can be altered from without. With Huxley, he believes that the government which rules within the body of the embryo proceeds along its way altogether uninfluenced by occurrences or experiences which affect the body or brain of the parent. The machinery of adaptation has its "predetermined line" of action. We may carp at the word; but Huxley's meaning seems clear enough: he described a sequence in a natural order, not a consequence of a supernatural order. How far we have advanced along the thorny path which the great Darwinians mapped out for us may be judged fairly from the address itself. The question of use-inheritance is crucial; and while every failure to demonstrate its occurrence serves only to establish the Darwinian theory more firmly, there are those who still hope to find in the intricacies of the problem a door of escape from the position assumed by Darwin and Huxley and, we believe, the best and most philosophical workers in biology to-day. Man, even scientific man, does not seem altogether willing to assume his rightful place in the Universe; albeit the place which Darwinism assigns to him is fundamentally securer and philosophically grander than any other which individual or collective wit has designed. We are still far from plumbing the depth of wonder of the Universe of which we are a part, in which we "live, move, and have our being," and the "many centuries" of Sir Arthur Keith that separate us from that aim is a phrase that is good only because it does not bring imagination to a halt. This aspect of the Darwinian theory is still not widely apprehended; none of the natural sciences comes so near to intriguing the personal prejudices of its votaries as biology; but as potent to confuse present work and thought is that sterilising influence of great ideas which, while they liberalise for a time, do so spasmodically. Many workers, all unconsciously, turn from Darwinism because it does for them not too little but too much. Forty, thirty, and even twenty years ago, comparative anatomy and embryology pressed forward irresistibly with Darwinian enthusiasm. During the "many centuries" ahead the present reaction will probably have less significance than appears now; but, for the clarification of present work, Sir Arthur Keith's advocacy is timely.

IN a lecture entitled "Charles Darwin, 1809–1882" delivered to the teachers of the London County Council on March 21, and now published (London: Cambridge University Press, 2*s*. 6*d*. net), Prof. Karl Pearson has brought out with great clearness the importance of the successive revolutions in thought caused by modern discoveries in astronomy, geology, and anthropology, unified as the two latter are by the crowning achievement of Darwin. Prof. Pearson is no doubt justified in attributing the comparatively slow progress of scientific investigation before Darwin to the fact that even among scientific men the date of 4004 B.C. was commonly accepted for the creation of the universe. Many excuses may be offered for this obsession, but it is fair to remember that the date represents only the computation by an Irish Archbishop of the figures given in the existing text of Genesis, and can scarcely be spoken of as having been "fixed by the Church." Perhaps Prof. Pearson is a little too much apt to revive the memory of "old forgotten far-off things, and battles long ago." However, there can be no doubt of the magnitude of the revolution effected by Darwin, a revolution which has made itself felt in every department of human thought. In view of recent occurrences in America, it can scarcely be considered unnecessary to insist once more on the indisputable fact that the doctrine of evolution, thanks to Darwin, is now as thoroughly established as any of the great generalisations of science. Prof. Pearson does well also to emphasise the admirable personal qualities of Darwin.

ABOUT twenty years ago (see NATURE, October 20, 1904, p. 602, and December 15, 1904, p. 156) the performances in Berlin of an intelligent horse—"Clever Hans"—were tested by a committee of psychological experts. The conclusion arrived at was that the performances of the animal, like those of the horse "Mahomet," exhibited in London several years previously, and of performing animals generally, depended chiefly upon observations of movements of the trainer. An experiment carried out by the Marconi Company in connexion with the Zoological Society, at Regent's Park on August 9, supports this conclusion as to the perceptual character of animal thought. The trainer of an Indian elephant at the Society's Gardens spoke to the animal from the British Broadcasting Company's studio, and his voice was distinctly heard in a loud-speaker arranged against the elephant-house. Four orders were given by the trainer, and, though they are always obeyed immediately when he is near, the elephant took no notice of them clearly uttered by the trumpet attached to the wireless receiver. It is possible, of course, that though the words could be heard easily by the people present at the experiment and listening for them, the absence of the trainer deprived the elephant of the associative relation between sound and action. This might be tested by connecting an electrophone with a gramophone record of the trainer's orders, the trainer himself being present but not actually speaking. We should then learn whether an elephant can recognise "His Master's Voice," like the Scotch terrier of the well-known advertisement of gramophones.

For the protection of inventions, justification of the patent system is based upon the demands of natural justice and upon economic grounds of pure expediency, a justification which has been recognised in all countries. Similarly for the protection of scientific ideas which are not inventions, justice demands a measure of protection even if expediency speaks with a voice less certain. From time to time, therefore, the cry is raised for protection to be accorded to such important discoveries as do not come within the category of inventions for which patents are obtainable; and now the matter is raised again, this time by the League of Nations. Thus the *Times* for July 30 informs us that the Intellectual Co-operation Commission of the League has decided to submit to the Council and to the Assembly a draft convention for the protection of scientific discoveries. In submitting the draft, the Commission is asking the Governments to establish for scientific discoveries "a copyright similar to that granted for literary and artistic work." What exactly is contemplated by the proposal is far from clear, neither the general idea nor the details having come to hand. If, however, the proposal deals only with the literary expression of a discovery, as might be inferred from the Press notice, it is difficult to see in what way the author of the scientific discovery would in any manner receive benefit. A discovery once published may be expressed in many different ways, such that no one of them need infringe copyright in the others. If the proposal is nothing more, the addition then to the legal systems of nations that it will make will be virtually nil. If, however, it submits a scheme whereby the discoverer of a natural principle or law of world-wide utility may receive a reward commensurate with the importance of the discovery, it is to be welcomed on all hands. Even if the proposal should be found to concern itself only with the literary expression of a discovery, it may yet serve a useful purpose, since it may result in directing public attention once again to the callous neglect of the interests of those to whom the world in the past has been so vastly indebted.

A week of great interest has just ended at Oxford—one of real importance and significance. The seventh International Congress of Psychology has just concluded its meeting there, the last one having been held in Geneva in 1909. For the first time since the War, psychologists from all parts of the world assembled to discuss current problems of psychology. It is mainly due to its president, Dr. C. S. Myers, director of the National Institute of Industrial Psychology, that this result was achieved, and that the entire week passed off so amicably and instructively. The congress was limited to about two hundred members, and included representatives from Great Britain and Ireland, America, Austria, Belgium, Czechoslovakia, France, Germany, Holland, Hungary, Japan, Norway, Poland, Roumania, Spain, Sweden, and Switzerland. They were housed in New College and in Balliol and Manchester Colleges. There were numerous papers and discussions upon scientific and practical aspects of psychology, but no useful purpose would be served merely by recounting their titles. The proceedings opened on Thursday, July 26, with a meeting at which the president made a happy inaugural speech, and a letter was read from Lord Curzon, Chancellor of the University, welcoming the congress to Oxford. A reception was held the same evening in the gardens of New College. On the following afternoon Dr. and Mrs. William Brown entertained the members of the congress at a garden party in the gardens of Worcester College. On Sunday, July 29, the congress listened to a sermon given by Rev. Canon Barnes in the Cathedral, in which he alluded to the way in which science and religion could aid each other. In the afternoon a delightful excursion was made by river to Nuneham, where, thanks to the kindness of Lady Harcourt, the members of the congress were conducted by her and her daughters over the house and grounds. The congress ended in the evening of August 2 with a dinner at Christ Church. Psychologists may feel justly proud at having achieved so much, not only in advancing their own science, but also in promoting peace and goodwill amongst nations generally. About seventy members of the congress paid a visit to Cambridge on Thursday, visiting the Colleges and the Psychological Laboratory, which owes its existence to Dr. C. S. Myers, President of the Congress.

Mr. H. Spencer Jones, Chief Assistant at the Royal Observatory, Greenwich, has been appointed His Majesty's Astronomer at the Cape, in succession to the late Mr. S. S. Hough.

Applications are invited from persons possessing an honours degree in electrical engineering or physics, and having experience of electrical research, preferably in the technique of alternating current measurements at high frequencies, for the post of a technical assistant at the Royal Aircraft Establishment, Farnborough. The applications should be addressed to the Superintendent.

The following awards for the year 1923–24 have been made by the Salters' Institute of Industrial Chemistry, and approved by the Court of the Company. Fellowships are awarded to Mr. T. B. Philip, Imperial College of Science and Technology; Mr. W. G. Sedgwick, Armstrong College, Newcastle-on-Tyne; and Mr. D. T. A. Townend, Imperial College of Science and Technology. Fellowships are renewed to Mr. C. G. Harris, Jesus College, Oxford; and to Mr. J. H. Oliver, Imperial College of Science and Technology. Mr. W. Randerson, a fellow for 1922–1923, having been elected to an Albert Kahn travelling fellowship for the year 1923–24, is made an honorary fellow for the year.

The Civil Service Commissioners announce that an open competitive examination for not fewer than 12 situations as probationary assistant engineer in the Engineer-in-Chief's Department of the General Post Office will be held in London, commencing on November 6 next. Limits of age: 20 and 25, with certain extensions. Regulations and form of application will be sent in response to requests by letter addressed to the Secretary, Civil Service Commission, Burlington Gardens, London, W.1.

THE British Photographic Research Association, which was the first Research Association to be formed under the Department of Scientific and Industrial Research, completed its term of five years in May last. A thorough and searching investigation of the work accomplished has been made by the Department, which has also taken into consideration the researches which are either in progress or are contemplated, with the result that a further grant in aid for a period of years has been promised. Although the financial position of the photographic industry, which is comparatively a small one, is at present at a very low ebb, it is very satisfactory to note that the leaders of the industry are so convinced of the valuable work done by the Research Association, and of the good results which are likely to accrue, that it has been decided to carry on its operations. The Association has had to contend with considerable difficulties during its first five years, but, under the directorship of Dr. Slater Price, it has now a well-established reputation not only in this country, but also in Europe and America. A number of papers dealing with fundamental principles have been authorised for publication in the various scientific journals.

THE Maidstone Museum has set a good example to other provincial institutions of this class by issuing a set of post-cards, published at 1½*d.* each, illustrating its prehistoric collections. These include a clay bowl attributed to the Bronze Age; palæoliths of the Chellean period; a group of eoliths; some neolithic flint implements—all found in the vicinity. The series also includes a set of good examples of Roman glass.

Our Astronomical Column.

D'ARREST'S COMET.—MM. Dubiago and Lexin continue the search ephemeris of this comet (for Greenwich Noon): they use practically the same elements as those deduced by Mr. F. R. Cripps. There is still a prospect of finding the comet, as the greatest surface brightness is not attained until September 12; but the object is in considerable south declination in September and October.

	R.A. h. m.	S. Decl.		R.A. h. m.	S. Decl.
Aug. 24.	17 6·6	9° 8′	Sept. 8.	17 43·1	16° 58′
29.	17 17·5	11 49	13.	17 57·9	19 22
Sept. 3.	17 29·7	14 26	18.	18 13·8	21 34

THE SHOWER OF AUGUST METEORS.—Mr. W. F. Denning writes:—"The fine warm weather and absence of strong moonlight enabled these meteors to be well observed during the period from August 3-11.

"The display, however, up to the time of writing (August 12) has not been an abundant one, though a fair number of Perseids appeared each night, and the radiant showed its usual displacement to the east-north-east.

"Mr. J. P. M. Prentice, at Stowmarket, recorded the flights of 250 meteors up to August 9, and had recognised a number of the usual minor showers, including α Capricornids, δ and γ Aquarids, δ Cassiopeids, γ and θ Cygnids, Sagittids, ϵ Taurids, $\alpha-\beta$ Perseids, β Piscids, and Lacertids. Mr. Prentice saw a splendid Perseid fireball on August 9, 12h. 32m. G.M.T., with an estimated magnitude greater than that of the full moon. The streak lasted 23 seconds, and its colour was bright blue surrounded by bright red.

"Mr. A. King watched the shower from Lincolnshire on and after August 3, and saw a fair number of Perseids. At Bristol some observations were made on August 4-11, during which period the Perseids were only moderately active. The brightest meteor seen at Bristol was a Cygnid on August 11, 9.40 G.M.T. It was brighter than Jupiter, and traversed a short path from 289° + 66° to 289° + 72°; it left a white streak for a second, across δ Draconis."

PROF. R. SCHORR'S "EIGENBEWEGUNGS-LEXICON."—Prof. Schorr, director of Bergedorf Observatory, Hamburg, has just brought out a very useful work of reference in the form of a comprehensive catalogue of practically all the known proper-motions of stars. It is arranged in zones of declination, 1° wide, the designation of the stars being taken from the Durchmusterungs of Bonn, Cordoba, and the Cape. It is numbered by columns (two to a page) and there are 400 columns, each containing some fifty stars. Only one determination is given of each motion, presumably the best available; the authorities are given in each case. The centennial motion is given to two decimals of a second of time in right ascension, and one decimal of a second of arc in declination; a few stars are given to one figure less than this.

To diminish cost the work was typewritten, and then multiplied by a mechanical process, the result being perfectly clear and legible. The price is fixed at thirty Swiss francs.

Already a first supplement has appeared, containing 1739 stars; some of these, marked "!," are improved values for stars already in the Lexicon, but the majority are additional stars.

This is the second very useful work that Prof. Schorr has issued in a few months, his new reduction of Rümker's Hamburg Catalogue having lately appeared (NATURE, April 28, p. 564).

THE FREE PENDULUM.—Mr. F. Hope-Jones delivered a lecture on this subject to the British Horological Institute on April 19, and it has lately been issued as a pamphlet. He lays stress on giving the pendulum that we rely on as primary time-keeper as little work to do as possible; his three desiderata are: (1) the maintaining impulse must be given at the zero (lowest) position; (2) it must only be given occasionally; and (3) there must be no other interference with the pendulum.

Mr. Hope-Jones states that this problem has been solved, quite independently, by five men in the last twenty-five years: Mr. Rudd in 1898, Sir David Gill in 1904, Mr. Bartrum in 1913, Father O'Leary, S.J., during the War, and Mr. W. H. Shortt, who has been at work since 1911 on the matter, his clock being installed at Edinburgh Observatory early in 1922. The details of each of the five methods are briefly given, but the last is considered much the best. The fundamental pendulum, constructed of invar, is in an air-tight case, pressure 3·5 cm., kept at constant temperature. It receives its impulse every half-minute, at the lowest position; the remontoire is worked by the slave-clock, which is synchronised by a "hit or miss" action to within 0·01 second. Two diagrams of the changes of weekly rate in periods of three months are given; the range of weekly rate is 0·02 second per week. Prof. Sampson notes that the clock is superior to the Riefler instrument, though that is a very fine clock.

A clock with uniform rate is of great importance in fundamental astronomy for the removal of the small systematic errors in right ascension; they have been greatly reduced, but not wholly removed.

Research Items.

