THURSDAY, JULY 25, 1901.

ANOTHER BOOK ON BRITISH BIRDS.

A Handbook of British Birds. By J. E. Harting. New and Revised Edition. Pp. xxxi + 520; 35 plates. (London: John C. Nimmo, 1901.) Price 2*l.* 2*s.* net.

IT is now some years since the first edition of this book appeared. The present volume, Mr. Harting points out, is nearly treble the size of the original; and, we might truthfully add, is proportionately as interesting.

The author claims for it that,

"as an attempt to show, in one volume, the precise status of every so-called British bird, distinguishing the rare and accidental visitants from the residents and annual migrants, it conveys information of a kind which is not to be found in any other work on British birds."

Be that as it may, the present volume will prove a valuable addition to the library of every working ornithologist. More especially, perhaps, this book will appeal to the outdoor naturalist and to the "collector." But the "cabinet" naturalist will feel himself scarcely less in need of this work, for scattered throughout its scholarly pages will be found innumerable instances of Mr. Harting's intimate knowledge of his subject, both in the fields of bionomics and of literature.

It is obvious that, in a book of this kind, some sort of systematic arrangement must be followed, and Mr. Harting has been confronted with the difficult task of deciding which of the numerous systems of classification that have from time to time been proposed should be adopted in the present volume. His choice has fallen upon the one more or less in favour during the early part of the nineteeth century. A great feature of this system is the prominence given to the accipitrine birds. Mr. Harting justifies his choice in the following words:—

"The most striking character which distinguishes birds from all other vertebrates (save the *Chiroptera*) is the power of flight, and since that peculiarity is most highly developed in the falcons, which are able to overtake and capture the fastest birds upon the wing, not even excepting swallows and swifts, it seems not unreasonable on this account, if for no other, to place the raptorial birds as the highest type of the class *Aves* at the head of any scheme of classification."

Mr. Harting's contention most certainly demands our serious consideration. Nevertheless, to many the revival of this claim to preeminence for the Raptores will seem reactionary, especially to those who, after mature deliberation and ripe experience, are convinced that the headship of the class Aves must be vested in the Passerine forms, the Corvidæ standing as the type.

Strangely enough, one of the strongest supporters of the last-mentioned view, Prof. Newton, is retained, so to speak, by Mr. Harting for the other side. Justification for this is made out on the ground that Prof. Newton followed this precedent when editing the fourth edition of Yarrel's "British Birds" in 1871. But Mr. Harting has overlooked the fact that since that date the editor of this famous book has changed his views; so that in 1884 we find him, as we have just indicated, a doughty champion for "the new learning." The thirteen years that elapsed between the publication of the fourth edition of Yarrell and the masterly article in the "Encyclopædia Britannica" were memorable years in the annals of ornithology—memorable because of the brilliant work of Parker, Garrod, Gadow and Forbes; and no student of ornithology, least of all Prof. Newton, watching the development of their researches could fail to be impressed with the facts they brought to light, and, being impressed, could resist the conclusions to which these appeared to lead.

But seventeen years have elapsed since the "Encyclopædia" article was written, and in these days of prolific publication we are apt to lose sight even of the many gems buried in these ponderous tomes. Happily for us, the substance of Prof. Newton's article, "Ornithology," was incorporated in the introduction to his "Dictionary of Birds"—a book which has been aptly described as marking "an epoch in ornithology"—wherein it was probably read by many for the first time. Since this is the more accessible of the two, we will quote what Prof. Newton has to say, therefrom. In his introduction to this work, in dealing with the Passeres, he writes, "Thus we reach the true *Oscines*, the last and highest group of birds." Further on he quotes, in the strongest terms of approval, Prof. Parker's dictum, that

"In all respects, physiological, morphological and ornithological, the crow may be placed at the head, not only of its own great series (birds of the *Crow-form*), but also as the unchallenged chief of the whole 'Carinatæ.'"

And finally, towards the conclusion of the introduction, he writes:—

"It is therefore confidently that the present writer asserts . . . that at the head of the class *Aves* must stand the family *Corvidae*, of which family no one will dispute the superiority of the genus *Corvus*, nor in that genus the preeminence of *Corvus corax*—the widely ranging raven of the northern hemisphere."

Whether the crows and the forms associated therewith will be allowed to retain this preeminence—which is to-day generally recognised—time will show. This darkly suggested insecurity of tenure will come probably as a relief to Mr. Harting. He may further take heart of grace in that this indication of a "rift within the lute" has come from a no less qualified authority than Mr. Beddard, who suggests ("Classification of Birds," 1898) that the Passeres and their allies should, perhaps, be rather regarded as primitive, archaic types. "More especially," he writes, in the opening words of the discussion on this subject, "does it appear to me that ornithologists are in error concerning the position of the picarian and passerine birds," and he proceeds to adduce a number of reasons which tend to support this view—reasons which are weighty, and which demand a very careful examination from every aspiring taxonomist.

It will be perceived from the foregoing that the relative positions of the different groups of birds, one to another, are yet by no means clearly defined; therefore, until systematic ornithology assumes a more definite shape, Mr. Harting may fairly claim the right to choose for his book that arrangement which most nearly meets his own views.

In dealing with the systematic position of the swifts and swallows, Mr. Harting will again find himself in opposition to the views held at the present day, at least in this country. Mr. Harting will have it, as some have done before him, that the swifts and swallows are near akin, and brings forward in support of this contention the views expressed by such undoubted authorities as the late W. K. Parker and Mr. F. A. Lucas. But on the other side we have a still greater weight of authority, greater if only in point of numbers, no less than seven ornithologists, whose names are as household words among us, having emphatically committed themselves to the conviction that the swifts are near allies of the humming-birds. These illustrious seven are Beddard, Furbringer, Gadow, Garrod, Newton, Sharpe and Stejneger. About the finality of their decision there can be little doubt.

Other points in the scheme of classification adopted by Mr. Harting would furnish material for comment did space permit, but these are of comparatively minor importance.

In the matter of nomenclature, Mr. Harting will be accused of unorthodoxy; but in much of what he has done in this matter, and in his defence thereof, he has our sympathy.

Orthography and etymology are conspicuous features of this book, and many of Mr. Harting's observations under these heads are extremely interesting. His scholarly handling of these difficult matters will impress every reader of this work. An immense amount of labour must have been spent in digging in this, to most of us, very uninviting field. But the results undoubtedly are well worth the trouble which has been expended.

The field-notes, as might have been expected from Mr. Harting, are exceedingly interesting. We cannot help thinking that in places these could with advantage have been enlarged upon. The author is one of the favoured few who has watched the bittern in the act of "booming." This remarkable noise is, we now know, produced whilst the beak is pointed vertically upwards, an attitude commonly assumed by this bird. Till recently it was generally held that the "booming" of the bittern was made whilst the beak was thrust down either into the mud or water.