THE SWISS NATIONAL PARK AND ITS MOLLUSCA.—First mooted in 1906, a National Park for Switzerland was finally established in January 1919. It is situate in the Lower Engadine, almost on the extreme eastern border of Switzerland, and abutting on the Italian frontier. It comprises an area of about 151·5 sq. km., and has been put in the charge of a Commission, which has wisely decided on a complete investigation of its fauna, flora, etc., a task which the Schweizerische Naturforschende Gesellschaft has undertaken to carry out. For the purposes of this survey, however, it has been resolved to include the territory to the north of the Park down to the banks of the Inn, as well as some to the east, so as to furnish a more satisfactory physical area to deal with as a whole. The first portion of this undertaking, the "Molluscan Fauna," by Ernst Bütikofer, has just been published by the Schweizerische Naturforschende Gesellschaft in Bd. lv. of their Denkschriften. If this be a fair sample the complete work will be well worthy of its authors. Following a general account of the characters of the eleven districts into which, for purposes of description, the district has been divided, come the molluscan fauna of each, a systematic description of the various species and varieties, with tables of their horizontal and vertical distribution, and an excellent bibliography. Close on eighty forms, if we include those in the appendix, are dealt with, and the photographs of shells are mostly particularly good.

PROTOZOA AND POTATO MOSAIC.—As recently reported in NATURE (July 21, p. 111), Ray Nelson has reported in America that a protozoal organism is associated with the phloem of potato plants affected by the disease known as mosaic, which is usually grouped among the "virus" diseases in which the causal organism is assumed to be ultra-microscopic. The July issue of *Phytopathology*, the journal issued by the American Phytopathological Society, contains no less than four brief papers, with which the names of seven investigators are associated, all pointing out that the structures described by Nelson are also present in the phloem of Solanaceous plants which are not affected by mosaic but, so far as can be determined, are perfectly healthy. There seems to be little doubt that Nelson has redescribed and photographed peculiar protoplasmic inclusions, present in the phloem of some Angiosperms but not in all, and which, as Irving W. Bailey and other writers point out in *Phytopathology*, are probably identical with the "slime bodies" described by Strasburger (in 1891) in the phloem of *Robinia Pseudacacia*. These "slime bodies" do not seem to be identical with nuclei, though they often are seen in contact with them. Ernst W. Schmidt, in his recent monograph upon the Angiosperm sieve-tubes (Jena, 1917), concluded that the nucleus was typically present in the Angiosperm sieve-tube. Possibly this recent American rediscovery of these other cytoplasmic inclusions will lead to a re-exploration of the cytology of the sieve-tube, a subject which would seem to be by no means exhausted.

POPLARS.—Forestry Commission Bulletin No. 5, just issued by H.M. Stationery Office, price 1s. 6d., is a remarkably full account of the different poplars which are suitable for the production of timber on a commercial scale in Great Britain. The first chapter, due to Prof. A. Henry, is concerned with their botanical description, and is illustrated with two plates, showing clearly the distinctive characters of the twigs and leaves of the twelve important species and hybrids. The second chapter, by Mr. W. H. Guillebaud, who specially investigated the growth of poplars in the north of France, is devoted to silviculture, and discusses fully propagation, planting, thinning, pruning, rate of growth and yield. In the third chapter, Dr. J. W. Munro deals with injurious insects and Mr. W. E. Hiley with fungi and bacterial diseases. The last chapter, by Mr. W. H. Dallimore of Kew, is an admirable account of the character and uses of poplar wood, and should prove of great interest to both landowners and manufacturers, as the use of home-grown poplar timber is capable of great extension. For example, the wood of aspen is indispensable for the match industry, and has hitherto been mainly imported from Northern Russia. The recent plantation on a large scale of this tree in Argyllshire by Messrs. Bryant and May indicates that supplies of aspen timber from abroad at a reasonable price cannot in the future be depended upon.

UPPER-AIR OBSERVATIONS IN NORTH RUSSIA.—A Professional Note, vol. 3, No. 32, carried out by Mr. W. H. Pick, has been published on the above by the Meteorological Office, Air Ministry. The observations are based upon pilot balloon ascents between February 25 and September 13, 1919, at three stations in north-west Russia. The stations are Murmansk, at the head of the Kola Creek, in latitude about 69° N., Archangel on the south-western coast of the White Sea, in latitude 64° 33′ N., and Lumbushi on the Murman Railway, in latitude about 68° N. The ascents were all carried out with one theodolite only, the balloon being given a vertical lift of, theoretically, 500 ft. per minute. The high latitude in which the observations were obtained renders them of value. There were at Murmansk 57 occasions on which the surface wind was in the north-east quadrant, and on 10 of these—that is, 17·5 per cent. of the total—the wind backed continuously up to 2000 feet. On the other hand, there were 164 occasions on which the surface wind was not in the north-east quadrant, and in only 5 of these—that is, 3·0 per cent. of the whole—did the wind back continuously upward. At Murmansk three ascents reached to a height of 40,000 feet, where two of the winds were N.W. and one S.W. Two ascents reached to 60,000 ft., where both winds were S.W. Seven ascents reached 20,000 ft., at that height four of the winds were S.W. and two N.W. Of the ascents carried out at Archangel only one reached 20,000 ft., where the wind was southerly. Of the ascents at Lumbushi, six attained a height of 20,000 ft., giving two north-westerly winds, three north-easterly, and one southerly.

THE CLIMATE OF KHARTOUM.—Physical Department paper No. 9, prepared by Mr. L. J. Sutton, has recently been issued by the Ministry of Public Works, Egypt. The discussion deals with the meteorology of Khartoum, which place was installed as a second-order station in 1900, and is approximately 390 metres above sea-level. Maps of isobars are given for the several months which show the normal distribution of pressure over the surrounding region, which is of great help in following the changes of weather conditions which occur at Khartoum in the different seasons. It is during the period from the middle of June to September that the weather conditions are most disturbed. Thunder-storms and *haboobs*, or storms of wind, are frequent, and the short rainy season is experienced. In October to May there is an entire absence of rain. The observations are discussed for the period of twenty-two years, from 1900 to 1921. Atmospheric pressure varies very regularly throughout the year; a minimum is reached about the beginning of May, and a second minimum occurs about the beginning of October. The diurnal range of the barometer is very regular and does not vary much in the course of the year. The coldest month is January, with a mean temperature of 22°·5 C.; the warmest month is June, with a mean temperature of 34°·1 C. The short rainy season causes a second minimum, 31°·2 C. in August. The second maximum temperature occurs about the end of September, approximately, the same time as the second minimum of pressure. Diurnal range of temperature is greatest, 14°·5 C., in April, and least, 10°·1 C., in September. Statistical values are also given of humidity, vapour pressure, cloud, sunshine, wind, and the upper winds. The amount of rainfall is small, averaging only 148 mm., or rather less than 6 in. for the year; nearly 90 per cent. of this falls in July, August, and September. The discussion will serve as a specimen for other stations.

GOLDFIELDS OF WESTERN AUSTRALIA.—The Department of Mines of Western Australia has issued an important description of the gold deposits of Western Australia, written by Mr. A. Gibb Maitland. The author classifies the gold-bearing deposits under the following five heads: 1. Simple or fissure veins, carrying auriferous quartz with or without accessory minerals. 2. Composite veins or lodes, which are made up of a number of more or less parallel lenticular veins. 3. Sheeted zones, consisting of a series of closely spaced and parallel veins, generally of small dimensions. 4. Stockworks, which are irregular networks of small auriferous quartz veins. 5. Shear zones or bands of schistose rocks, impregnated with various sulphides, iron pyrites often predominating, and containing little or no quartz. In addition to the above classification, the author, when discussing the individual goldfields, also mentions the so-called "lode formations," which he defines as "impregnations of zones of previously existing rocks and confined largely to shear zones, characterised by much crushing and fracturing as well as the deposition of quartz along such fractures." It would appear that such lode formations are especially important in the Boulder and Kalgoorlie districts of the East Coolgardie gold-field, which is itself by far the most important of the Western Australian gold-fields, having produced over 17 million ounces of gold out of a total of 31 million ounces produced by Western Australia, whilst no other individual goldfield has produced above 3 million ounces. The gold production of Western Australia reached a maximum in the year 1903, when the output was just above 2 million ounces; since that time it has been gradually declining, until in 1918 it was only 876,511 ounces, but the account here published shows that there is good reason to hope that the present output may be reasonably expected to be maintained for a considerable time to come.

THE EARTH'S MAGNETIC FIELD.—In the issue of *Terrestrial Magnetism and Atmospheric Electricity* for March-June, Dr. L. A. Bauer gives the chief results of a preliminary analysis of the earth's magnetic field for 1922 based on the British Admiralty magnetic charts for 1922 and those of the United States Hydrographic Office for 1920 corrected to 1922. He finds that the field at any instant is compounded of an internal field having a potential and representing about 94 per cent. of the total, an external field also having a potential and a non-potential field of about equal strengths. The time change of the field is equally complex. On the whole, during the past 80 years the north end of the axis of the internal field has moved slowly towards the west and south, and the intensity of magnetisation has decreased at the rate of 1/1500 of itself per annum. The intensity over land areas is greater than over ocean areas in the same latitude, and the decrease during the past 37 years greater over ocean parallels than over land parallels of latitude.

PRODUCTION OF SMOKELESS FUEL.—A pamphlet entitled "The Story of the Scott-Moncrieff Retort for producing Smokeless Fuel," printed by Moultons (Printers) Ltd., Brighton, contains material of some historical interest in connection with the efforts which have been and are being made to solve the problem of the low-temperature carbonisation of bituminous coal for the production of smokeless fuel. It deals with the recent and pioneering efforts (dating back to 1870) of Mr. W. D. Scott-Moncrieff. Since 1921 he has been engaged in experiments made at the Newhaven Gas Works in order to perfect a retort for which "final success" is claimed. In an enclosed analytical report are given tables of results of carbonisation trials which seem typical of those to be expected from the carbonisation of Durham and Yorkshire coals at temperatures about 600° C. The fuel produced is stated to be "smokeless and suitable for transit," and the "results exceed all expectations." Insufficient evidence is adduced to enable the reader to judge the validity of these claims. One can only await with interest the appearance of further details, with the hope that, if a solution has been found of a problem which has proved so baffling, both on the technical and the economic sides, credit will fall to one of the pioneering workers.

OXIDATION OF CARBON.—The well-known method of oxidation of organic substances by a mixture of chromic and sulphuric acids has been recently re-examined by J. L. Simon, and the results, some of which were unexpected, have been communicated in a series of notes to the *Comptes rendus* of the Paris Academy of Sciences. With the usual mixture of potassium bichromate and sulphuric acid some compounds are completely, others only partially, oxidised. The substitution of silver bichromate for potassium bichromate in the mixture was found to give complete combustion in some cases where the classical mixture gave only partial oxidation. Interesting and unexpected results were obtained on applying these two mixtures to the oxidation of the various forms of carbon. Pure graphite, using the silver oxidising mixture, was completely oxidised to carbon dioxide (with a trace of carbon monoxide) in half an hour at 100° C.: in the absence of silver the combustion was partial, from 66 per cent. to 72 per cent. being burnt. In a later communication (July 23) it is shown that the deficit in the absence of silver is related to the constitution of the compound, and the aromatic compounds can be clearly distinguished from others by the different figures given by the two reagents. As regards the different forms of carbon: in the presence of silver, graphite is completely burnt, diamond is not oxidised at all, while for various forms of charcoal, coke, and coal, only from 1 per cent. to 6 per cent. is burnt. The fact that it is possible to oxidise graphite by thirds is in agreement with the view of a hexagonal distribution of the carbon atoms, and there is a marked experimental difference between graphite and certain varieties of black carbon which it is natural to attribute to a difference in constitution.

Fossil Human Bones, possibly of Pleistocene Age, found in Egypt.

AT a meeting of the Royal Anthropological Institute, held on July 17, Prof. C. G. Seligman, president, in the chair, Dr. D. E. Derry described the fossilised human bones recently discovered in Egypt, which, on the ground of their condition, he is inclined to regard as of Pleistocene age. The discovery is one of very considerable importance, as this is the first occasion on which fossilised human bones have been obtained from Egypt. Early in January of the present year Mr. Guy Brunton, while excavating for the British School of Archæology in Upper Egypt, found at Gau-el-Kebir, on the east bank of the Nile, about thirty miles south of Assiut, a remarkable collection of bones, mostly animal, but with pieces of human bones mixed with them in the heap. Some of the bones, including the human fragments, were heavily mineralised, while others were only partially so, and some not at all. The whole collection was contained in an Early Dynastic grave, and had obviously been placed there for some purpose. Among the bones were carved bone and ivory objects of the XIXth Dynasty. The presence of the latter is explained on the assumption that this was the site of a workshop for the manufacture of articles in bone and ivory, and that the great heap dumped into the pit of an early grave represented the workman's material. The presence of fresh-water oyster shells attached to some of the bones proves that they came from the river, or, what is more likely, from a swamp fed by the river, which in all probability was much nearer the site of the discovery than it is now. The bones exhibit evidence of having been exposed for a long time to the mineralising influence, as they are very heavy, black, and highly polished, probably from the friction of water-borne sand.

The first evidence of human fossil bones in the heap was found by Mr. Brunton. This consisted of the right half of a frontal bone. Afterwards the whole heap, probably about two tons of bones, was gone through and several other fragments both of skulls and limb bones were recovered. Pieces of three skulls were found, as well as part of a mandible. Fragments of hip bones, upper and lower limb bones, and an axis vertebra were also obtained. Two skulls are represented only by the frontal bone of each. These are remarkable for their small size and shallowness, with consequent small brain capacity. The third skull consists of the whole right parietal bone with a large part of the left parietal, welded into one piece. As it stands this appears to have been a well-shaped head with a maximum cranial breadth of 143 mm. This fragment is, however, much more heavily mineralised than the two frontal bones, which would appear to have belonged to a more primitive race. Some very unusual anatomical features are exhibited by the mandibular fragment and also by the piece of a right ilium.

The position in which the bones were found precludes the possibility of assigning them to any geological period; but an examination of the animal remains by Prof. Watson has revealed the presence of at least two extinct animals, a crocodile and a buffalo, both of Pleistocene date, while the mineralisation of the human fragments is as extensive as that of any of the animal remains.

In the discussion which followed the reading of the paper, Sir W. M. Flinders Petrie pointed out that in regard to the dating of the bones it must be remembered that owing to the constant and consistent deposit of mud by the Nile, amounting to about $3\frac{1}{2}$ ft. in a thousand years, the bed of the river was rising continually. Any object deposited while the Nile was thus rising would be lost irretrievably beneath the mud. These bones must therefore have been deposited while the Nile was falling from six hundred feet above to one hundred feet below its present level. The date of deposition must therefore be at least 15,000 years ago, plus the time occupied by the fall of the river to the level of the swamp which had been postulated as the place of deposit.

Sir Arthur Keith said the discovery was extraordinarily interesting and puzzling. These fossilised bones, the first to be found in Egypt, presented no outstanding features marking them off from modern man, and no diagnosis of race was possible, but this did not preclude their high antiquity, and they might well be Pleistocene. Fragments of hippopotamus bone from the Nile mud, now at South Kensington, exhibited staining and a high polish exactly similar to that of some of Dr. Derry's specimens. Sir Arthur laid stress on the importance of the fringes of the great desert belt as the possible site of the evolution of our race; Dr. Derry's discovery, though we could not place it exactly, was of the first importance. Probably men of our type existed in Egypt more than 18,000 years ago, and populated Europe, possibly more than once. Prof. Seligman said the cubic capacity of 1040 c.c. of the small skull suggested a comparison with the smaller skulls from the Thebaid described by Dr. Randall-MacIver, and, in conjunction with the steatopygous predynastic figures discovered by Sir W. M. Flinders Petrie, pointed to the necessity of a further comparison with Bushmen skulls.

Recent Fisheries Investigations.

SOME very interesting reports, in continuation of Series II. (Sea Fishery Investigations), have recently been published by the Ministry of Agriculture and Fisheries. No 6 of vol. 4 is written by Mr. J. O. Borley, and describes the samples of bottom deposits collected in the southern North Sea by the vessels of the Marine Biological Association. The report is illustrated by charts and many very beautiful photographs. The deposits are graded in various ways, partly by mechanical sieving and partly by a method of levigation, and the results show a correspondence between the average sizes of the particles and the transporting power of the current systems. In general the particles are coarsest where the tidal streams are most rapid, and *vice versa*. It is not improbable that there is attrition of particles on the sea bottom, but this cannot be very great. At 20 fathoms (that is, not far from the average depth of the North Sea) the currents are competent to grade bottom materials: at this depth wave action on the surface has a notable effect at the bottom.

No. 1 of vol. 5 is a summary of very extensive market statistics, collected in regard to the cod, during the years 1913–14. No. 2 of vol. 5 is highly important. It is written by Mr. H. J. Buchanan-Wollaston, and deals with the spawning of the plaice in the southern North Sea (the Flemish Bight) during the years 1913–14. The method is an extension of the Hensen quantitative plankton one, but novel and beautifully manageable mathematical methods of dealing with the results have been developed: some of these are highly ingenious, and have, perhaps, application to problems other than those for which they have been devised. The results are interesting almost to the degree of being "sensational." In January of 1913–14 the rate of production of plaice eggs over the whole area sampled was 180,000 millions per 3 days, and in February the rate dropped to 157,000 millions per 3 days. That works out at about two million million eggs per month and about five million million per year. To produce these eggs some twenty millions of female plaice at least must have been required. The rate of mortality is very high, and only about 10 to 30 per cent. of the eggs hatch out. The production was far higher in 1914 than in 1911.

No. 3 of vol. 5, written by Mr. J. O. Borley and his collaborators, deals with the plaice fisheries during the war years, and discusses the results of the special investigations made in various parts of the British sea-fishery area. The report and recommendations of the plaice committee of the International Fishery Council are appended.

No. 4 of vol. 5 breaks entirely new ground so far as the British sea fisheries are concerned. It is an account of the various kinds of gear now used in sea fishing in England and Wales, and has been written by Mr. F. M. Davis. The descriptions are clear; the drawings are very well done, and the Report represents a vast amount of very careful local investigation.

J. J.

The Floor of the Valley of Ten Thousand Smokes.

THE amazing display of fumarole action over an area of some fifty square miles, which arose in association with the volcanic outbreak of Mt. Katmai in Alaska in 1912, was described and illustrated by its discoverer, R. F. Griggs, in NATURE, vol. 101, p. 497 (1918). In 1920 (vol. 104, p. 595), J. W. Shipley, of Winnipeg, chemist to the first Katmai expedition, gave an illustrated account of the "great mud-flow" through which the vapours fume, and he attributed the material to an eruption of Mt. Novarupta, preceding that of Katmai. He concluded that the spreading of the volcanic dust and scoriæ down the valley towards the Bering Sea was assisted by rains, and that heat from below had hardened the surface and produced the cracks that traverse it.

The National Geographic Society, which organised the expedition led by Dr. Griggs, has now begun the publication of a series of scientific memoirs on special features of the district, following on the general description that was noticed in NATURE, vol. 111, p. 269 (1923). No. 1 of the "Katmai Series" of contributed papers is on "The Origin and Mode of Emplacement of the great Tuff Deposit of the Valley of Ten Thousand Smokes," by the well-known petrologist Clarence N. Fenner, of the Geophysical Laboratory of the Carnegie Institution of Washington.

The author finds, from a thorough study of the valley-floor, that the tuff was erupted from a large number of vents that opened along fissures mainly occurring in the lowland, and that these fissures determine the present lines of fumaroles. The fragmental material flowed while hot enough to char all vegetation in its path; no doubt it was still liberating gases, and the phenomena of Mount Pelée of Martinique were repeated. Katmai exploded somewhat later, since its ashes rest upon the volcanic detritus connected with the fumaroles.

Most of this detritus consists of highly siliceous glass, which has caught up basic matter from older igneous rocks; the mixed blocks possibly come from the moraines around Novarupta, the cone of which is formed of a soda-rhyolite that has penetrated and mingled with a dark medium andesite (p. 56 of memoir). But the author regards it as more likely that similar rock underlies the valley generally. Jurassic sandstones and shales have been blown to fragments by the explosions in the valley-floor; but the source of the andesitic admixture has not been traced here or at Novarupta.

Dr. Fenner's conclusion is that a sill of igneous rock penetrated the sedimentary series beneath the valley, burst into explosive activity along the cracks that opened, and deluged the country with fragmental matter that continued to give off gases and to spread as a quasi-liquid towards the coast. The numerous beautiful photographs accompanying his contribution, including several of Novarupta, complete its value as a petrological study carried out mainly in the field. We may now regard the Valley of Ten Thousand Smokes as one of the finest examples of the uprise and emanation of magmatic waters, and as a further reminder that igneous rocks as they reach us in hard specimens are something very different, both chemically and physically, from their representatives in the cauldrons of the crust.

GRENVILLE A. J. COLE.

Cultivation of Metal Crystals by Separation from the Gaseous State.

F. KOREF describes experiments on the deposition of crystalline tungsten on a wire consisting of a single tungsten crystal, which is heated electrically in a mixture of hydrogen and tungsten hexachloride vapour in an electric oven.[1] When the oven is fairly cool (about 110° C.) and the pressure is kept down to 12 mm. of mercury, the wire being raised to 1000° C., the metal deposits in crystalline form, growing from the unit crystal, so that the dividing line between the two is scarcely visible in a magnified section, which, when etched, shows the characteristic structure of a tungsten crystal. The external form shows more or less distinct crystalline surfaces and edges, though the surfaces are not perfectly plane, being sometimes concave cylindrical, while the edges are not always sharp. It is concluded, however, that the whole mass forms one crystal, which has grown from the original crystal wire. The number of bounding surfaces seems to depend on the direction of the crystal axis in the original wire, the prism being four-, six-, or eight-sided. The diameter can be increased from 0·05 to 0·15 mm., the temperature being kept constant during the deposition by regulating the heating current.

Although the original wire is flexible the crystal grown from it is brittle; but it becomes flexible after being heated for a few minutes to 2500° C.; no difference in the structure can be observed after this annealing, either microscopically or by X-ray examination. Burger has made a similar observation on tin crystals, obtained from molten tin. Apparently the atoms do not alter their positions during the heat treatment; but in some way, possibly by rotations about their centres, come into new relative relations to one another, and link together more perfectly to form a stronger and more flexible whole.

If the attempt is made to cultivate the crystal beyond the dimensions given above, the surfaces become deformed by the growth on them of numerous small pyramids, the molecules (atoms) no longer

[1] *Zeit. Electrochem.*, 28, pp. 511-517, December 1, 1922.

taking their places in regular fashion on the surfaces of the original crystal; but aggregating themselves about certain minute elementary crystals formed on the surface, which act as "buds" about which further growth takes place. When the pressure and temperature of the oven are high, this takes place from the commencement, and there is no regular crystal growth; but a deposit is formed in scaly layers round the original wire, which is either spongy or dendritic in character.

At the correct temperature and pressure the wire will continue to grow as a single crystal in spite of preliminary deformations, such as twisting, winding into a helix, or even drawing through a die. An attempt was made to draw down the annealed cultivated crystal into a fine wire, in the hope that further cultivation would be possible upon it; but this failed owing to the fact that the whole pressure coming on the edges overloaded the structure. The resulting wire no longer formed a single crystal; and when additional tungsten vapour was deposited on it, each of the small crystals of which it was composed grew independently; the resulting wire was brittle, and could not be made flexible by heating. A similar result was obtained with an ordinary tungsten wire, which did not consist of a single crystal; in this case it was found that heating to 2500° C. for fifteen minutes caused a great many of the small crystals formed at first to unite, so as to give a much coarser structure. This welding of small into larger crystals, without mechanical pressure, has not, apparently, been previously observed.

State Afforestation in 1921–22.[1]

THE Forestry Commissioners, who have just issued their third annual report, were appointed in November 1919, to carry out a definite programme of afforestation, involving the planting of 150,000 acres of new land in the ensuing ten years, the cost to be defrayed from the Forestry Fund, a sum of 3,500,000*l*. voted by Parliament for the whole period. Acquirement of land, planting operations, and other activities, including education and research, were proceeded with according to plan during the first two years; but the unfavourable financial position of the Government necessitated a reduced programme in the third year, so far as expenses were met with out of the Forestry Fund. Fortunately the Commissioners obtained a large grant out of the Unemployment Fund, and their operations have practically not been restricted. During the year ended September 30, 1922, the Commissioners expended 244,414*l*. out of the Forestry Fund, and 154,017*l*. out of the Unemployment Fund, in all 398,431*l*., a sum in excess of the normal programme.

The new land acquired for State afforestation during 1921–22 amounted to 23,937 acres. The Commissioners now possess 92,426 acres of plantable land. The area planted by the Commissioners in the year was 10,693 acres; and in addition to this, 10,192 acres were planted by private owners and corporations by means of grants, which were given on condition that unemployed labour should be used. These figures are very satisfactory. The usefulness of forestry for relief work is abundantly shown in the report, which is replete with statistics of the areas and species in the various plantations and nurseries.

Grants in aid of higher forestry education, in all 2206*l*., were given to the University schools at Oxford, Cambridge, Bangor, Armstrong College, and the two Agricultural Colleges at Aberdeen and Glasgow. The Commissioners have now three schools for training woodmen, at Parkend (Forest of Dean), Chopwell (Co. Durham), and Beauly (Inverness-shire), at an annual cost of 10,160*l*. On research and experiment, the expenditure was 6126*l*. Experimental plots of various species of trees are now 120 in number. Investigations are being carried out in regard to Chermes, *Phomopsis Douglasii*, tree growth on peat, larch hybridisation, etc.; and a census of woodlands is in progress.

[1] Third Annual Report of the Forestry Commissioners. Year ending September 30, 1922. (H.M. Stationery Office, 1923.) Price 1*s*. net.

The British Medical Association.

THE meeting of the British Medical Association at Portsmouth began on July 20, and the address of the president, Mr. C. P. Childe, was given on the evening of July 24 to a large audience, among whom were a number of distinguished visitors largely from the Oversea Dominions. The president in his address made a strong plea for better housing conditions in the industrial centres, and insisted that an enormous amount of the time and money which is at present being spent on the treatment of diseases like rickets and tuberculosis could be saved if adequate care were given to the housing problem, for in his opinion the absence of fresh air and sunlight in many of the crowded industrial centres was in itself largely responsible for the widespread occurrence of these diseases.

The detailed work in the sixteen different Sections went on from July 25 to July 27, during which a very wide field of subject was under discussion.

In the Section of Pathology and Bacteriology there were discussions upon diseases of the stomach and their methods of investigation, by Dr. C. Bolton; the value of serological tests in diagnosis, by Prof. H. R. Dean; and one on the part played by fungi in disease, by Dr. Castellani. Demonstrations were given, in the afternoons, of specimens which had been collected, forming a museum of very great interest.

In the Section of Radiology a discussion was opened by Dr. R. W. Salmond on the X-ray examination of the urinary tract. During the discussion it was evident that different weight was given by radiologists to the value of screen examinations of the region of the kidney.

The second subject for discussion in this Section was that of medical diathermy, opened by Dr. E. P. Cumberbatch, and followed by Dr. C. A. Robinson, who gave a detailed account of the treatment of gonorrhœa by means of diathermic currents; the temperature which can be tolerated by the tissues is sufficiently high to cause the death of the causative micro-organism, and beneficial results ensue.

In the Section of Tuberculosis a discussion was opened by Prof. Reyn, of Copenhagen, on the subject of the artificial light treatment of lupus and other forms of tuberculosis. From the clinical investigations which have been continued during a large number of years at Copenhagen, the conclusion has been reached that the results obtained in the treatment of lupus by means of ultra-violet light, initiated there by Finsen, are much improved if the local intensive treatment is supplemented by a general irradiation of the whole body. Dr. Sequeira reported a similar result from his experiences at the London Hospital; Prof. Russ thought that it was now possible to assign to certain parts of the spectrum their particular function in this form of therapy, and if this were the case selection of the best form of radiation source became an important consideration.

The social aspects of tuberculosis were discussed in this Section as well as in that of Public Health.

A large exhibition was organised representing practically every aspect of medical work. This was supplemented by additional exhibits of interest to special Sections, such as radiology, pathology, parasitology, anatomy, etc., but considerations of space do not allow of more detailed notice here.

The meeting was very largely attended. The work of the local committees resulted in a very wide choice of excursion to the visitors, which was highly appreciated by them.

Einstein and the Philosophies of Kant and Mach.

THE Bulletin de la Société Française de Philosophie for July 1922, which has just been published (Armand Colin, Paris), contains the report of the reception of Prof. Einstein in Paris on April 6, 1922. It is of exceptional interest, for Einstein did not make an original communication, but assisted at a discussion of the theory of relativity.

Prof. Langevin introduced the discussion, and Messrs. Hadamard, Cartan, Painlevé, Perrin, Becquerel, Brunschvicg, Le Roy, Bergson, Meyerson, and Piéron took part. It elicited from Einstein two pronouncements of special significance in regard to the relation of his theory first to Kant and secondly to Mach. We quote them in full. The first was in reply to M. Brunschvicg, who had said that the Kantian philosophy in separating a *container*, space and time, from a *content*, matter and force, had ended in antinomies, while Einstein's conception, which is characterised by the fact that *container* and *content* are inseparable, had delivered us from them. To this Einstein replied: "I do not think my theory accords with the thought of Kant, that is, with what that thought appears to me to be. What appears to me the most important thing in Kant's philosophy is that it speaks of *a priori* concepts for the construction of science. Now there are two opposite points of view: Kant's apriorism, according to which certain concepts pre-exist in our consciousness, and Poincaré's conventionalism. Both agree on this point, that to construct science we need arbitrary concepts; but as to whether these concepts are given *a priori* or are arbitrary conventions, I am unable to say."

The second pronouncement was in reply to M. Meyerson, who had challenged him to declare how far he was in agreement with the theory of Mach. Einstein replied: "There does not appear to be a great relation from the logical point of view between the theory of relativity and Mach's theory. For Mach, there are two points to distinguish: on one hand there are the immediate data of experience, things we cannot touch; on the other there are concepts which we can modify. Mach's system studies the existing relations between data of experience; for Mach, science is the totality of these relations. That point of view is wrong, and, in fact, what Mach has done is to make a catalogue, not a system. To the extent that Mach was a good mechanician he was a deplorable philosopher. His view of science, that it deals with immediate data, led him to reject the existence of atoms. Probably were he still with us he would change his opinion. I would like to say, however, that on the other point, namely, that concepts can change, I am in complete agreement with Mach."

The Life-Cycle of the Protozoa.