The "drumming" or "bleating" of the snipe naturally calls forth some comment from the author. Opinions differ still as to the mechanism by which this is produced. The author is confident that it derives its origin from the vibration of the primaries. Meeves, it will be remembered, contended that it owed its origin to the vibration of the outer tail feathers, which have peculiarly thickened shafts. Still later observers have tried to show that it is due to the operation of both wings and tail, a violent current of air being driven through the tail feathers by the rapid vibration of the wings.

The introduction of coloured plates constitutes a new feature in this handbook.

"They have been executed in response to a repeated demand for a book on British birds with accurately coloured plates *in one volume*."

This, it is contended, it has been possible to do by figuring the head, and sometimes the foot, only. But this demand was surely for a book giving more or less lengthy diagnostic characters, *supplemented* by coloured plates. Mr. Harting's book does exactly the reverse, for his diagnoses, which are rare, are supplementary to the plates. No one would, of course, object to this if the plates completely fulfilled their purpose. This they fail to do, inasmuch as several undoubted British birds are not figured at all. Even if the missing heads were added, the book would still be lacking, for more immature stages are necessary, and some heads must be re-drawn, being quite inaccurate. These latter, however, are very few in number.

There are thirty-five plates in all, stated in the title-page to be "from the original drawings by the late Prof. Schlegel." Only a few of these, however, are by Schlegel, the majority having been drawn by Keulemans many years ago, and some are copied from Wolf. Their arrangement must have been entrusted to a foolish person, for a more stupid, exasperating distribution would have been impossible. Instead of being placed at the end of the book, they are distributed between every ten pages of so. Thus the plate illustrating the buntings faces the text dealing with the sand grouse and capercallie, that containing the finches is intercalated between the text devoted to the pheasant, the small wading birds faces the description of the wild-duck, and so on!

But these are minor blemishes in a work of considerable value, blemishes easily remedied in a second edition which is almost sure to be demanded. The binding, printing and paper leave nothing to be desired, and the book, judged as a whole, should take high rank in ornithological literature. W. P. P.

PRACTICAL PHYSIOLOGY.

An Introduction to Physiology. By William Townsend Porter, M.D., Associate Professor of Physiology in the Harvard Medical School. Pp. xvi + 314. (Cambridge, Mass.: The University Press, 1901.)

THIS new text-book of practical physiology is interesting from two distinct points of view. It is the first important work on the subject which has appeared by an American author, and the faculty for the invention of simple yet efficient mechanical devices which is characteristic of Americans is here reflected in clearly written descriptions of inexpensive apparatus which will, in large part, be novel to the British physiologist, who has, unfortunately, grown up to believe that adequate instruction cannot be given in physiology without expensive and elaborate apparatus and laboratory fittings. But the book has other importance, in that it is an indication of the extent and nature of the teaching that can be given to the medical student under the new system of dealing with the purely scientific subjects of the medical curriculum which has recently been inaugurated at the Harvard Medical School.

The present is a most opportune time to consider any new schemes which have appeared in other lands for the teaching of these "preliminary and intermediate medical studies," as the new London University styles them, when there is so much vexation and anxiety of heart as to how concentration of teaching and saving of labour may be effected under some general scheme which will give the reconstituted University of London a medical faculty in living reality, and not merely one which exists as a coherent body only in a printed list.

If one may judge by the extent of Prof. Porter's text-book, the Harvard student is taught a wider course of practical physiology than is attempted to be taught at any of our London medical schools, and, further, if he be taught the subject in the carefully inductive manner outlined by the author in his preface, he also obtains much more true scientific training in addition to this more extensive course. The latter point is the more important of the two, for, as Prof. Porter truly puts it in his preface, "the student should be trained rather than informed," for "the trained observer can, and must, be trusted to inform himself."

This wider course is covered in a period of four months, while in this country the student of medicine spends two years over physiology. Things do go proverbially quick in America, but this is not the reason for the disparity in time; the explanation is that the Harvard man spends *all* his hours of study during those four months upon physiology, whereas in this country the medical student's time is spent in attempting to make an intimate mixture of physiology, anatomy, organic chemistry and therapeutics. At the end of the two years the result is that the British student has wasted much time in hopping about from one branch of the tree of knowledge to another, and has not spent a sufficient interval at any one sitting upon any particular branch to gain much real benefit from it. So that finally he neither knows much of the experimental facts of any one of the subjects, nor, which is of more importance still, has he gained any training in scientific method or been imbued with any of the modern spirit of scientific inquiry or research.

His weary brain has been enslaved at unpalatable task-work all the two years, grinding up, at the same time, all four of these important subjects so that he may make answer to stock questions upon them at examination time. He is not judged at all by his character as a student known to his teachers, for the good or bad work that he has turned out during that period, or for any talent or originality that he has shown. There is no attempt, nor is there time for any attempt, to allow him to show what subject he loves; indeed, the system is calculated to make him hate them all instead. He must simply grind and be ground to the same stereotyped pattern as all his fellows; he must, in short, read and struggle to pass his Inter. M.B. Ask any of these men what he is doing at any part of the period and you will hear, not that he is studying anatomy or physiology or any of the other subjects, but that he is going up for his "Inter." at such and such a date; the dominant idea is the woeful examination and how best to get through it, and not any attraction for, or interest in, his subjects of study.

For the continuance of this condition of things the teachers, and not the students, are responsible. When we introduce a rational system of studying these subjects, which will teach our students to think, to examine critically the work done by others who have gone before them and to make attempts to proceed farther by themselves, a new era will dawn in which students will take an interest in their work and will rejoice in knowing that they will be judged on what they have been doing throughout their course, and not upon the extent to which they have impaired their memories and intellects by merely memorising the opinions of other men from their text-books and lectures.

Contrasted with the scientific progress of our time, the maintenance of our present system of examinations, and the perversion of the work of our costly laboratories into mere preparation for them, instead of teaching these subjects as a training in scientific observation and research, may truly be described as conservatism run to seed.

If it be granted that our main object ought to be, during these earlier years, to give the student a training in the methods of scientific investigation in the broad field of biology, and not to cram his mind with experimental facts gathered from the text-book or lecture-room, then the system introduced at Harvard of studying one subject thoroughly at a time and, when this has been mastered, from the point of view expressed above, passing on to the next, is undoubtedly a move in the proper direction. This is more especially true in the case of the branches of biological study where a knowledge of one subject is required before another can be advantageously taken up; where there is, so to speak, a definite *natural* order in which the subjects should be taken up. The writer's one experience under our present system, to give an example, is that the first two months or more of attendance on lectures in physiology are absolutely wasted, because the student begins his study of anatomy at the same time as physiology; if he completely finished his anatomy before he came to physiology, and then had all his time for physiology, our task would be much lighter, nor would the student be handicapped at all in his study of anatomy by not having learnt his physiology. Again, he ought to have completed a course on cellular physiology and done all his minute anatomy or histology, including his practical work in histology, before he commences to study the physiology of the mammal.