PROF. C. A. KOFOID delivered, on December 27 last in Boston, an address as vice-president of Section F (Zoology) of the American Association for the Advancement of Science and as president of the American Society of Zoologists, on the life-cycle of the Protozoa (*Science*, vol. lvii. pp. 397-408, April 6, 1923). He remarked that the striking similarities of the most ancient fossil Protozoa to recent afford some ground for the inference that the Protozoa living to-day differ but little from those when life was young. A consideration of the accounts of the origin *de novo* of nuclei from chromidia leads to the conclusion that adequate evidence of such origin is lacking. Prof. Kofoid holds that, as sound cytological investigation of the Protozoa progresses, it becomes increasingly evident that the descent of the nuclei and the individuality of the chromosomes, found in the Metazoa, holds also for the Protozoa, and it may be inferred that the Protozoa are equipped with the essential structural basis—chromosomes and mitosis—for the mechanism of heredity.

The searcher for the origins of biological phenomena finds in the Protozoa a fertile but perplexing field. Here have arisen all the fundamental types of symmetry—spiral, leiotropic, dexiotropic, radial, bilateral, and modifications of these. Here also are several distinct types of mitosis, different locations of the centrosome, and extraordinary derivatives of this organ ranging from the nematocysts of Dinoflagellates to the complicated neuromotor system of the trichonymphid flagellates. Sex and sexual dimorphism have also had their origin in the Protozoa. Prof. Kofoid also refers to the universal occurrence of asexual reproduction in the Protozoa, and to the development after fertilisation of a multicellular stage, which he terms a somatella, in which there is generally no progress to the point of division of labour and differentiation of tissues, although the differentiation of sexual and somatic cells occurs in some cases, *e.g.* Volvox. The sequence of events within the cyst of Entamœba—involving elaboration of glycogen and the formation of the chromatoidal substance with its relation to the growth processes—is regarded as suggestive of the sequence in the egg and of the relationship of specific yolk substances to cleavage and differentiation in the metazoan egg. The observations of Jameson on maturation in the Sporozoa show that the haploid condition persists throughout the period of growth and asexual reproductions, while the diploid lasts but one cell-generation. Such conditions give occasion to wonder whether or not sexual reproduction may not have been elaborated gradually and independently within widely different groups in the Protista, and afterwards in them and in higher forms of life the diploid state has extended its domain more and more throughout the life-cycle.

Prof. Kofoid considers that the life-cycle of the malaria parasite—the zygote, the multicellular stage which follows and leads to the formation of sporozoites, which on introduction to man undergo growth and asexual reproduction to form merozoites, and the eventual production of gametocytes—may be compared with the fundamental processes of fertilisation, cleavage, asexual reproduction, and gametogenesis in the Metazoa, except that histogenesis and organ differentiation do not appear. He believes it may perhaps be helpful and serve to facilitate progress if we emphasise the similarities of organisms and seek to find the common processes underlying them all, rather than to emphasise their differences and thus obscure our vision of fundamental problems of life.

Science in Poland.[1]

IN 1881 the Mianowski Institution was founded at Warsaw with the object of promoting the interests of science in Poland. During many years the Institution had to struggle with the suspicious hostility of the Russian Government; notwithstanding bureaucratic cavil and quibble, the Institution edited between 1881 and 1916 more than 1000 volumes of scientific publications (originally written in Polish or translated), assisted hundreds of Polish scientific men in their work, subsidised various laboratories and research institutes, and accomplished much other valuable scientific and national work.

In 1918 and 1919, as soon as Poland was free, the influence and activity of the Institution expanded in a most satisfactory manner. In 1920 a meeting of 533 Polish men of science, coming from all parts of the country, was held at Warsaw, under the auspices of the Institution, with the object of considering, from various points of view, the needs and claims of science in Poland and the immediate prospects of intellectual development of the country. Volume 3 of "Nauka Polska" contains most of the addresses delivered at the Congress. It deals, of course, with many subjects treated by different writers in a variety of tone and of style; it is impossible, however, not to be struck with the glowing patriotic enthusiasm and the noble attachment to the cause of science shown in its pages.

In the inaugural address Prof. Jan Rozwadowski, professor of comparative linguistics in the Jagellonian University of Cracow, takes an uncommon and highly interesting view of "Science and Life." Prof. Rozwadowski would almost suggest that even science may countenance much that is superficial, futile, irrelevant, and sometimes even insincere. Of acute criticism scientific men are rarely tolerant; yet this address, even if it contains debatable matter, shows delightfully how little right they have to throw stones at indifferent or ignorant outsiders. The width of thought, the balance and wisdom shown in this lecture are very remarkable.

It is impossible in a short article to deal with the wide range of discussion contained in other essays; we must content ourselves with enumerating some further titles. "Independence of Science and Research," "Science and Education," "Science and Art," "Social Aspects of Science," "Science and the State," "Organisation of Scientific Research," "Polish Physiography," "Science and Economic Life," "Polish and International Science"—such are the subjects treated by various writers in an interesting or inspiring manner.

The fourth volume of "Nauka Polska" contains much that is valuable and interesting both in matter and scope. Reference may be made to a collection (pp. 81-286) of essays discussing the prospects and possibilities of scientific research in small towns or in the country, far away from libraries, laboratories, and the inspiring influence of university surroundings. Eighteen authors present us with a survey of scientific work that can be accomplished in remote parts of a large country such as Poland. Particularly valuable is Prof. Banachiewicz's contribution on "Amateur Astronomy," an article remarkable for the ability with which a variety of sound information has been epitomised, technical language, as far as possible, being avoided. In a very interesting essay Prof. Birkenmajer gives a list of gifts and benefactions to the Jagellonian University of Cracow in the fifteenth and sixteenth century, beginning with the gift by Queen Jadwiga of Poland, in 1399, of her jewels and other precious objects for the re-erection and endowment of the Jagellonian University, founded by her grandfather in 1364. This noble example was followed by many later benefactors. Another noteworthy feature of the volume is a short but very suggestive essay by Prof. Rozwadowski on "Science, Art, and Religious Belief." We notice also the following contributions: "National and International Science," by Prof. Gawroński; "Longevity of Chemists" (and particularly of Polish chemists), by Prof. J. Zawidzki; "Organisation of Science in France and the United States of N. America," by Messrs. Drzewiecki and Znaniecki.

In conclusion we can only say that we have laid down these volumes with a feeling of real sympathy and warm appreciation.

[1] "Nauka polska, jej potrzeby, organizacja i rozwój," vol. iii. pp. viii+280, vol. iv. pp. ix+590. (Warsaw: The Mianowski Institution, 1920 and 1923.)

Formation of Organic Compounds from Inorganic by the Influence of Light.

DR. O. BAUDISCH contributes to *Science* of April 20 a very interesting account of work carried out by him on the photo-chemical production of organic nitrogen compounds and the influence of iron on nitrate reduction.

The purely chemical investigations originated from bacteriological experiments in which the author found that, in the case of cholera bacilli, the reduction of nitrates stands in direct relation to the oxygen respiration of the bacteria and also to their iron content. A somewhat analogous catalytic effect was discovered in investigating the reduction of nitrites by means of glucose in carbonate solution. Although no reaction takes place, even on heating under pressure, in the absence of iron, the smallest trace of an iron salt is sufficient to bring about the reduction of a large amount of nitrite. Under these conditions nitrates remain entirely unattacked, but are instantaneously reduced to nitrites even in the cold in the presence of oxygen and ferrous salts, an observation of considerable importance in connexion with biological reduction processes.

In contact with moist air, ferrous bicarbonate rapidly absorbs oxygen, yielding a labile peroxide compound, a reaction which the author compares to the fertilisation of an ovum. This is capable of forming a co-ordinated complex with the potassium nitrate, which then splits off an oxygen atom. Reduction of the nitrite is then assumed to proceed further to the extremely reactive potassium nitrosyl, K(NO), which at the same time reacts with organic substances present, especially aldehydes, to form carbon and nitrogen containing compounds. In this reaction ferrous bicarbonate and oxygen assume the rôle of light.

Ferrous bicarbonate peroxide is also capable of giving up the loosely linked oxygen molecule to oxidisable compounds, just as hæmoglobin absorbs oxygen and gives it back again for oxidation or dehydrogenation processes. The reaction is selective and depends upon the affinity of the compound to be oxidised, to form co-ordination compounds with the iron.

A comparison is drawn between the processes outlined above and the reducing action of soil bacteria, and it is concluded that the chemical reactions are, in both cases, very similar. The bacteria which do not need light most probably use the energy of the iron peroxide in rendering nitrates available for protein formation.

University and Educational Intelligence.

CAMBRIDGE.—Mr. T. Basil Buxton has been appointed as the first occupant of the newly created chair of animal pathology.

LEEDS.—The University has appointed Mr. J. A. S. Ritson to be professor of mining in the University, in succession to Prof. Granville Poole, who has been elected to a professorship at Armstrong College, Newcastle-on-Tyne. Mr. Ritson was educated at Uppingham and at Durham University (Armstrong College), where he graduated with distinction in mining and surveying, and has had considerable practical experience of colliery management in various parts of the country. He acted for some time as personal assistant to Sir William Walker, late Chief Inspector of Mines, and is at present senior inspector of mines in the Cardiff district.

ACCORDING to *Science*, the degree of doctor *honoris causa* of the University of Strasbourg has been conferred upon Dr. Simon Flexner, director of the Rockefeller Institute for Medical Research.

THE honorary degree of doctor of science of the University of Wisconsin has been conferred, according to *Science*, upon Prof. The. Svedberg, of the University of Uppsala, in recognition of his work on colloid chemistry and as director during the past term of the research work of the University.

A PROSPECTUS of the Faculty of Engineering of the University of Bristol, which is provided and maintained by the Society of Merchant Venturers in the Merchant Venturers' Technical College, Bristol, has just reached us. Courses of study are available at the College for persons intending to engage in civil, mechanical, electrical, or automobile engineering, and particulars of these courses are given in the prospectus. The ordinances and regulations relating to degrees and diplomas in engineering subjects are included, and some particulars of the Bristol Sandwich system of training engineers are also given. The prospectus can be obtained from the Registrar of the Merchant Venturers' Technical College, Bristol.

THE May issue of the *Phoenix*, the magazine of the Imperial College of Science and Technology, contains a brief account of two comparatively recent diploma courses inaugurated at the Royal School of Mines, dealing with the technology of oil and mining geology. The former course was started in 1913 in order to provide the petroleum industry with men thoroughly trained in certain branches, especially oil-geologists and chemists. The principles of drilling and allied oilfield-engineering are dealt with exhaustively, but the practical work is wisely left to the post-graduate stage of a student's training, when, engaged on work in an actual oilfield, he acquires that experience under far better conditions and in much shorter time than would be possible with an experimental rig designed for intermittent academic instruction, even if this were available. The application of geology to metalliferous mining is another advance made within recent years, and qualified mining geologists, as distinct from mining engineers, have not been long available in Great Britain. This state of affairs was remedied by the introduction of a mining geology course, which, like the older established course in mining, requires four years for its completion; arrangements are also made whereby an associate in either subject may, on working for a fifth year, acquire the double associateship in both mining and mining geology, the combined knowledge of these two subjects, and the wider training and qualification obtained, constituting attainments in every way essential to those whose ambition it is to rise high in their future profession. In both the technology of oil and mining geology courses, the importance of outdoor field-work is insisted on, and a great deal of the student's time is taken up with geological and topographical surveying.

STATISTICS of Public High Schools in the United States (Bulletin, 1922, No. 37) show that the school population has been doubling itself fairly regularly every ten years since 1890, the actual figures for that year and the end of each subsequent decade being: 202,963; 519,251; 915,061; 1,857,155. This rate of increase is about the same as that shown by statistics of secondary-school pupils in England and Wales during the past ten years; but whereas in the United States the pupils in the public high schools in 1920 were 1·76 per cent. of the total population, in England and Wales the percentage in secondary schools was only about half that figure. Of all secondary pupils, those in public high schools in 1920 formed 91 per cent. (in 1890, 1900, and 1910—68, 82, and 89 per cent. respectively), those in Roman Catholic high schools and academies 4 per cent., and those in other private institutions 5 per cent. The number of pupils to a teacher in the public high schools, after rising from 22·3 in 1890 to 25·5 in 1900, fell to 22 in 1910 and 20·5 in 1920. In private institutions the number fell from 13·2 in 1890 to 10·9 in 1900 and 10·5 in 1910, and rose to 12·3 in 1920. The tendency towards concentration of pupils in large schools is reflected in a sharp rise in the number of pupils per school from 89·6 to 139·5 in the public schools and from 65·9 to 88 in the private schools between 1910 and 1920.

THE rôle of the text-book in the public schools of America is subjected to some candid criticism in the annual report for 1922 of the president of the Carnegie Foundation for the Advancement of Teaching. Where text-books are prescribed by the State legislature the publishers' contracts run into millions of dollars, and editions vie in size with the season's "best-seller" novels. The criticisms are directed not so much at the dangers of collusion between publishers and legislators, which have been greatly diminished, as at the influence on school curricula of the large profits incidental to such large editions. To a teacher the production of a new text-book which shall obtain the approval of the State education department is the only road whereby his professional knowledge, experience, and talents may lead to affluence, and a vast amount of industry and ability has been devoted to this work. Many of the books produced are excellent, but their very excellence has accentuated two unfortunate tendencies: towards the multiplication of courses and of studies, and excessive separatism in teaching. "A reform of the school curriculum, planned to return once more to a conception of the school along simpler and more sincere lines, would find itself confronted with the fact that the means of instruction provided by the text-book publishers and the text-book writers and accepted by the authorities are . . . small doses administered at fixed times from stated text-books." This pigeon-holing system, under which the pupil's separate unrelated studies neither interest him nor give him a perspective, is of course not peculiar to the United States, nor are there wanting systematic attempts to displace it there. It is by way of revolt against it that the "project" method is now being encouraged in America, especially in elementary schools.

Societies and Academies.

SYDNEY.

Royal Society of New South Wales, June 6.—Mr. R. H. Cambage, president, in the chair.—A. L. **Kroeber**: Relationship of the Australian languages. Native terms for a number of fundamental concepts, chiefly names of body parts, were transcribed into a standardised orthography, and the data for each concept were entered on maps. Schmidts' fundamental separation of South and North Australian languages seems unnecessary. The languages are divided into groups, 8 southern and 7 northern; of 11 stems, each appears in a majority both of northern and southern groups, and each of 22 others in at least two southern and two northern groups. Genetic unity of all Australian languages seems probable.—J. **Read** and G. J. **Burrows**: Note on the dilution of ethylenebromohydrin with water. When ethylenebromohydrin is diluted with water a continuous absorption of heat occurs until a dilution of about 80 per cent.; further dilution from about 75 per cent. to 10 per cent. is attended by a continuous evolution of heat. Upon reversing the process an initial positive thermal effect is followed by a negative thermal effect. The volume of the solution is always less than the combined volumes of the two components: at 20° a maximum contraction of 1·07 per cent. occurs at a concentration of 50·041 per cent., corresponding closely with the ratio $1C_2H_5OBr : 7H_2O$. Density and viscosity measurements afford no indication of hydrate formation.—G. **Taylor**: The warped littoral around Sydney. Pt. I. The region within one hundred miles of Sydney is dominated by warps to the north, west, and south. Of these the well-known Blue Mountain monocline is the largest. The area is subdivided into 15 geographic regions symmetrically arranged about an east-west axis through Botany Bay. The central portion forms a "stillstand," bounded to the west by three silt-lakes along the Nepean. The coastal features are also symmetrically arranged. Port Hacking is a geographic parallel to Port Jackson, as Illawarra is to the Tuggerah coast. Sydney is unique in that a city of a million people is surrounded on almost all sides (at 50 miles distance) by a belt of country with scarcely an inhabitant. This is a result of geographic controls.—A. R. **Penfold** and R. **Grant**: The germicidal values of the principal commercial eucalyptus oils and their pure active constituents, with observations on the value of concentrated disinfectants. From commercial eucalyptus oils, and also the waste products obtained therefrom after rectification, cheap disinfectants having a high germicidal value can be manufactured. The crude oils gave coefficients varying from 5 to 12, while the pure constituents varied from 3·5 up to 22·5. The germicidal activities of the crude oils is due to certain aldehydes, alcohols, and phenols.—M. **Henry** and W. L. **Hindmarsh**: *Stypandra glauca* (a suspected poison plant). Experiments on thirty-two animals of five species, carried out in five different months and over a space of three years, were entirely negative. Sheep fed solely on *Stypandra glauca* for twenty-five days remained perfectly healthy.