Further, what advantage accrues from studying a number of subjects at the same time? The student cannot possibly become absorbed in one and grow to enjoy really the study of it, because he feels that his other subjects are becoming cold from neglect. He must, therefore, turn about from one to another, and surely no scientific progress can be made by reading in such a scrappy fashion. The person who can do it with conspicuous success is certainly not the kind of person we want to encourage; yet for such intellectual weeds we arrange a system which chokes out, or does the best that can be imagined to choke out, our choicest flowers. This furnishes a sufficient clue to the well-known observation that our men of highest genius in the past have often been those that the schools rejected, or found no occasion to honour.

The conscientious student who starts simultaneously the study of anatomy, physiology, organic chemistry and materia medica under our present system is surely to be pitied. He hears a lecture in anatomy and tries to take some interest in this; he passes on to one, say, in organic chemistry, and for the time switches his attention off anatomy on to organic chemistry; next he turns his mind to physiology, and finally, weary and baffled, he probably sleeps through a lecture on the preparations of morphia of the British Pharmacopœia. Such intellectual juggling gives the student an acquaintance with the jargon of science, but of scientific method and scientific spirit it most assuredly teaches him nothing.

Every text-book of practical physiology must necessarily be written primarily to suit the requirements of a particular laboratory and a particular teacher, since the types of instrument used in different laboratories vary much, and the selection of experiments chosen by different teachers is also a very variable quantity. Prof. Porter's book has been written to suit the requirements of the Harvard course, and a number of the instruments described have been devised by himself for that course and with a special view of combining economy with efficiency. In nearly all cases, however, the experiments described can easily be adapted to the forms of apparatus used in this country, and the directions are clear and easily followed.

The large number of simple sketches showing the student how to arrange his apparatus is a novel and important feature of the book. This is a great improvement on the usual photographs of apparatus seen in most text-books of practical physiology hitherto published, which are of no service, because the student sees the apparatus on the laboratory table before him, and on the reproductions of tracings, which have little value, since the student obtains copies for himself in the course of his work. In all cases in this book the illustrations are designed to aid the student in understanding what he is asked to do, and are not intended merely for ornament, although they are, at the same time, well drawn and reproduced.

The book is divided into two parts, of which the first treats of the physiology of nerve and muscle, and the second of the circulation of the blood. The first section is much the longer of the two, and includes many experiments which are not usually attempted in this country by the student, but are nevertheless well within his power and very instructive; as examples of this may be cited, the stimulation of involuntary muscle, polar stimulation of the heart, galvanotropism, the effect of calcium salts upon skeletal muscle, idiomuscular contraction, summation of inadequate stimuli, and the stroboscopic method of demonstrating the action current of tetanus. The second section, although shorter, also contains several experiments hitherto novel to the usual student's course.

On the whole, it may be said that the book is clearly written in an original style, and is a welcome departure from the hackneyed treatment of practical physiology which is usually presented to the student.

BENJAMIN MOORE.

AN AMERICAN INTRODUCTION TO BOTANY.

Plant Studies. An Elementary Botany. By John M. Coulter, A.M., Ph.D., Head of Department of Botany, University of Chicago. Pp. vii+392. (London: Henry Kimpton, 1901.) Price 7*s*. 6*d*. net.

DR. COULTER'S work is one of the kind now in fashion, as it is a text-book for beginners that deals argely with the bionomics or œcology of plants. The study of œcology is, beyond doubt, of value to beginners in that it immediately establishes a sympathetic interest in the plant as a living organism, which has wants to satisfy, a policy to pursue and warfare to wage. Yet a scientific survey of a plant's life in relation to environment is, in most respects, possible only after a thorough investigation into the physiology and structure of many plants; in other words, an œcological truth is rarely susceptible of brief and simple proof. Consequently, in placing this branch of the subject before the student at the outset of his studies there is always a danger of cramming the beginner with principles of which no adequate proofs are given, or indeed possible at that stage. In a work of small size like the one before us it was impossible for the author to give proofs of more than a few principles, and he has elected to lay stress rather upon the illustration of principles than upon their accurate demonstration. The work is therefore hardly adapted to serve as an introduction to scientific botany for the use of students working without a teacher's aid; nor does Dr. Coulter intend that it should so serve; he states definitely that the book is intended to supplement the teacher, the laboratory and field-work.

The first 220 pages are concerned in the consideration of the general œcology of plants and of special "societies" (hydrophytes, mesophytes and xerophytes). Though the views expressed are for the most part those to be found in the works of Kerner, Warming and Schimper, there are not wanting cases in which the author enunciates views that are unwarranted; for instance, very dubious in relation to the protection of flowers is the significance of the water reservoirs of the teasel and of *Bilbergia* (p. 136). Lacking in proof, too, is the statement, "In certain parts of the tropics the air is so moist that it is possible for some plants to obtain sufficient moisture from this source, without any soil-relation or water-relation" (p. 98). On p. 123 the term cross-pollination is made to include geitonogamy despite of the different physiological effects of the two processes.

While arousing interest and stimulating a certain kind of intelligent observation, the book hardly encourages close reasoning or accurate language. It is ever a question as to when the rigid precision of technical terms may give place to vague elasticity of more familiar language. And in this respect the author can hardly be congratulated. Such expressions as "earth influence" (in relation to geotropism), "light influence" (in relation to heliotropism), "soil roots," "water roots," "air roots," "soil-related," "leaf-related," "light-relation," "life-relation," "life-process," "seed plants," though strongly reminiscent of the Fatherland, hardly seem to be improvements either on ordinary English or on appropriate technical expressions. At times, indeed, it is not easy to grasp the meaning of some of the sentences; for instance, after telling us that a root "is either an absorbent organ or a holdfast, or very often both," the author continues, "For such work no light-relation is necessary, as in the case of foliage leaves; and there is no leaf-relation, as in the case of stems" (p. 89).

The latter half of the book briefly considers selected groups of cryptogams, and gives an outline of the general characters of "flowering plants," which last Dr. Coulter terms "spermatophytes."

Dr. Coulter's work is richly and excellently illustrated, a number of the illustrations being original. For this reason, and, further, because the author touches on questions elsewhere treated only in much larger works, the book may be found useful to such students as can employ it, as Dr. Coulter intends, merely to supplement the theoretical and practical instruction of a competent teacher.