CAPE TOWN.

Royal Society of South Africa, June 20.—Dr. A. Ogg, president, in the chair.—Sir Thomas **Muir**: Note on the successive differentiation of a product of linear functions.—J. Steph. v. d. **Lingen**: The differential bactericidal effect of the visible spectrum. The author discussed the results of Bie, Marshall Ward, Downing, and Russ, and also those obtained by Bayne-Jones and himself. In the work of these investigators the technique was to expose a culture for a given time and then to incubate it for 24 hours or more. On the results of the incubation conclusions were drawn with regard to the bactericidal effect of the various regions of the spectrum. The author described a new method for studying the bactericidal effect. Filters were placed in front of a series of small boxes (chalk boxes) each of which contained four nutrient agar slopes. After inoculating the slopes with bacteria they were placed in the boxes, which fitted into an incubator. In front of the incubator rows of tungsten lamps were placed so that the distribution of light was uniform on the cultures. By adjusting the intensity of the light to a suitable value, the inhibitory and bactericidal effects of the various regions of the spectrum could be studied, as well as the effects of total illumination and total darkness.—J. P. **Dalton**: On the attraction-coefficient for substances of low critical temperature. Some years ago the author found the dependence of van der Waal's a upon temperature for isopentane using Young's saturation data, but at the time sufficient saturation data were not available for testing the law of dependence for other substances. Since then the brilliant researches of Kamerlingh Onnes and his collaborators at Leyden have made available accurate saturation data for other substances of low critical temperature, and their results have been used to determine the constants of the above relation for argon, oxygen, nitrogen, and hydrogen. For these four substances a can well be represented as an exponential function of the temperature, and the agreement between the values of a calculated from the experimental data and those yielded by an equation of the type $\log a = \alpha - \beta T$ is very good.—C. W. **Mally**: X-rays as a means of detecting imperfections in fruit. An effort to find an infallible means of detecting internal defects in export fruit led to a trial with X-rays. Radiographs reveal the internal structure in detail. The ensemble of sound fruit is harmonious, whereas defects cause conflicting shadows to appear in the radiograph. The presence of fungal or bacterial organisms which produce decay is indicated in the radiographs by structural details being more or less obscure. This makes it possible in pathological research to determine with a great deal of certainty whether or not any given fruit that is to serve as a culture medium is sound and also to record the progress of the organisms by means of radiographs at regular intervals. The practical application to fruit inspection depends on satisfactory visibility on the fluoroscopic screen being attainable.

Official Publications Received.

Leeds University: Department of Pathology and Bacteriology. Annual Report by Prof. Matthew J. Stewart and Prof. J. W. McLeod. Pp. 11. (Leeds.)

Board of Scientific Advice for India. Annual Report for the Year 1921–22. Pp. vi+79. (Calcutta: Government Printing Office.) 1 rupee.

Department of the Interior: Bureau of Education. Bulletin, 1923, No. 7: Educational Work of the Young Men's Christian Association. By William F. Hirsch. Pp. 25. 5 cents. Bulletin, 1923, No. 9: Supervision of One-Teacher Schools. By Maud C. Newbury. Pp. iii+55. 10 cents. Bulletin, 1923, No. 23: The Social Studies in Civic Education. By Edgar Dawson. Pp. 16. 5 cents. (Washington: Government Printing Office.)

1-szy Zjazd Chemików Polskich w Warszawie, 3-6 kwietnia roku 1923. Pp. xxiv+64. (Warszawa.)

Roczniki Chemji: organ Polskiego Towarzystwa Chemicznego. Poc redakcja Prof. Jana Zawidzkiego. Rocznik 1921. Tom 1, Zeszyt 1-3. Pp. 177. Tom 1, Zeszyt 4-6. Pp. 178-337. Tom 1, Zeszyt 7-9. Pp. 338-487. Rocznik 1922. Tom 2, Zeszyt 1-3. Pp. 106. Tom 2, Zeszyt 4-6. Pp. 107-336. (Warszawa.)

Supplement to NATURE

No. 2807 AUGUST 18, 1923

The Adaptational Machinery concerned in the Evolution of Man's Body.[1]

By Prof. Sir ARTHUR KEITH, F.R.S.

INTRODUCTORY.

TELEOLOGY, a word so familiar to readers of the works of Archdeacon Paley and of Sir Charles Bell, has disappeared from the vocabulary of scientific men. Darwin killed it; he put an end to natural theology and to Bridgewater treatises. Yet all those wonderful contrivances which Paley culled from the animal kingdom remain true; they are facts which have to be explained. The human hand is, as Bell maintained, a most effectively designed structure;[2] a modern evolutionist can still study with profit the account he gave of the mechanical contrivances to be seen in every part of the human body.[3] Modern discovery has served but to heighten our sense of wonder at the ingenuity which Nature has lavished on the human body. The means she has installed for fighting infection and internal disorders are almost beyond belief. In complexity and in efficiency of design the human brain far excels any invention or organisation the most fertile imagination of man has yet conceived. Engineers, in designing all their contrivances, ensure stability during emergencies by allowing a "factor of safety"; in all systems of the human body the "factor of safety" is more than ample. In this respect the human body has been made almost "fool-proof."

If, then, teleology has disappeared from our evolutionary vocabulary, its substance remains; we have still to find a rational explanation for the manifest contrivances of the human body; a "doctrine of adaptation to purpose" is still a necessity. The followers of Paley had an easy task; they had but to wave a theological wand, and the origin of all of Nature's contrivances was instantly explained. But we followers of Charles Darwin have a much more laborious undertaking in front of us; we have to discover and demonstrate in the body of man, in the developing embryo, and in the growing child the actual machinery which has wrought its marvellous and purposive organisation. In this lecture, given in memory of Huxley at his old hospital and school, I propose to see how far modern discovery has revealed the nature of the adaptational machinery of man's body.

[1] The 12th Huxley Memorial Lecture, delivered at Charing Cross Hospital Medical School on June 27.

[2] The Hand, its Mechanism and Vital Endowments as evincing Design. London, 1833.

[3] Illustrations of Paley's "Natural Theology." An Appendix to Lord Brougham's edition.

HUXLEY AS HUMAN ANATOMIST.

Of all the men who stood round Darwin as helpful critics, Huxley has come out best; time has upheld his judgments and shown that when he doubted he had the intuition of genius. His opinions concerning the evolution and adaptations of the human body are of particular value, for, at two periods of his career, he was a close student of human anatomy. The first of these was spent in this school, from 1842 to 1846, when he passed from his seventeenth to his twenty-first year, and qualified for the practice of medicine. Then, after sailing the high seas of zoology for a dozen of years, he again made the human body one of his main themes of interest, and it remained so for a period of fully twelve years—from 1858 to 1871—when he again returned to the larger problems of zoology and evolution. No doubt his return to the study of man's body in 1858 was to correct certain doctrines which Owen was promulgating concerning it, and to support Darwin's "Origin of Species," which was issued at the close of 1859.

HUXLEY ON TELEOLOGY.

How, then, did Huxley explain the origin of those excellent contrivances in the human body which had commanded the admiration of so many generations of anatomists? It was not until 1876, when he was in the fifty-first year of his age and at the zenith of his intellectual power, that he gives us a glimpse within his mind and permits us to see how he viewed teleology —the science of adaptation. In the early spring of 1876 he gave a lecture in Glasgow, selecting "the hand" as his subject—the text which had served Sir Charles Bell for a Bridgewater treatise. How had man come by his hand? By what evolutionary means had the clumsy climbing anthropoid hand become the dexterous grasping hand of man? If Huxley had believed, as Lamarck, Spencer, and Darwin did, that "functionally wrought" modifications could become hereditary—that a simian stock, were it to use its arms and hands as man now uses his, would in the course of many generations come to have human hands and arms—then the evolution of the human hand was a comparatively easy problem. At no time of his life did Huxley believe that the effects of use or disuse did become hereditary. In 1890 he wrote:[4] "I absolutely disbelieve in use-inheritance as the evidence now stands."

Having thus rejected the only known means by which useful or purposive modifications of the body can be brought about, we turn with some degree of curiosity to his lecture in Glasgow[5] on the evolution of the hand. The exact title which he gave to his discourse was "On the Teleology and Morphology of the Hand." This is how he approached the problem of adaptation:

"To be a teleologist and yet accept evolution, it is only necessary *to suppose that the original plan was sketched out—that the purpose was foreshadowed in the molecular arrangements out of which the animals have come.*" Then twelve years later (in a letter to Romanes in 1888) he wrote[6]: "It is quite conceivable that every species tends to produce varieties of a limited number and kind, and that the effect of natural selection is to favour the development of some of these, while it opposes the development of others, *along their predetermined line of modification.*"

Huxley as an Evolutionary Predestinarian.

Thus it will be seen that Huxley, on the evidence then at his disposal, had come to the startling conclusion that the shaping or controlling forces which, in due season, were to give man his hand, lay latent in the germ-plasm of that simian stock which ultimately blossomed into human and anthropoid shapes. The evidence which forced Huxley to take up the position of an evolutionary predestinarian must have been indeed cogent. Only a few years previously (1868), Sir Richard Owen had given utterance to a somewhat similar belief, when he wrote:[7] "Generations do not vary accidentally in any and every direction, but in preordained definite and correlated courses." Huxley, as was afterwards the case with Weissmann, believed that the creative machinery of evolution lay in the womb of the germ-plasm.

Modern Predeterminists.

Manifestly, if the evolutionary fate of man is already determined by the properties of his germ-plasm, as Huxley believed, it is a truth of the utmost consequence to medical men. We cannot, if this be true, in any way control the future of humanity, except by the application of Darwin's law of selection. Man's destiny lies hid in the potentialities of his germ-plasm. Huxley's belief is widely shared by modern students of evolution. No one has had better opportunities of noting how evolution has worked in shaping higher mammals during the Tertiary period than Dr. H. Fairfield Osborn, of the American Museum of Natural History. He finds ample evidence of a "definite or determinate origin of certain new characters, which appear to be *partly* a matter of hereditary disposition."[8] He finds that evolutionary tendencies, like that which leads to the formation of horns and antlers, may lie latent in an ancestral stock, and only become manifest at subsequent times and in different ways in certain of the descendants of that stock. That evolutionary manifestations of this kind have taken place in the evolutionary history of the higher primates—the group to which man belongs—there can be no doubt.

In recent times this conception of evolution working out its effects in predetermined directions has been forcibly suggested by Bateson. In his presidential address to the British Association in Australia in 1914 he expressed himself thus:

"If then we have to dispense, as seems likely, with any addition from without, we must begin seriously to consider whether the course of evolution can at all reasonably be represented as an unpacking of an original complex which contained within itself the whole range of diversity which living things present. . . . At first sight it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the diverse types of life."

In this passage Bateson plainly suggests that the machinery of evolution has proceeded on its way, untrammelled by any outward circumstance, right from the first appearance of living protoplasm. We have here the doctrine of evolutionary predestination stated in its most extreme form. Whether such a belief as this of Bateson is well founded or not, it shows us that one who has given a lifetime to the study of variation and of heredity is of opinion that the evolutionary machinery which has given man his brain, his hand, his foot, and his posture has worked out its effects undisturbed by the surrounding conditions of life. In brief, functionally wrought modifications have had no part in shaping the human body.[9]

Before proceeding to set out the evidence concerning the nature of the machinery which shapes man's body, there is another opinion, akin to that of Huxley, which

[4] Life and Letters, by his son, Leonard Huxley, 1900, vol. 2, p. 268.
[5] Life and Letters, vol. 1, p. 456. I have been unable to obtain any published account of this lecture save that given by Mr. Leonard Huxley in the "Life and Letters."
[6] Life and Letters, vol. 2, p. 188.
[7] Anatomy of Vertebrates, vol. 3, p. 808.
[8] The Origin and Evolution of Life, 1918, p. 278. In this work the reader will find references to literature bearing on predeterminism in evolution.
[9] It is unnecessary to give here a list of the men who have concluded that plants and animals tend to vary in definite directions, whatever be the circumstances in which they are placed. The evidence relating to this matter has been very ably summarised in recent times by E. S. Russell, Form and Function, London, 1916; and by Prof. R. Anthony, "Le Determinisme et l'Adaptation Morphologique," *Archives de Morphologie*, Paris, 1922.

deserves to be considered here. It was given by Prof. G. Elliot Smith,[10] and is founded on a prolonged and intimate study of the brain of man and of the brains of animals which have a close structural relationship to man:

"And if all the factors in his (man's) emergence are not yet known, there is one unquestionable, tangible factor that we can seize hold of and examine—the steady and uniform development of the brain along a well-defined course throughout the Primates right up to man, which must give us the fundamental reason for man's emergence and ascent. . . . Thus at the dawn of the Tertiary period there were developed the germs of all the psychical greatness which, in the million or so of years that have followed, culminated in the human mind."

Without a doubt the brain of the great anthropoids is but an elaborated edition of that which serves the needs of monkeys, and, in turn, the brain of man, while framed on exactly the same plan as that of the great anthropoid, far transcends it in complexity of elaboration. In the evolution of these three stages, represented by the brains of man, anthropoid, and monkey, we are witnessing, not an unpacking, but an ever-increasing degree of specialisation as von Baer and Spencer recognised long ago. In the organisation of the brain of the monkey we see something which is comparable to the civilisation of a primitive people, such as the aborigines of Australia; in that of the anthropoids, one which may be compared with the life led by a semi-civilised people, such as the natives of the Congo, while in the human brain we reach a stage of complexity represented by the highest modern civilisation. Whether we speak of brains or of civilisation, the machinery of evolution must be of an analogous nature in both of them. What is the nature of this machinery?

How Adaptations appear during the Development of the Embryo.

Since the time of Darwin and of Huxley our knowledge of the factors which take a part in controlling the development, and therefore the evolution, of the brain and of its appended sense organs, such as the eye, the ear, and the nose, has entered a new phase. We shall take the formation of the eye as our first example because in design and execution it far excels any camera yet invented; it has been the theme of many a teleological sermon, and a consideration of its development will take us right to the heart of our subject—the origin of purposive or adapted structures. After the publication of the "Origin of Species," Mr. J. J. Murphy, of Belfast, cited the eye as a structure which could not be accounted for by any theory of selection then propounded. "It is probably no exaggeration to suppose," wrote Mr. Murphy,

that in order to improve such an organ as the eye at all, it must be improved in ten different ways at once, and the improbability of any complex organ being produced and brought to perfection in any such way is an improbability of the same kind and degree as that of producing a poem or a mathematical demonstration by throwing letters at random on a table.[11]

Darwin, with that customary candour which regulated his search for truth, quotes in full this cogent and, to my way of thinking, just criticism, and Darwin's reply was that the eyes of men, as of animals, did show slight degrees of individual variation, and that he could conceive the twilight eye of the owl or of the lemur as having arisen by a selection and accumulation of these minute variations. Mr. Murphy modestly estimated the parts of the eye which must undergo a simultaneous modification, if sight was to remain efficient, as ten in number; he would have been inside the mark if he had said ten thousand. We cannot conceive how the countless elements which go to the construction of an eye can assume their appropriate place, form, and function unless we postulate a machinery which regulates the development and growth of every one of them.