OUR BOOK SHELF.

B. Eyferth's Einfachste Lebensformen des Tier- und Pflanzenreiches. Naturgeschichte der mikroskopischen Süsswasserbewohner. Dritte, vollständig neubearbeitete und vermehrte Auflage. Von Dr. Walther Schönichen und Dr. Alfred Kalberlah. Pp. 700. Taf. 16. (Brunswick: Benno Goeritz, 1900.)

THIS new edition of Eyferth's work will no doubt be of great use to students of microscopical forms of both vegetable and animal life. It includes representatives of most of the European families and genera of minute plants and animals, and there are sixteen excellent photographic plates giving typical illustrations of the genera. The nomenclature adopted for the botanical sections is that of Engler and Prantl in their "Natürliche Pflanzenfamilien," and the authors state that all recent additions to this branch of scientific literature have been taken into consideration, more especially with regard to results and conclusions arrived at by special workers at the various groups. The species enumerated, and to which are appended short descriptions, are stated to be representative ones about which there is no uncertainty of determination; but in the family Desmidiaceæ the species included are by no means representative, many of the very commonest ones being left out in preference for others which are uncommonly rare and hardly likely to be observed by the ordinary student of microscopical forms of life, for which person the book is undoubtedly written. One also wonders at the inclusion of Naegeli's genus *Oocardium* amongst the Desmids, and the presence of such useless genera as *Holocanthum*, *Schizocanthum*, *Pleurotaeniopsis* and *Pleurenterium*, which are introduced directly from Engler and Prantl. A most typical genus of the blue green algæ—*Gloeochaete*—is placed in the Rhodophyceæ, and so is *Porphyridium*, which has most claim to be regarded as a reddish form of a blue-green, Aphanocapsa-like alga. The animal sections are given rather more completely than the vegetable, but the nomenclature of the Sarcodina seems to be considerably erroneous. The systematic position of *Hydrurus foetidus* amongst the Protozoa is truly remarkable.

G. S. WEST.

Handbook of British, Continental and Canadian Universities, with special mention of the Courses open to Women. Supplement for 1901. Compiled for the Graduate Club of Bryn Mawr College by Isabel Maddison, B.Sc., Ph.D. Pp. 70. (Pennsylvania: Bryn Mawr College, 1901.)

THIS is a supplement to a handbook published in 1896 to show the courses open to women in universities. As practically all European universities and colleges are now open to women, the original title was modified when a new edition was called for in 1899, and the book has become a short guide showing for the benefit of men as well as women the university systems, requirements, &c., of various countries. The present supplement contains corrigenda and addenda, bringing the handbook up to date as regards the lists of professors, lectures and the constitutional changes. Though the book is not to be compared with the Minerva Jahrbuch in point of value for reference, it may be of service to educationists interested in the facilities for the higher education of women.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Subjective Lowering of Pitch.

MR. SHERWOOD (p. 233) seems to have misunderstood my meaning. I did not intend to imply that a singer should be conscious of his own flatness (*i.e.* if loudness causes subjective lowering of pitch), but that his voice, being relatively loud to himself, should sound to him flatter than it really is; and that he would try to counteract the impression by singing sharp. This is the reverse of experience. A singer having a good ear for external music, but singing flat, evidently hears his own voice *sharper* than it really is. Such a singer keeps his voice up better in a chorus, or when the accompaniment is loud enough to produce a subjective impression as strong as that of his own voice.

Malvern, July 14. F. J. ALLEN.

Phototherapy.

As stated in NATURE, July 11, p. 259, Prof. Finsen of Copenhagen proposed, in 1893, that patients suffering from small-pox should be kept in rooms from which the chemical rays of light are excluded by means of red curtains or red glass. He was anticipated in this treatment by John Gaddesden, who wrote the famous medical treatise "Rosa Medicinæ," and died A.D. 1361. He cured a son of King Edward I. of small-pox by wrapping him in scarlet cloth in a bed and room with scarlet hangings. He says of the result, "est bona cura; et curavi eum in sequenti sine vestigio variolarum," "Dict. of Nat. Biogr.," and "Biographie Générale." M. H. CLOSE.

THE CONGRESS ON TUBERCULOSIS.

FOR some time past most elaborate preparations have been made for this Congress, and latterly it was feared that, owing to the postponement that was necessary on account of the death of Queen Victoria, the attendance, especially of workers from abroad, might be seriously affected. Fortunately, this anticipation has not been realised, and from the list of delegates and the number and importance of the papers promised there appears to be every prospect of a most successful and useful series of meetings.

If the work of the Congress was to be of an educational nature, it could scarcely be hoped that much time could be devoted to new work; and that it would be educational in the best sense of the word soon became evident. Certainly few congresses have succeeded in arousing such interest in matters affecting the health and general welfare of the community.

From the King, who gave his patronage, to the numerous municipal representatives and delegates of learned and philanthropic societies all classes seem to be represented; and that the interest aroused is not merely on paper is evident from the list of those who were present at the opening meeting on Tuesday. The Duke of Cambridge presided at the command of the King, and was supported by the American Ambassador and other Ministers and Ambassadors, the Duke of Northumberland, Earls Derby, Cawdor, Spencer and Cadogan, Lord Lister, the Lord Mayor and a whole host of distinguished scientific men. The Colonies were well represented by Lord Strathcona, Sir Andrew Clarke, Sir Walter Peace and others, whilst the Foreign delegates numbered between two and three hundred. The work of bringing a goodly company together had evidently been in competent hands. Will the work of the Congress be equally good? So far this question may be answered in the affirmative; and should the rest of the meetings be as successful as those of the first and second days, the Congress will have thoroughly justified its existence.

The Secretary General in his opening report referred to the Pathological Museum as one of the chief educational works of the Congress, and there can be little doubt that no such collection of tuberculous specimens has ever before been brought together. Every known tuberculous lesion in man and in the lower animals is illustrated, and every bacillus that in the smallest degree resembles the tubercle bacillus is represented. Classical specimens of Potts, Addison and Astley Cooper are all shown, and of specimens of later date a really typical collection has been made. After other features in the history of the Congress had been alluded to by the Secretary General, the Congress was declared open and a telegram was sent to the King. An answer to this telegram, wishing the Congress all success, came before the close of the meeting. The delegates were then addressed by the Marquis of Lansdowne, Earl Cadogan, the Lord Mayor of London, Lord Strathcona and Lord Lister, whose remarks are reported by the *Times* as follows :—