The existence of such a machinery was made evident by experiments on tadpoles carried out by Dr. Warren H. Lewis at Baltimore from 1903 onwards.[12] The optic cup, which ultimately forms the retina of the eye, grows out from the wall of the brain towards the embryonic skin or ectoderm. When this cup comes into contact with the ectoderm, the overlying cells begin to proliferate and arrange themselves so as to form a transparent or crystalline lens. Dr. Lewis transplanted the outgrowing optic cups of tadpoles, and found, if they were placed under the ectoderm of the neck or of the belly, that the result was the same; an optic cup caused the overlying cutaneous cells to alter their nature and form a lens. Dr. Lewis realised the significance of his discovery; in the developing embryo, although only of certain species, one group of living cells can enslave and control the behaviour of another group. He gave us a glimpse of the kind of evolutionary machinery employed in fashioning a highly purposive structure such as the eye. Any one who has followed the success with which physicists have unravelled the structure of the atom in recent years will not despair of an equal success attending the efforts of embryologists to uncover the means by which one

[10] British Association Reports, 1912 (Dundee), pp. 575-598.

[11] The Variation of Animals and Plants under Domestication, 1868, vol. 2, p. 222.

[12] "Experiments on the Origin and Differentiation of the Optic Vesicle of Amphibia," *Amer. Jour of Anat.*, 1904, vol. 3, pp. 507, 805; 1907, vol. 7, pp. 144, 259. See also Spemann, *Zoolog. Jahrbuch*, 1912, vol. 32, p. 1.

group of embryonic cells regulates the growth of a neighbouring group.

Our knowledge of the machinery by which the growth of embryonic tissues is controlled and shaped is likely to increase rapidly, for in recent years embryologists have copied the methods invented for the study of bacteria, and have succeeded in growing the live tissues of embryos in artificial media. It has been proved time after time that the epithelial cells of an embryo, such as the living cells of renal tubules, if grown apart from other cells, spread outwards in a more or less disorderly manner; but if connective-tissue cells are added to the culture, then the epithelial cells form orderly ranks, just as they do in the kidney tubules of the embryo.[13] Carrel[14] found that the juices of embryonic tissues contain substances which cause cultures of living cells of any kind to proliferate rapidly and to continue alive for an endless series of generations. Thus it will be seen that the machinery which regulates the behaviour of groups of cells within the body of the embryo is one of the utmost complexity, and yet is of a kind which can be handled and studied by biologists. Nor can we doubt for a moment that the machinery of development and of growth which we find at work in the embryo is also the machinery of adaptation and of evolution. In every phase of the development and evolution of the human hand we see this adaptational machinery at work.

Behaviour of Young Nerve Cells.

There is no need to tell even the uninitiated that the brain and nervous system of man comprises many thousands of millions of microscopic units or nerve cells. Each unit of the brain has its appropriate place in a tremendously complex system, and has its special duty in dealing with the tide of messages which flood that system in every hour of conscious and subconscious life. When a child is born all the nerve centres which regulate the complex apparatus of breathing start into instant and effective operation. When the mother's teat is placed within its lips the nerve centres which regulate this intricate series of actions start to work as if they had served an apprenticeship before they appeared in the orderly development of the babe's nervous system. We cannot yet explain satisfactorily the means by which such really marvellous evolutionary results have been reached, such as reflex nerve centres, ready for action at the moment of birth, but at least we can claim to have before us a prospect of giving a rational account of how the various groups of nerve units are assembled so as to give a functional result.

Our present knowledge of this matter is largely due to the researches of Dr. Ariens Kappers[15] of Amsterdam, and to investigations made by his pupils. Nerve cells may not remain in the sites at which they are developed; in their younger stages they have the power to migrate. Dr. Kappers found that a group of embryonic nerve cells or neuroblasts, which are afterwards to control definite sets of muscles and therefore to be concerned in carrying out certain actions of the body, migrate towards the sources of their information. Those young executive nerve cells take up their permanent stations at points most suitable for the performance of their life's work. If we conceive a mob of war-seasoned men to deploy automatically and to take up effective battle-stations we have before us a picture of what is to be seen taking place among the nerve cells in the brain of the growing human embryo. Developing nerve cells send out processes which effect unerring contacts with other distant cell-groups of the body. Dr. Davidson Black[16] found that certain cell-groups on the cortex of the brain proceeded in their development only if the processes of another distant group of cells had entered into contact with them. We have here another instance of one embryological group of cells determining or controlling the development of another group. Enough has been said to show that the machinery which regulates the development and growth of the brain is one of the utmost complexity. We have no reason to suppose that it is of a kind which lies beyond the comprehension of the human mind, although it may take centuries of neurological inquiry to lay bare its nature. The one point we are certain of is that the factors which regulate the development, growth, and arrangement of the countless units of our nervous system do work in such a way as to produce an effective functional result.

The Evolution of Muscular Adaptations.

In no system of the human body do we find more instructive examples of mechanical adaptation than in the muscles which carry out the movements of our bodies and of our limbs. The nature of the machinery involved in the elaboration of muscular adaptations may be illustrated by the development of muscles which guard the mouth, eye, nose, and ear, and are concerned in expression. The bud which gives rise to the muscles on one half of the face begins at one localised site of the human embryo, a site in the embryonic neck, marked by the hyoid arch. From this site the young muscle cells or myoblasts migrate outwards, over the neck and scalp, round the ear, eye, nose, and mouth; as they reach their destinations they fall into ranks and take up such positions as permit

[13] Ebeling and Fischer, *Journ. Experim. Med.*, 1922, vol. 34, p. 317.
[14] See A. H. Drew, *British Journ. Experim. Path.*, 1922, vol. 3, p. 20.

[15] "Further Contributions to Neurobiotaxis," *Psychiat. en Neurolog. Bladen*, 1916, Nos. 5, 6.
[16] *Journ. of Comp. Neur.*, 1913, vol. 23, p. 351.

them, when fully differentiated, to perform effectively their respective functions. The influences which control their movements and regulate their dispositions we do not know as yet. But whatever the nature of these regulating forces may prove to be, we can see that they are exactly of the same kind as those which control the differentiation of facial musculature in monkeys and anthropoids. The degree of differentiation of the facial musculature of man is but the final stage of a continuous series of evolutionary forms to be traced in the faces of monkeys and anthropoids. The elaboration of the facial musculature runs more or less parallel to the elaboration of the brain.

The manner in which muscular adaptations arise may be better exemplified if we take a muscle which is concerned in purely mechanical actions, such as the latissimus dorsi. This muscle is concerned in pulling the upper arm backwards as in rowing. It works in the human body from a wide firm base, placed in the lower part of the back—one which extends from the sixth dorsal spine to the crest of the ilium. As points of origin it also utilises the lowest three or four ribs, and occasionally also the lower angle of the scapula. This muscle, occupying the lower half of the back, makes its appearance in the human embryo in the lower part of the neck, just below the embryonic shoulder-blade. By the end of the sixth week of development the army of cells which compose the muscle have extended or migrated downwards as far as the fourth rib, reaching the twelfth rib about the seventh week, and the iliac crest by the time the human embryo is two months old.[17] The success with which the developing muscle cells reach their ultimate destinations is one of surprising accuracy; they may take hold of a spine or a rib too far up or too low down, but the total result is always one which makes the whole muscle into an effective mechanical engine. Such variations may make the muscle a little less or a little more useful to the individual. The young muscle cells, when they have reached their definitive sites, arrange themselves in serried ranks, each rank hitched directly or indirectly to the lever through which the collective army of cells exerts its strength.

Now, this muscle has almost the same attachments in the gorilla and chimpanzee as in man; there is a greater range of individual variation in its points of origin; the marksmanship made by the migrating myoblasts is less accurate than in man. In the orang this muscle obtains no direct origin from the ribs, while in the gibbon five or six ribs are seized. In the gibbon, however, there is no direct muscular origin from the crest of the ilium. In the old-world monkeys, and also in their American cousins, the origin of the latissimus is restricted to the lower three or four dorsal spines; the origin from the iliac crest is slight or indirect; while the fibres rising on the side of the thorax are not directly attached to the ribs. Very occasionally one sees fibres rising from the lower angle of the scapula of monkeys, a variation in attachment which has become very common in man. In these variations of attachment we are seeing evolution at work, and its machinery lies in the forces which regulate or control the migratory movements of the young muscle cells.

Influence of Nerve-connections.

It is true that nerve fibres have entered, and formed a union with, the muscle mass in the neck before migration has set in; the nerves are carried along by the migrating muscle horde; differentiation of the muscle fibres begins at the point at which the nerve enters the muscle mass. When muscular fibres are fully differentiated they depend on their union with nerve fibres for a continuance of their health and life. But the migratory impulse, be that impulse what it may, lies not in the nerve union but in the muscle elements themselves, for Ross G. Harrison[18] found, if the limb of a developing tadpole were deprived of its nerve supply, the muscles still became duly differentiated in their usual stations.

Adaptations may appear first as occasional Variations.

Let us take another example to illustrate the manner in which a new muscular feature has been evolved in man's body. The muscles of the calf of man's leg have taken on an enormous growth to raise the heel in walking. The structure of the deeper muscle of man's calf, the soleus, has taken on an extremely complex and efficient arrangement of fibres; its origin from the posterior aspect of the bones of the leg is particularly extensive. In all dog-like or pronograde apes this muscle has a narrow origin from the smaller bone of the leg, the fibula, and this is also usually the case in the orthograde apes, or anthropoids. In man the origin of the muscle has undergone an extension, a large part migrating from the fibula and obtaining an extensive attachment to the tibia. But this extension to the tibia which is constant in man occurs as a frequent variation in all the anthropoids. Out of 8 gorillas examined, 3 had a tibial origin for this muscle; this was also the case in 2 out of 12 chimpanzees, 1 out of 8 orangs, and 2 out of 12 gibbons. In the anthropoids there is a tendency for the soleus to extend its origin to the tibia; in man this tendency

[17] Warren H. Lewis, Keibel and Mall's Manual of Human Embryology, 1910, vol. i. pp. 454-522.

[18] *Anat. Record*, 1908, vol. 2, p. 145; *American Journ. of Anat.*, 1906, vol. 5, p. 121; *Journ. of Experim. Zool.*, 1907, vol. 4, p. 239.

has become a fixed habit. This is but one instance of what is often to be observed in the study of human evolution, where an occasional variation in apes has become the established form in man.

How has this tendency to vary in a definite direction arisen? It is a direction which increases the functional efficiency of the human leg. Has this tendency arisen in apes as a result of the manner in which they climb? Or is it, as Huxley would have us infer, a tendency which is inherent in the developing soleus and has come into existence under the influence of some unknown factor which regulates the developmental movement of muscle cells? I think that Huxley's interpretation is the true one.

Let us take another example. Under the skin of the sole of man's foot lies a muscle known as the short flexor of the toes. In man all its four bellies, designed for the outer four toes, have a solid basis of origin on the bone of the heel; from such an origin the collective muscle can play a helpful part in maintaining the arch of man's foot. Now in the monkey's foot, while the muscle for the second toe arises from the heel, the muscles for the three outer toes retain a primitive origin from an adjacent surface provided by moving tendons. In the gibbon it is usual for the muscle of the third as well as of the second toe to have moved its origin to the heel; in the great anthropoids, particularly in the orang, the muscle of the fourth toe has also left the tendon and migrated to the heel; in man all four have moved. Here we see a human character arising as the culmination of a tendency which can be observed, to a greater or less degree, in the feet of all those animals which are most closely related to man, yet more primitive than him in structure. The migration of origin, on the part of the embryonic muscular cells, is of a useful or purposive kind. We cannot avoid the conclusion that the growth and development of young muscle cells are controlled by influences or means which work towards a functional result.

The Origin of a Muscle peculiar to Man.

Man possesses a muscle which is peculiar to himself —the peroneus tertius—and it will help us to understand how new structural features have been, or are being, evolved if we note the manner in which this muscle makes its appearance during the development of the leg and foot of the human embryo. The peroneus tertius raises the outer border of the foot and assists in applying the sole of the foot to the inequalities of the ground in walking. If we examine a hundred human legs we shall find ninety in which the peroneus tertius is a complete and separate muscle, but in the remaining ten we shall find some in which it is separated only to a greater or less degree from an adjacent and older muscle, the long extensors of the toes, and some in which it is quite unseparated from this muscle, as is the case in the legs and feet of anthropoid apes. In the gorilla one notices occasionally a tendency for the outer fibres of the tendon going to the fifth or small toe to stray or migrate towards the outer border of the foot. When we turn to the developing leg to ascertain how this new muscle makes its appearance in the human embryo, we find, towards the end of the second month of development, that the mass or colony of muscle cells which are to extend the toes, becomes separated from the common extensor mass of the leg, and that, in turn, the muscle cells which are to form the peroneus tertius separate or are cleft from the outer side of the long extensors of the toes—from the part concerned in extending the little toe and incidentally in turning upwards the outer border of the foot. The peroneus tertius represents a colony of muscle cells which have broken away from the parent muscle—the long extensor of the fifth toe. The tendon fibres have broken away from those going to the toe and migrated backwards along the outer border of the foot, thus giving them an advantageous position for the performance of their function in walking.

We have here all the properties manifested by developing muscle masses—a power of cleavage or separation, and a power of migration. What causes these outer muscle cells which are destined to act on the most external of the digits to break from the parent mass and assume a separate functional identity? I agree with Huxley that there are no grounds for believing that the behaviour of embryonic muscle cells is in any way influenced by experiences gained by adult muscle fibres. When vertebrate limbs came first into existence the muscle colonies which deployed to form the extensors of the toes, grouped themselves so as to get a functional result. In the case of the outer toe there was a double function, the extension of the toe and the everting of the foot. In the human foot the muscle cells which evert the foot have separated themselves from those which extend the little toe. The evolutionary machinery lies in the behaviour of the embryonic muscle cells or myoblasts.

Instances of Parallel Inheritance.

Let me cite two other examples which go to show that myoblasts possess evolutionary tendencies which work towards a purposive or functional end. The interosseus muscles of the hand and foot of monkeys arise, not from the adjacent surfaces of metacarpal and metatarsal bones, as they do in man, but from the bases of these bones, in the palm of the hand and sole of the foot. In the human embryo the interosseus muscles appear in the same palmar position as that which is retained in monkeys. In the most primitive of anthropoid apes—the gibbon, and also in the highest of South American monkeys—the howler monkeys—Ateles—the origin of the interosseus muscles have migrated so as to take a partial hold of the adjacent surfaces of the metacarpal and metatarsal bones. In the great anthropoid apes—the gorilla, chimpanzee, orang—and in man, these muscles have sunk in between and seized the adjacent surfaces of the metacarpal bones of the hand and metatarsal bones of the foot. This migratory tendency has seized upon, or become manifested in, the muscles of the hand as well as in those of the foot, although these members are subject to different functional influences. We can account for such evolutionary manifestations only by supposing that in a remote common ancestor of all the members of the higher primates there was a latent tendency in the myoblasts of the interosseus muscles to deploy and group themselves in a new way, one which gave a better functional result.