He said they met under immeasurably happier auspices than could possibly have been the case not many years ago. Thanks to the labours of the illustrious man who would address the general meeting on the following day, they now knew the enemy they had to deal with, which before the discovery of the tubercle bacillus was shrouded in impenetrable obscurity. They also knew, thanks to Pasteur, that that microbe was incapable of originating *de novo* in the human body; that, while some constitutions were more prone to its invasion than others, it must always be derived from similar organisms in the external world. Hence there came to be opened up the splendid prospect of the prevention of tuberculosis. But it was by no means only prevention that they were looking at. They also aimed in the present day at the cure of consumption. In this respect matters were very much more hopeful than they had been till quite recently. The physician might learn a great deal in this point of view from the experiences of the surgeon. There were a great many surgical complaints which they now knew to be just as much tubercular as pulmonary consumption—that was to say, they were just as much due to the growth of the tubercle bacillus. Yet the surgeon knew that in many of these cases the disease might be completely cured ; that, in consequence of the means—of which they were getting to know more and more every day—which the animal organism had of resisting microscopic invaders, the tubercle bacillus was not only arrested in its progress, but swept away altogether, and the result came to be a healthy state of the tissues and parts in which it was. These experiences showed that tuberculosis was not necessarily an incurable disease. That was an immense point to have demonstrated. Thus, they were not surprised to learn that physicians were coming to look upon the cure of consumption more hopefully than they used to do, by treating it on recognised principles and on the same broad, general lines as surgical tuberculosis. For his own part, as a surgeon, he had had cases of pulmonary disease brought but little under his notice; but he had been surprised, even in his limited experience, at the numerous cases among his own patients in which people who many years ago had consumptive lungs had subsequently become free from all traces of the disease and had lived healthy, robust and useful lives. These cases he ventured humbly to regard as cases of cure of consumption. Then there were attempts now being made by the use of various specific means to deal with consumption even in its more advanced forms. He must not refer to that at the present time further than to say that some of them at least had very promising aspects. They might be sure that these means would be most carefully considered by the Congress, and he need not say how cordially he hoped and anticipated that their deliberations would be fraught with good There was another point in which he believed the Congress would be useful besides the concentrated wisdom of the eminent men who had come as delegates to take part in it. If the prevention of tuberculosis was to be effectively carried out, the general public must aid the physician and the surgeon in the endeavour. He anticipated that that splendid gathering of scientific men from all parts of the world, meeting under Royal patronage, for which he might venture to express their profound gratitude, would indicate to the public the vast importance of the work they were engaged in and would lead to their cooperation in the endeavour to minimise and possibly eventually to stamp out entirely the greatest scourge of the human race.

Some idea of the standing of the delegates may be gathered from the following list of those who were presented to H.R.H. the Duke of Cambridge, and who spoke, each on behalf of his nation :—Prof. Osler, from the United States of America: Prof. von Schrötter, Austria ; M. le Senateur Montefiore Levi, Belgium ; Prof. Charles Gram, Denmark ; Prof. Brouardel, France ; Prof. von Leyden, Germany ; Prof. Thomassen, Holland ; Prof. Frédéric Koranyi, Hungary ; Sua Eccellenza Senator Enrico di Rienzi, Italy ; Prof. Holmboë, Norway ; Prof. Cortezo, Spain ; Prof. Hofmarshal Printzsjöld, Sweden : Dr. Louis Secretan, Switzerland. Greece and Roumania were also represented, as well as the Universities and all the medical societies and public health bodies in the kingdom.

The work of the Congress has been arranged in four sections. In the first all questions concerning the relations of the State and municipalities to the prevention of tuberculosis are to be discussed, and if the number of papers announced is any criterion, little should remain undiscussed at the conclusion of the Congress. The second section deals with medicine, including climatology ; the third with pathology, including bacteriology ; and the fourth with tuberculosis in animals.

In addition to the purely sectional work, three general addresses will be given. The first of these, by Prof. Koch, of Berlin, dealing with the preventive measures to be taken in connection with tuberculosis, is printed in full in this number ; Prof. Brouardel, of Paris, will give the second address ; and Prof. McFadyean, of the Royal Veterinary College, the third. Prof. Koch is also announced to open a discussion on tuberculin—a discussion that should be of a very interesting character.

The "social" programme is unusually attractive, but in no way interferes with the efficient working of the important or business meetings of the Congress. We shall watch with interest the further proceedings of the Congress.

THE LIQUEFACTION OF HYDROGEN.

THE liquefaction and solidification of hydrogen form the last of the definite stages, so far, in the progress towards the absolute zero of temperature. To make the account of this stage clear, it will be necessary to compare it briefly with those which preceded it.

During the third decade of the last century, Faraday found that, whereas different substances have different boiling-temperatures at ordinary pressure, or different condensation-pressures at ordinary temperature, the lowest boiling point could be lowered further by reducing the pressure artificially. Thus by exhausting with a vacuum-pump the vapour from a vessel containing solid carbonic acid, he was able to obtain cold intense enough to liquefy a large number of gases exposed to the low temperature and, at the same time, to considerable pressure. This may be called the vaporisation method of cooling. Pictet in 1877 showed how its effect might be intensified by using the cold so obtained by the low-pressure boiling of one substance, such as sulphur dioxide, to condense at high pressure some more volatile gas, such as carbonic acid, the subsequent boiling of which at reduced pressure would produce a further reduction of temperature. The successive falls of temperature obtained in this way have caused this to be known as the cascade system of refrigeration. Pictet himself thought that by this means he succeeded in liquefying and solidifying hydrogen, and, though this was probably a mistake, the method has proved a very useful one. By the choice of more suitable substances, carbonic acid and ethylene, Wróblewski and Olszewski in 1883 succeeded for the first time in cooling oxygen or air to such a low temperature that under moderate pressure it condensed and remained as a visible liquid, of which, when it was allowed to boil at ordinary pressure, a portion remained liquid at a lower temperature. This cascaded vaporisation method, the direct descendant of Faraday's system, was subsequently used by Dewar in improved apparatus on a larger scale, and was the only means of obtaining considerable quantities of liquid air down to 1895. Attempts were made by others than Pictet to apply it to the liquefaction of hydrogen. But the critical temperature of hydrogen, above which no pressure can liquefy it, is so low that even air boiling into a vacuum at, say, -210° C., or solid nitrogen at -225° C., is not cold enough to cool it below its critical point. If an intermediate gas could have been found, with a critical point high enough to admit of its being condensed under high pressure at the lowest temperature of liquid air, and boiling under reduced pressure at a temperature below the critical point of hydrogen, the problem would have been solved. Nature having provided no such gas, Dewar tried to make one by mixing nitrogen and hydrogen, in the hope that, after the manner of oxygen and nitrogen in air, they would liquefy together. Olszewski made a similar attempt with a mixture of oxygen and hydrogen; but no one succeeded in liquefying hydrogen by the employment of vaporisation cooling, though intensified by cascading in four stages.

Meantime, another method of obtaining a cooling effect had been employed. Thomson and Rankine had shown theoretically in 1852, and Giffard practically in 1873, that if compressed gas be allowed to expand in a cylinder doing work against a piston, the work done externally is represented by a corresponding diminution of the heat-energy of the gas. Similarly, if an iron vessel containing highly compressed gas have the valve opened, the contained gas is forcibly driven out against the resistance due to the generation of a very high velocity. The work of driving it out against this resistance is at any moment being done by the expansion of that which remains inside the vessel, and this remaining gas is cooler in virtue of the work so done. This is the cooling of a gas by work-expansion. In 1877 Cailletet made use of this method to give the first definite practical proof that it was possible to liquefy oxygen, then known as a permanent gas. The vessel in which he had it enclosed under high pressure was a strong glass tube of small bore, which was surrounded by liquid sulphur dioxide or nitrous oxide to give the compressed oxygen a preliminary cooling. The opening of a water-valve then allowed the gas to do the work of driving some water forcibly through, and the gas, after this work-expansion, was so much colder that part of it was condensed into a visible, though evanescent, mist or vapour of oxygen. In 1884 Wróblewski and Olszewski applied the same method to hydrogen, using for preliminary cooling the lowest temperature of liquid air under reduced pressure, and obtained a similar result. Thus a combination of cooling by work-expansion with preliminary cooling by cascaded vaporisation succeeded in practically proving that hydrogen could be liquefied, though it was not possible by any such combination to keep, examine and work with liquid hydrogen.

But there is a third method of cooling a gas—that of free expansion. In the case of the iron vessel containing compressed gas, that gas which is at any moment expanding from the valve is found to be colder immediately after expansion than it was immediately before, though it has, in the act of expansion, done no tangible external work such as it does when expanding within the vessel or behind a piston. It has, however, displaced atmospheric air, given itself considerable residual momentum, and overcome the forces of intermolecular and intramolecular attraction. In virtue of this work done, it has undergone some cooling, the cooling of free expansion. This cooling from free expansion is much less for a given change of pressure than that from work-expansion, or that from vaporisation; so much so that Thomson and Joule had proposed no use for it, and great practical authorities, Siemens and Coleman, had declared that nothing could be accomplished by it—a judgment apparently confirmed by the abortive result of Piazzi Smyth's persevering efforts to utilise it. It is obvious, however, that if there were a method of refrigeration in which the cooling could be continually intensified by accumulation, this method would have a great advantage and would lead ultimately to lower temperatures than other methods which had the benefit of greater initial cooling. This proved to be the case with the method of free expansion. In 1894 Hampson proposed to intensify continually the cooling on this method by accumulating in the compressed gas to be expanded all, or nearly all, of the refrigeration produced by the free expansion of previous portions. This was to be done by letting the compressed gas expand through a nozzle or valve from one end of a long tube and making all the gas, when expanded, immediately return over the tube which it had previously traversed as compressed gas towards the expansion-valve. In the course of this return it cools the succeeding portions of compressed gas which are flowing past it inside the tube, so that as they pass to the expansion point they contain all the cooling which has been previously effected. Thus the compressed gas is continually expanding from a lower temperature than before, and is consequeutly reaching, with the added expansion-cooling, a lower temperature than had been reached by previous portions of expanded gas. This intensification goes on until the cooling is great enough to liquefy a small portion of the expanding gas. The losses in this system are due to imperfect interchange of temperature between the compressed and the expanded gas and to the penetration of external heat, so that its performance depends on the efficiency and compactness of the interchanger or counter-current accumulator. This method of obtaining intense refrigeration involves the combination of free expansion of gas (not liquid) with intensification by counter-current interchange. Hampson constructed and worked his apparatus in 1896, and in its present form it begins liquefying air in less than ten minutes without employing auxiliary refrigerants. A process involving substantially the same combination was invented at or near the same time by Linde, who, in 1895, succeeded in liquefying air with it in fifteen hours. His form of apparatus has since liquefied air in two hours, but requires auxiliary refrigeration in the form of ice and salt or a subsidiary ammonia machine.

The special advantage of the Hampson or Linde method for the liquefaction of hydrogen is that it can take gas at an initial temperature from two to three times as high as its critical temperature, and cool it progressively to the point at which it condenses continuously, without the assistance of any substance boiling below its critical temperature—a condition which had been the stumbling-block of the methods employed by Wróblewski, Olszewski and Dewar. With such an appliance available it would seem that the last difficulty in the way of liquefying hydrogen had been removed. Joule and Thomson, however, had observed that hydrogen, on free expansion, instead of being cooled, is actually heated a little. But they had also observed facts which showed how this difficulty could be overcome. The amount of cooling on free expansion varies with the expansion-temperature and with the nature of the gas. Firstly, as to temperature. The lower the initial temperature the greater the cooling for a given degree of expansion, the variation being inversely proportional to the square of the temperature on the absolute scale. Thus, for every atmosphere that the pressure falls in expansion, air at normal temperature is cooled about a quarter of a degree Centigrade. But expanding from three-quarters of that temperature, or −56° C., it is cooled nearly twice as much, or half a degree, for each atmosphere that the pressure falls. And Thomson considered that, if allowed to expand from an initial temperature of 100° C., it would undergo no cooling at all. The differences of cooling for different substances point in the same direction. Joule and Thomson found that gases which are at a lower point in the scale of corresponding states show more cooling on free expansion than others. Thus oxygen, which is not so far above its critical point as nitrogen, shows more cooling; and carbonic acid, which is actually below its critical point, shows much more. It was a reasonable conclusion then that hydrogen also, if it were made a much less perfect gas by being cooled down to a temperature not much above its critical point, would undergo considerable cooling on free expansion. Early in 1896 Onnes calculated that if hydrogen were cooled to −210° C. before free expansion it would be in the same position in the scale of corresponding states as oxygen expanding from −20° C. Now oxygen expanding from −20° is in a very favourable condition for cooling on free expansion, for it can be liquefied by that method from an initial temperature of +30° C., and hydrogen can readily be cooled below −200° C. by air boiling at low pressure.

In 1898 Dewar had an apparatus constructed to work on the principle above described, and succeeded in collecting hydrogen as a stable liquid, thus obtaining temperature which he subsequently estimated by platinum-resistance thermometer at −238·4° C., or 34·6° A., by constant-volume hydrogen thermometer at −253° C., or 20° A. Later, he boiled liquid hydrogen at low pressure and found it to be, like nitrogen and carbonic acid, one of the substances which readily freeze themselves by evaporation. In the solid hydrogen thus obtained he reached the lowest temperature known, which he estimated at from 13° to 15° A.—temperatures confirmed by his subsequent observations by helium thermometer.