Another striking fact is that the muscles which have become reduced or vestigial in man have also become reduced and vestigial, although usually to a less extent, in the anthropoid apes. All of these muscles, plantaris, palmaris longus, psoas parvus, latissimo-condyloideus, omo-cervicalis, etc., are laid down in a normal way during the development of the embryo; after being laid down retrogression sets in. We have here again to deal with functional tendencies. The machinery of reduction is resident in the processes which govern the development of structural systems in the embryo. As W. Roux supposed, there may be a struggle for survival between the system of cells which make up the body of an embryo.

The Adaptational Properties of Bone Cells.

By the fourth month of fœtal life young nerve cells and young muscle cells have taken up their definitive position and arrangement. On the other hand, white blood corpuscles retain all through the life of the individual the migratory power which is lost by most other cells of the body early in fœtal life. The cells which line blood and lymph vessels and those which line the peritoneal and pleural cavities[19] retain all through life a power to proliferate and produce new tissues which are of a purposive kind. Such cells retain the chief characteristic of embryonic cells—the power to arrange themselves as part of a functional complex. Bone cells also retain powers of purposive action. Nothing is better known than that, if a bone of a rickety child bends under the weight of the body, the bone cells lying in its concavity will proliferate and build a buttress to strengthen the shaft. It is not necessary for us to speculate here as to the exact stimuli which cause bone cells to behave in this manner; it is enough for our present purpose to note that they react to fulfil an end necessary for the occasion.[20]

John Hunter discovered the remarkable power which bone cells possess to remodel bones during growth. While bone cells are building at one part of a bone, they are, at another part of the same bone, busily engaged in taking down their previous handiwork. The co-ordinated manœuvres of the armies of bone cells concerned in the growth of the jaws and eruption of the teeth are extraordinary. When teeth are erupting and also long after they are cut, their bony sockets are being constantly altered and remodelled by the hundreds of thousands of osteoblasts embedded in the bone surrounding the dental roots. While new bone is being laid down on the outer side of the jaw under the gum, the corresponding bone on the inner side of the gum is being absorbed. But in the tooth socket itself the opposite is happening; new bone is being laid down on the inner side of the tooth socket, while it is being removed from the wall forming the outer side of the socket. New bone is being laid down under the roots so that the socket as a whole is being raised and moved in an outward direction. The crowd of osteoblasts involved in this operation are clearly co-ordinated in their action; they move on towards a functional result. Although we do not know the exact means by which their action is co-ordinated we have, in the qualities and tendencies, possessed by bone cells, part of the machinery of evolution. Cartilage cells, during embryonic life, must be co-ordinated in their growth and arrangement. In the fœtal hand we find they have fashioned the joints to meet the needs of the muscles which act on them, thus permitting harmonious movements of the wrist and digits. The development and behaviour of embryonic cartilage cells constitute part of the machinery of human evolution.

Co-ordination in the Growth of Bone, Muscle, and Nerve Cells.

I have dealt with the behaviour of young cells of bone, muscle, and nerve centres in the developing embryo in order that we may appreciate the complexity of the process involved in producing a new structural adaptation of the human body. When we sit up or walk, our vertebræ are balanced one upon another by means of a complex series of muscles acting upon an equally complex series of levers, the whole controlled by intricate groups of nerve cells situated in the spinal cord and brain. The anatomical evidence[21] leaves us in no doubt that the spinal mechanism of man has been evolved from one very similar to that now seen in the anthropoid apes. Indeed in the young chimpanzee and gorilla many of man's spinal adaptations are already present. In the evolution of a human from an anthropoid spine we have to conceive, (1) that the multitudes of bone cells involved in the building of vertebral processes of the embryo were so influenced in their operations that the levers they built were altered in strength, inclination, and form; (2) the countless myriads of myoblasts involved in the formation of the spinal musculature were so influenced that they took up new positions and effected new combinations; (3) the cartilage cells, which mould the contours of the intervertebral joints, were moved to alter the shapes of the articular surfaces so as to provide the needed contours; (4) the nerve cells of the spinal cord and brain, presiding over the reflex and voluntary movements of the spinal muscles, had to undergo increase in numbers, rearrangements in grouping, and readjustment of contacts. We have to postulate that in the human embryo there exists a machinery which co-ordinates the development and growth of all the diverse hordes of embryonic cells concerned in the formation of man's spinal mechanism and causes them to move in a direction which, at all stages of evolution, yields a harmonious functional result.

Theory of Hormones.

There is only one theory which affords a rational explanation of how such complex adaptations can be brought about—the theory of Hormones postulated by Starling in 1905.[22] Although Prof. Starling devoted

[19] An account of the actions and reactions of vascular tissues will be found in the writings of W. Roux from 1878 onwards. I have dealt with the adaptative reactions of peritoneal cells in Human Embryology and Morphology, 1921, 4th edition.

[20] I have dealt with the growth reactions of bone cells at some length (Menders of the Maimed, 1919, chapters xiv., xv., xvi., xvii., and xviii.)

[21] "Man's Posture: Its Evolution and Disorders," *Brit. Med. Journ.*, 1923, 1, pp. 451, 493, 545, 587, 642, 669.

[22] Prof. E. H. Starling, "The Chemical Correlation of the Functions of the Body." The Croonian Lectures at the Royal College of Physicians. *Lancet*, 1905, vol. 2, p. 339.

the greater part of his Croonian lectures to demonstrate the part played by chemical substances or hormones in co-ordinating the functions of the body he clearly realised that hormone control formed the basal machinery of all evolutionary processes in the animal kingdom.

"In the lowest organisms, such as the bacteria and protozoa, the only adaptations into which we can gain any clear insight are those to the environment of the organism, and in these cases the mechanism is almost entirely a chemical one. . . . In the lowest metazoa, such as the sponges, there is still no trace of any nervous system. The co-ordination between the different cells of the colony is still determined by purely chemical means. . . . If, as I am inclined to believe, all the organs of the body are regulated in their growth and activity by chemical mechanisms, similar to those I have described, an extended knowledge of hormones gives complete control of the body."

We are justified, on all grounds, in looking upon the human embryo, in the earlier stages of its developing, as a colony of protoplasmic units or cells, organised under a system of government controlled by hormones. Each member of the colony, we must suppose, has the power of circularising, by means of the hormone postal system, some or all of the other members of the colony in such a way as to notify its needs and compel their co-operation. With each step in the differentiation of the embryonic tissues there must be a further elaboration in the hormone system of intercommunication and government, until the fœtal stages are reached, when the growth-regulating substances become installed in special controlling centres represented by the glands of internal secretion—the pituitary, adrenal, thyroid, etc. We know that juices expressed from embryonic tissue contain substances which stimulate the proliferation and growth of living tissues; we know from observations already cited that one group of embryonic cells can control the manner in which another group develops, but we have to admit, also, that our knowledge of the action of hormones in fashioning the growth of organs is still in its infancy. The vista presented by this unexplored field of knowledge is infinite in extent and complexity, and will provide embryologists with many centuries of labour. Their labour will reveal in full the true nature of the machinery which underlies the production of structural adaptations which occur in every part of the animal body in every stage of its evolution.

The Significance of Acromegaly.

A long and close study of the bodies of men and women who have been the subjects of that strange disorder of growth known as acromegaly, has convinced me that the system of hormones, which controls and co-ordinates the growth of various organs and parts of the body is organised, like the nervous system, on a reflex basis. There are reflexes of growth just as there are reflex actions of muscles; both kinds of reflexes serve definite purposes in the economy of the body. The glands of internal secretion provide substances which control the action of organs and of parts of the body; they also produce substances which co-ordinate the growth of the organs or parts concerned in these actions. In the subjects of acromegaly the pituitary gland is enlarged and its structure more or less disorganised; the parts of the body which respond to hard toil, such as the hands, feet, and jaws, become greatly and irregularly overgrown. All the systems of the body—muscular, bony, respiratory, circulatory, alimentary, and renal systems—are involved; all show an abnormal degree and kind of overgrowth.

We find a clue to most of the growth disorders of the human body, such as acromegaly, in a knowledge of the mechanism of normal growth. Growth disorders—dwarfism and giantism—are but derangements of the various parts of the normal machinery of growth. Sir James Mackenzie regards the symptoms of illness, manifested by suffering men and women, as derangements of the normal reflex functions of their bodies. In a like manner we may consider disorders of growth, such as acromegaly, as a derangement of a normal mechanism—that which co-ordinates the response made by the various parts of the body to exercise and training. When a man passes into training, whether it be to use his hands as a labourer, his biceps as a blacksmith, his legs as a runner, or his arms as a rower—the responsive growth is not confined to the muscles of his hand, arm, or leg. All the bones of the body respond to a greater or less degree, so do the heart and lungs, so do all the systems of his body; he has to eat and digest more. We cannot imagine such a co-ordinated functional result being brought about, one which affects every system of the body, unless we postulate a controlling system of hormones. Nor can there be a doubt that acromegaly, in all its stages and degrees, represents a diseased manifestation of this adaptational system.

To fit all the bits of this puzzle into a connected whole we have to suppose that muscles in sustained action do emit certain substances which pass into the circulation and thus reach the pituitary gland. We have to suppose that in the pituitary these substances elicit responses leading to the emission of other substances which pass into the circulation and thus reach and influence organs which are correlated in action with the muscles directly involved. We have here all the elements of a reflex system—the pituitary serving as a chief centre or hormone-brain. In acromegaly the disordered condition of the pituitary leads to a flooding of the body with adaptative hormones after the most trivial of muscular actions, and hence its unregulated growth.

Barwell's Disorder.

In the Museum of Charing Cross Hospital, Huxley's old school, there is the skull of a boy which shows a very instructive disorder of growth. It is not a unique specimen; many cases of an exactly similar kind are known. The boy came into the hospital for treatment of a tumour-like swelling of the face, for which Mr. Barwell tied the right carotid artery. The boy died, and it was found that, on the right side of his skull, all those structures which are concerned in mastication, and only the structures concerned in this function, were greatly and uniformly hypertrophied. The condition was clearly produced long before birth, for all the teeth, including those of the milk dentition, were nearly twice the normal size on the right side of the mouth. So were the jaws and all the bony struts of the face which support the jaws; so were the muscles of mastication, the temporo-mandibular joint—in short, all dental, bony, muscular, vascular, and nervous structures concerned in mastication. We cannot conceive how such disorders of growth could be so sharply limited to a single functional system unless we agree that the machinery which regulates growth and development is organised not on an anatomical, but on a functional basis.

Use-inheritance.

In the foregoing paragraphs an attempt has been made to picture the means by which the development and growth of the various cell groups, which make up the body of the embryo, are co-ordinated and controlled. Such evidence as we have justifies us in the belief that there is an automatic system of control worked by means of hormones, and that this machinery, in all its variations, tends to produce a functional or adaptational result. The very important question remains to be considered: can this machinery, which controls the differentiation of the tissues of an embryo, be influenced from without? Or does it, as Bateson believes, work on towards its destined result, in spite of all surrounding conditions and influences? The genital glands and their contents, of both man and woman, are exposed to all the substances, be they nutritive or hormonic in nature, which flood their circulatory systems. In 1906 J. J. Cunningham [23] applied the theory of hormones to the problems of heredity. He conceived it possible that the genital cells could be influenced, and so altered in their constitution, by hormones thrown off by all the organs and parts of the parent body. There is no inherent physical obstacle to prevent one from entertaining such a belief. Such a conception implies the possibility of hormones—function-regulating substances—of a parent coming into contact with and influencing the controlling action of the embryonic hormone-system. If it were possible, as is assumed in every form of Lamarckian belief, for parent products to come in contact with, and thus alter, the machinery which controls the growth of the embryo, it would be a consequence of the utmost import for mankind. By a full use of our brains, of our teeth, or of our hands, we might hope to influence the development and growth of the corresponding parts in our children.

Evidence of the Teeth.

I have selected the teeth to test the question as to the part played by use in the evolution of structural adaptations. There can be no doubt that the manner in which the crowns of man's sixteen upper teeth fit against corresponding surfaces of the lower sixteen, give us as fine a structural adaptation as we may hope to cite. There is the additional advantage that, as the teeth are the most persistent of fossil remains, we know more of this system in the forerunners of man and of living anthropoid apes than of any other parts of their anatomy. Further, in highly civilised races teeth are not only more liable to decay and to irregularities of eruption than in primitive races, but there is also, in civilised peoples, a marked tendency to a reduction in size and number of the dental series. We see, too, in the evolution of the dentitions of the higher primates, when the pattern of the enamel changes in one tooth, it changes in all of them; if one tooth alters, the opposing teeth have to alter in conformity; we see that if the dentition strengthens, all the members of the series participate; when reduction sets in, all the teeth suffer a reduction in a definite order. But these changes cannot be due to use, for the crowns of the teeth are laid down, and the opposing chewing surfaces fully formed, while the dental germs lie buried in the gums and long before the crowns come into use. When they do come into use, the teeth formed in the upper jaw possess the exact surfaces needed to oppose those of the lower jaw. After usage, especially in apes and primitive man, the opposing surfaces become worn off; if use had any effect here it would be to produce teeth with eroded crowns.

It is clear that functional adaptation, so far as concerns the production of teeth, is a property resident in the embryonic tissues; the effects of usage in the parent can have no influence on the machinery which shapes the dental crowns in the mouth of the fœtus and infant. If this is true of one system of the human body, it is probably true of all other adaptational systems—such as the brain, hand, and foot. Nature would have been foolhardy to entrust the future of any race whatsoever to the voluntary efforts or natural inclinations of the parents. As far as possible she seems to have safeguarded the progeny by isolating the gonads from the functional influences of the parental body.

The Germ-plasm can be permanently injured.

Yet there is one line of evidence which shows that the spermatozoa of the male and the ova of the female can be acted on or injured from without. Darwin [24] has related the case of a cow in which one eye was injured when she was in calf. The calf was born with the corresponding eye small and blind. In more recent years Marey [25] has recorded an identical result in a mare; one eye was injured when she was pregnant, and the foal was born with the corresponding eye small and blind. Hitherto we have been inclined to regard such cases as mere coincidences, but the well-known experiments of Guyer and Smith [26] provide a rational explanation. They injected into the veins of doe rabbits, about the end of the second week of pregnancy, doses of a substance which has a selective and toxic action on the lens of the eye. Many of the young were born with defects of the eyes—cataract of the lens being particularly frequent. When these young rabbits grew up and bred, many of their young showed the same defects. The developmental disorder could be transmitted in the spermatozoa as well as in the ova. These experiments show that the germ-plasm can be reached from without, and by means of a toxic substance can be permanently injured, so that progeny issuing from it will show ever afterwards a characteristic and localised defect. Prof. Ch. R.

[23] Hormones and Heredity, 1921.

[24] Variations in Plants and Animals under Domestication, 1868, vol. 2, p. 34.

[25] Le Déterminisme et l'adaptation morphologique, R. Anthony, 1922, p. 88.