Liquid hydrogen has already been turned to useful account in scientific work by Ramsay and Travers in their researches on the rare inactive gases of the atmosphere. For the purpose of obtaining pure neon by a process of fractional distillation, it was necessary to have so low a temperature that liquid hydrogen had to be employed as a cooling agent. To make this, Travers designed an apparatus on the plan described above, to work in combination with a Hampson air-liquefier which they had at their disposal. The plan involved the preliminary cooling of hydrogen by liquid air at low pressure and its further cooling by free expansion with intensification by counter-current interchange. The Dewar form of the apparatus appears, from such descriptions of it as have been published, to be on the same general plan. The Travers apparatus is fully described, with a drawing to scale, in a paper by its designer in the *Philosophical Magazine* for April 1901. For the present purpose a clearer idea of its working will be obtained from a simplified diagram of it, such as is here given. To avoid complexity, the insulation, the joints and many other details have been omitted.

The operation is as follows: hydrogen is compressed in a pump, the plungers of which are lubricated with water, to a pressure of about 200 atmospheres. The lubrication water and any hydrogen dissolved in it or blown off with it pass together from the water-separator by the tube T for further separation at low pressure in a chamber guarded by a water-seal, whence the gas returns by U and O to the gas-holder. The high-pressure gas from the compressor and a drying purifier passes by the tube A through a coil in the vessel B, containing solid carbonic acid in methylated spirit, by which the hydrogen is cooled to −79° C. Thence it passes through the coil C in another vessel containing liquid air, and the temperature is thereby reduced to about −185° C. In the next vessel lower it is reduced, in the coil D, to a temperature below −200° C. by liquid air boiling at reduced pressure. The liquid air for this purpose is admitted, as required, by the valve E from the vessel above; and the low pressure is maintained in the vessel D by an exhaust-pump connected with it by the tube F and the passage R S. The compressed hydrogen at the temperature of low-pressure liquid air then passes through the coil K in the vessel P, forming the counter-current interchanger, and so reaches the expansion-valve M. It is in this lowest vessel that the operation takes place which has made the liquefaction of hydrogen possible. The vessel and coil K have been previously reduced to the temperature of low-pressure air in the following way. The vessel is connected with the exhaust-pump through the annular passage L and the tube F by opening the tap G and closing H. The tap Q at the bottom of the vessel having

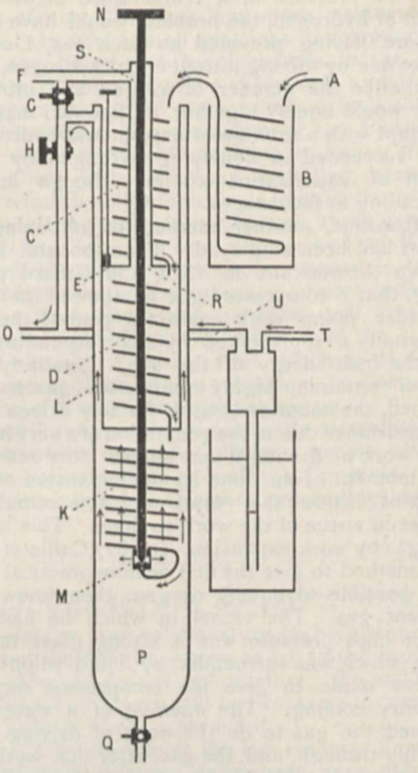

FIG. 1.—A, from compressor ⟶ high-pressure gas; M, expansion-valve ⟶, low-pressure gas; O, to gas-holder; F, to exhaust-pump; T, from water-separator of compressor.

been opened, a supply of liquid air is drawn up into the vessel by the suction of the exhaust-pump; and the tap being then closed, the exhaust pressure causes the liquid air to boil at a reduced temperature, cooling the vessel P, the coil K, and the compressed hydrogen within it to about −205° C. The vessel is now cut off from the exhaust-pump by reversing the taps G and H, which remain in the position shown, and the remaining liquid air is drawn off again through Q, which is then closed. The valve M is now opened by turning the spindle controlled by the hand-wheel N, and the hydrogen at about −205° C., issuing into the chamber P, is cooled by free expansion through, say, 10°, to −215° C., and then returns by the passage L and the pipe O to the gasholder. But before doing so it begins the process of intensification by passing over the coil K and giving up to this coil and the high-pressure hydrogen within it the ten degrees of additional cooling below -205° C. which it had gained by expansion. Thus the high-pressure gas which succeeds it reaches the expansion-valve at -215° C., and expanding from a lower temperature gains by free expansion a greater amount of cooling, say 15°, so that it now passes away over the coil at -230° C. and cools to this temperature the compressed gas by which it is succeeded. This intensification proceeds until the cooling reaches the boiling point of hydrogen at the pressure obtaining in P. That pressure is practically atmospheric, since the vessel communicates with the gasholder, which is sealed by a few inches of water. Liquid hydrogen then collects in the lower part of the vessel P.

One of the results of liquefying hydrogen has been to show that helium is a still more volatile gas. It is possible, therefore, to reach a lower temperature than that of liquid—probably even than that of solid—hydrogen by applying to helium the same process of free expansion with intensification by counter-current interchange which has succeeded in liquefying hydrogen. But helium is an exceedingly rare gas, so that the cost of further advances will be very great. Moreover, the most volatile gas probably becomes solid and loses practically all vapour-tension at a temperature above the absolute zero, so that for the attainment of that interesting point no combination of the three methods of cooling above described will suffice. Some fourth system of pumping energy will have to be devised before any portion of matter can be absolutely deprived of heat, and it is for the discovery of this fourth method that onlookers interested in low temperature research are now waiting.

PROFESSOR TAIT.

IN the month of February, Prof. Tait, owing to a lingering illness, resigned the chair of natural philosophy in the University of Edinburgh. Since then the graver symptoms of his illness had somewhat abated, and it was hoped that he might live to enjoy some years of rest and relaxation.

This hope was disappointed by his sudden death on July 4, at Challenger Lodge, Wardie, whither he had been removed for change of air on the invitation of his friend and former pupil, Sir John Murray.

The end of his blameless life and brilliant career brings to many an irreparable gap in their circle of friendship, and to the University of Edinburgh the loss of her chief ornament. Of late years Tait had confined himself more and more to his class work, to the management of the affairs of the Royal Society of Edinburgh, and to the pursuit of his manifold scientific investigations. But, although his direct participation in University affairs diminished, his colleagues never lost the impression that a great man dwelt among them, and not one of them would have dreamed of taking action in a matter likely to interest Tait without considering his opinion. To those who knew him intimately, and therefore loved him, the coming years will never fill his place, although they may alleviate the sense of loss by weaving around it happy memories of flashes of his keen and rapid intellect, of the merry geniality and quaint eccentricity of his singularly beautiful character, and of his staunch, almost quixotic, devotion to an approved cause or to a friend.