[26] M. F. Guyer and E. A. Smith, *Journ. Experim. Zoology*, 1921, vol. 31, p. 171.

Stockard[27] induced permanent changes in the germ-plasm of guinea-pigs by exposing one generation of animals to extreme and continuous doses of alcohol. Dr. J. G. Adami[28] cites several instances of a similar nature, and has summed up the evidence relating to "the inheritance of acquired conditions in the higher mammals." Many of the cases recorded to prove acquired inheritance relate to changes which have been produced in the skin, particularly in its pigment-carrying cells. On the evidence which has accumulated there is good reason for believing that light can act upon epidermal and other elements of the skin in such a way as to effect changes in certain factors or elements of the germ-plasm. The observations and experiments made by J. T. Cunningham[29] on the colouring of flat fish, and the more recent observations which Dr. Kammerer[30] has made on salamanders exposed to light, and to dark backgrounds, can be interpreted only if we admit that reactions in the skin can affect the reproductive cells lying within the genital glands of the animals subjected to experiment. Notwithstanding this admission I do not think, as I shall mention later, that the loss of pigment in fair Europeans is due to any direct action of light on the skin. It is one thing to injure or influence the germ-plasm in such a way as to alter the machinery which controls the development of the embryo; it is quite another thing to alter that machinery in such a way as to make it produce a new mechanical adaptation. We know of no means by which the machinery of mechanical adaptation can be altered from without.

Are the Modern Conditions of Life altering the Germ-plasm of the Human Stock.

The admission that the genital cells can be injured or altered by substances circulating in the body of the parent is of the utmost consequence for mankind. The conditions of modern civilisation are making us the subjects of a colossal experiment. Six thousand years ago, our ancestors, scraping a subsistence from moor and shore, passed their days amidst the same conditions as surrounded the earliest types of evolving man. Man's body was adapted for rough fare and unregulated exposure. Modern civilisation has revolutionised the conditions of life in every detail. We use our brains, our skins, our muscles, our lungs, our teeth, stomach, and bowels, our hands and feet, for purposes which are new to them. Our tissues are kept soaked with juices containing substances which are still strange to them. Our crowded communities favour the prevalence and spread of all forms of infectious disorders in young and old. We are discovering that a rough and raw dietary contains certain elements which are essential for health. It would be strange if the evolutionary machinery of the human body kept on working in the same way as when the conditions of life were, if not simpler, yet much more primitive. A prolonged and minute comparison of human remains found in ancient and modern graves in England has convinced me that structural changes of a minor kind are affecting certain parts of the skeleton in at least one-third of modern instances. The narrow bony opening to the nose, with its jib-like nasal spine, its raised and sharp sill, so often seen in modern English skulls, are conditions never present in Englishmen of the pre-Roman periods. Contracted palates, crowded and defective teeth, deformed jaws, sunken cheek-bones do not become common in English graves until we reach the eighteenth century. The appearance of these structural changes in Englishmen cannot be attributed to the introduction of any new racial element from abroad. No doubt these facial changes are due in part to the soft nature of our food, and the disuse of our muscles of mastication.

Lack of use alone will not, however, explain the form taken by these structural alterations; they are injurious rather than helpful; they cannot be classified among the contrived adaptations. We have reason to suspect that defects of eyesight grow more common. There are grounds for believing that the great bowel, including the cæcum and appendix, becomes more liable to disorder and to disease with each succeeding generation. Twenty years ago Metchnikoff[31] expressed the belief that the great bowel of man had become a useless structure, and that he would be better off without it. The result of recent surgical experience has been to convince medical men that the man with a normal great bowel is an infinitely fitter and happier person than the man without one. The only question that remains to be settled is whether it is better to be with or without a colon which has become incurably diseased.

There is thus a certain amount of evidence to support the belief that certain parts of the body are less robust, some of them actually undergoing a structural change, in a considerable proportion of people living under modern conditions of life. There is also no doubt that these changes and susceptibilities occur much more frequently in some families than in others. To what extent these new features have become hereditary and therefore due to an injury of the germ-plasm, we cannot yet say. But in the light of experiments like those of Guyer and Smith, and of Stockard, medical men have grounds for suspecting that the source from which new generations of our race issue may not be invulnerable, that our germ-plasm may become tainted under the conditions to which our bodies are now subjected.

The Law of Recapitulation is only partially true.

In the foregoing paragraphs I have turned aside from my main thesis—the nature of the evolutionary machinery which has given man his gifts of brain and body. The nature of this machinery will never be understood by those who still harbour the belief that the human embryo, in its developmental stages, recapitulates the evolutionary history of the human body. I do not think any one familiar with the stages passed through by the developing human embryo would now agree with Huxley when he wrote:[32]—

[27] "An Experimental Study of Racial Degeneration in Animals treated with Alcohol," *Archiv Int. Med.*, 1912, vol. 10, p. 369; Proc. Soc. Experim. Biol. and Med., N.Y., 1911–12, p. 71; 1913–14, p. 136.
[28] Medical Contributions to the Study of Evolution, 1918, ch. v.
[29] Hormones and Heredity, 1921.
[30] Nature, 1923, vol. 111, p. 637.

[31] The Nature of Man, translated by Dr. P. Chalmers Mitchell, 1904; see also Keith, "The Functional Nature of the Cæcum and Appendix," *Brit. Med. Journ.*, 1913, vol. 2, p. 1599.
[32] Collected Essays, vol. 2, p. 5.

"A man in his development runs for a little while parallel with, though never passing through, the form of the meanest worm, then travels for a space beside the fish, then journeys along with the bird and the reptile for his fellow-travellers; and only at last, after a brief companionship with the highest of the four-footed and four-handed world, rises into the dignity of pure manhood."

It is true that we cannot explain the infinity of stages passed through by a human embryo, from the fertilised ovum, representing the lowest unicellular stage of living things, to the fully formed child, unless we believe that man, like all animals, has been evolved from the simplest of beginnings. But every one of these transitional stages represents a new form of being, never one of which has been seen at any stage of the world's history leading an independent adult existence. Every organ and part of the human body passes through an extensive series of developmental changes which receive a full and adequate explanation from the theory of evolution, but not one of these changes, from the first to the last, copies a form seen in any adult animal; at every point of development old or recapitulatory phases are masked by the unceasing introduction of new and individual features. The student of the human embryo and fœtus is impressed not by its recapitulatory behaviour but by the manner in which new features are being intercalated. Such facts favour Huxley's view that the machinery of evolution works in the body of the embryo uninfluenced by adult experience.

The Use made by Nature of the Capitalistic System.

Scientific men do not need to be told that capital is needed for the development and improvement of an invention; capital is as necessary for the progress of a civilisation as for the extension of a business undertaking. Nature discovered very early in the history of the world that capital is needed for evolutionary progress. A breakfast egg represents the capital set aside for the development of a fowl, and during the incubation period the stock of yolk makes possible any form of experiments which the embryonic cells may tend to make. In the higher mammals the capitalistic system has become fluid and elastic—represented by the mother's blood and milk. The placenta and all accessory structures needed for the lodgment of the young in the mother's womb were invented and elaborated by embryonic cells during the incubating stages in the development of lower vertebrates. The simple yolk capitalistic system, evolved and elaborated by the embryonic cells of lower vertebrates, became, in the higher vertebrates, transformed into the elaborate organisation which gives rise to the placenta, thus securing for the young months of free lodging. When we inquire into the nature of the process which gives rise to the placenta we find that it concerns certain embryonic cells which, in the lower vertebrates, proceed to form part of the belly-wall, part of the bowel, and part of the bladder. These same groups of cells in higher mammals have taken on themselves an entirely new purpose. Instead of proceeding to form the parts of the body just mentioned, they give rise to the placenta and membranes which envelop the embryo. Here we see that embryonic cells and the machinery which regulates their evolutions have inherent in them a power of working out the most intricate inventions and of effecting structural adaptations of the most serviceable kind.

The Genesis of Man's special Structural Features.

We need not be surprised, seeing how plastic and resourceful the embryonic tissues are, to find most—but not all—of man's characteristic features appear in a modified form as transitional phases in the fœtal stages of man's nearest allies—the anthropoid apes. Man's outstanding structural peculiarities have been produced during the embryonic and fœtal stages of his evolutionary history; the corresponding and somewhat similar characters which appear in fœtal anthropoids become masked in these animals by the superaddition of coarser animal features which develop as their intra-uterine life closes, and particularly as their adolescent and adult stages are passed. At birth the brain of the baby gorilla is almost as big as that of the human baby; but whereas the period of rapid growth continues in the human brain throughout infancy, the brain of the gorilla proceeds after birth at a slow pace. The human brain retains the rapid rate of fœtal growth for two years after birth. My friend Prof. L. Bolk[33] of Amsterdam, who has done so much to prove that man's distinctive characters represent a heritage accumulated in the fœtal phase of his development, has shown that the downward bend of the front part of the base of the skull, and the consequent backward position of the face, occur at an early point of development in all mammals. The cranial bend becomes undone and the face thrust forwards as development proceeds in all mammals, save in man, in whom these fœtal features are retained until, and throughout, adult life. The nearest approach to the adult human form occurs in the fœtal stages of anthropoid apes. The fœtal cranial bend is not a primitive or ancient character; it was worked out in fœtal life; never, until the evolution of man took place, did this feature survive to reach an adult stage.

Let us take another feature—man's hairless skin, and in the case of the white races its comparative lack of pigment.[34] In the chimpanzee fœtus, at the seventh month of development, the hair is distributed on the body exactly as in a baby at birth; there is the same long and fine hair on the scalp; the same smooth skin covered with a short, almost invisible down. The skin, too, which afterwards becomes deeply pigmented and black in the adult chimpanzee, at this stage is gray, tinged with a trace of brown. At a still younger stage the skin is almost free from pigment. The young of many of the higher primates are born with fair hair—often tinged with red. Fair hair is a fœtal character of primates which has become permanent in Northern Europeans and is found distributed

[33] "The Problem of Orthognathism," *Proc. Konin. Akad. van Wetensch. te Amsterdam*, 1922, vol. 25, Nos. 7, 8; "On the Significance of Supra-orbital Ridges in the Primates," *ibid.*, 1922, vol. 25, Nos. 1, 2; "On the Character of Morphologcal Modifications in consequence of Affections of the Endocrine Organs," *ibid.*, 1921, vol. 23, No. 9.

[34] See my Herter Lectures, "The Evolution of Human Races in the light of the Hormone Theory," *Johns Hopkins Hospital Bulletin*, 1922, vol. 33, pp. 155, 195; also Prof. C. S. Stockard's "Human Types and Growth Reactions," *Amer. Journ. Anat.*, 1923, vol. 31, p. 261.

sporadically in North Africa and Central Asia. Here again we see characters which were worked out in fœtal months passing on to become characters of adult life.

Such examples could be multiplied to a wearisome extent. I do not wish to minimise the number and importance of transient simian features which appear in the body of the human fœtus and infant; they are well known and of great significance. But I do desire to give a true interpretation to such human features as are represented by man's small face and jaws; his forehead, tending to be devoid of supra-orbital ridges; his large head poised on a long and relatively slender neck: they are features first produced in the fœtal stages of higher primates and now retained by man in his adult state. The tendency to preserve such fœtal characters is seen in certain genera of South American monkeys. But all the fossil progenitors of ape and man we have yet discovered have a face, jaws, skull, and neck of the more primitive and bestial type.

The Bearing of Fœtal Inheritance on Huxley's Conception.

I return to Huxley's disbelief in "use-inheritance" and to his conviction that animals—including man—tend to evolve "along their predetermined line of modification." It is clear that the mammalian placenta, particularly that kind of placentation which occurs in the womb of man and of anthropoids—identical systems—cannot in any way be accounted for by "use-inheritance." They have been worked out by properties inherent in embryonic tissues. The fact that the most characteristic features of the human body appear first in embryonic or fœtal life, and that human-like characters appear transiently in fœtal stages of anthropoid apes, the further fact that many constant structural modifications of man's body are seen as occasional variations of the ape's body, all bear out Huxley's dictum that evolution tends to evolve along predetermined lines of modification. The machinery of evolution works out its untrammelled ends in the embryo and the fœtus, except in so far as that machinery can be injured or deflected by what may be termed poisons of the germ-plasm. It is clear, too, that if we are to cast man's horoscope we can read the omens only in the tendencies manifested in his embryonic and fœtal stages. We can alter man's future only in that limited way discovered by Darwin—by applying his principle of selection.

A Simile.

To make my meaning clear, let me borrow a simile from human affairs. Some thirty years ago, in the incipient stages which led to the modern development of the great motor-car industry, small workshops sprang up in almost every town and supplied a car of local design for local needs. The struggle for survival set in, and successful types, ousting local types, led to the formation of great firms which catered for the needs of continents. The workmen engaged and the types of car made became specialised and standardised. These great firms, we know, keep an eye on the market—benefit by experience—and modify their types to suit demand. Invention succeeds invention in their workshops. But in the factory where human types of body and mind are produced I am presuming there is no intelligence department. I am also presuming, as Huxley did, that the workmen—the cells of the embryo—employed in turning out new human machines, are specialised into vocational, hereditary castes—each caste turning out its work in a certain way—a way which ensures a functional result. I am presuming, too, that the workmen represented by the embryonic cells are co-ordinated in their toil by an elaborate system of intercommunication—already described—the system of hormones. All hands in the human factory are co-ordinated—not by orders from managers or foremen, but by a self-regulating system of hormone-control which works out functional ends automatically. Variations—useful adaptations—are produced by a bias which is inherent in the machinery of control. The mere fact that I have to resort to so crude a simile shows how ignorant we still are of the machinery of animal evolution.

Conclusion.

John Hunter gave utterance to an important truth when he said man's bony and vascular tissues retained the same automatic purposive behaviour as is manifested by the lowest forms of organised life, such as the hydra. In the formative period of the human embryo, and on the phase when adaptational contrivances are being worked out in its heart, brain, muscles, and skeleton, the embryonic cells retain many of the purposive, almost conscious, attributes possessed by primitive unicellular organisms. No doubt the behaviour of embryonic cells, as of the simplest protozoa, will prove to be reflex in nature—mere protoplasmic reactions to appropriate stimuli. In bringing about the collective reactions of embryonic tissues, which mould them to form structural adaptations, we may presume that hormones play a leading rôle. The hormone system, to give the results it does, must be framed upon a teleological basis.

If we would rightly understand the evolution of the machinery of adaptation, or, what is the same thing, the machinery of government, in the developing body of an animal, we shall do well, as Herbert Spencer suggested, to study the evolution of a people rising from savagedom to civilisation. In the earlier stages of the evolution of human society we see that the machinery of government is represented by the automatic working of a herd-instinct—an instinct tending in all its operations towards the preservation of the community. The instinct is biassed in the direction of producing functional or effective results. We have to study what, in our present ignorance, we must call the "herd-instincts" of the vast community of protoplasmic units embraced by the body of a human embryo, if we would understand how the structural contrivances of the human body have been evolved. I, for one, believe with Huxley that the government which rules within the body of the embryo proceeds along its way altogether uninfluenced by occurrences or experiences which affect the body or brain of the parent. In short, man has come by his great gifts—his brain, his upright posture, his strange foot and his nimble hand—not by any effort of his own, but, like a favoured child of the present day, has fallen heir to a fortune for which he has never laboured.

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