Tait was in most senses an Edinburgh man. He was born at Dalkeith on April 28, 1831. His early education was obtained at the Dalkeith Grammar School, and at the Circus Place School in Edinburgh. Like his namesake, the late Archbishop of Canterbury, Tait was a distinguished pupil of the Edinburgh Academy; and loved to tell amusing stories of his mathematical master, Dr. Gloag, whose stern, eccentric character was one of his favourite recollections. At the University he studied for a session under Kelland and Forbes. The former became his colleague and lifelong friend, and he cherished the memory of the latter even in such insignificant matters as the details of class-certificates and class-examinations; and, when the priority or credit of Forbes's work was called in question, he defended him with a ferocious knight-errantry that surprised those who knew Tait little and seemed so characteristic and charming to those who knew him well.

Some of Tait's Academy schoolfellows are still alive, and they speak of him with a mixture of love and respect which shows that he must have been a leading figure among them. Clerk-Maxwell was his most intimate school and college friend, and the friendship thus begun continued to the end of Maxwell's life, absolutely undisturbed by the fact that the two were rival competitors for the Edinburgh chair in 1860. The two men were in truth the Damon and Pythias of British science. Each in his special way was strong in mathematics, both had intense love for physical science, and both were men of wide and varied culture. Each understood perfectly both the strong and the weak points of the other, and both were men of playful disposition and of absolute frankness and sincerity. Those who have occasionally seen letters that passed between them will readily agree that their correspondence should be preserved with a view to ultimate publication; for it would undoubtedly prove one of the most interesting scientific documents of the nineteenth century.

The promise of the two illustrious Edinburgh friends was amply fulfilled in Cambridge. Tait was senior wrangler and first Smith's Prizeman in 1852, being then twenty-one years of age, and Maxwell was second wrangler and first Smith's Prizeman, equal with Routh, in 1854. They were happy in their private tutor, William Hopkins, of whom Tait always spoke with the highest appreciation, and to whose tuition he attributed with characteristic generosity much of the mathematical skill which doubtless came to him by the grace of God. He often contrasted the method and spirit of Hopkins' teaching with the work of the modern coach; but in his depreciation of the latter he perhaps scarcely allowed enough for the brilliancy of Hopkins' pupil and the altered circumstances of the tutor of to-day.

Into the boisterous joviality of Cambridge undergraduate life in his time Tait entered fully, and one often envied the boyish zest with which in middle age he would recall the part he had taken in many a college prank at Peterhouse in his youth. He was, indeed, all his days a sympathiser with the frolics and the foibles of ordinary men, and his stately figure and the genial smile on his rugged, manly face will be as much missed on the green at St. Andrews and in the smoking room of the "Royal and Ancient" as it will be in the quadrangle of the University. Tait was a keen golfer, and for forty years his invariable recreation was an annual holiday at St. Andrews, which he spent mainly on the links. He watched with great delight the triumphal progress to the championship of his amiable son Freddy, and it was said, probably with truth, that Freddy's fame was dearer to him than his own scientific renown. There is little doubt that Freddy's untimely death in the South African war and the agonising weeks of suspense that preceded the final news of his fate hastened the onset of his father's last illness, and it is certain that it darkened the close of a singularly placid and happy life.

In 1854 Tait was appointed professor of mathematics in the Queen's College, Belfast, and there he became acquainted with Andrews the chemist, and through him with Rowan Hamilton the mathematician. These two men exercised a decisive influence on his future life, and, as was his way, he repaid them both with the tenderest regard and reverence. Andrews stimulated his love for well-directed physical research, and helped him to cultivate that marvellous power of clearly apprehending and plainly formulating both the facts and the theories of natural philosophy which was the greatest part of his genius as a physicist. Through the works and personal influence of Hamilton he was led to the study of quaternions—the source and inspiration of his most important contributions to pure mathematics.

In 1860 he was elected to the chair of natural philosophy in Edinburgh, which he was to hold for forty years with ever-increasing distinction. In that time a great army of students[1] has passed through his class room, and few have done so without carrying away with them the image of a great man and a notable teacher. A select number, not a few, have caught some of the original fire of their master and have gone abroad upon the earth to spread his ideas and practise his methods.

Of late years, mainly from want of funds, the laboratory equipment of Edinburgh University has been temporarily eclipsed by grander installations elsewhere; but it must never be forgotten that Tait was one of the first teachers in Great Britain to organise laboratory teaching for his students. Among his first "researchers" were a remarkable trio—Robert Louis Stevenson, William Robertson Smith and John Murray. No man but Tait could have drawn forth and brought together three men so highly distinguished, so utterly different. The popular estimates of the contributions of Murray and Stevenson to science would likely be correct; but it is probably not generally known that Robertson Smith made at least one important contribution to physical science, and was for a time Tait's assistant. He visited his old master regularly as long as he lived, and adored him, as everyone did, without exception, who had once come under his influence.

It appears to have been about the time of his appointment to the Edinburgh chair that Tait first became personally acquainted with Lord Kelvin. Kelvin (then William Thomson) was also a Peterhouse man, but had left Cambridge before Tait came up, and was already, independently and in conjunction with Joule, and concurrently with Rankine and Clausius, writing his classical memoirs on the theory of energy. The first edition of Tait and Steele's "Dynamics," published in 1856, does not, so far as a rapid examination could detect, contain either of the words *work* or *energy*. In its original form it was founded on Pratt's "Mechanical Philosophy," and written on the old-fashioned Cambridge lines, which knew not of Lagrange and Hamilton. Six years later it is on record[2] that in his introductory lecture Tait handled the notions of the "energetic" school with a freedom which bewildered his uninitiated hearers, and laid down the broad lines of a thoroughly modern course of natural philosophy. Probably, therefore, he had come under the influence of Joule and Kelvin before he became personally intimate with the latter. The conjunction with Kelvin produced the famous treatise on "Natural Philosophy," by Thomson and Tait, now familiarly known as T and T′. This wonderful book was published in 1867, and at once began to make a new era in mathematical physics. At first, owing to its highly condensed structure, its influence spread very slowly; but now it would be impossible to find an important treatise, or even a course of college lectures, on natural philosophy that does not show traces of its teaching. The work, it is true, is but a fragment, but the continuation is to be found in dozens of treatises written by men who have been nourished by the strong meat of its serried pages. The collaboration was so perfect that it is not easy to point out the parts due to Kelvin and to Tait.[3] During a somewhat intimate acquaintance, extending well over twenty years, the present writer never heard Tait drop a hint that would enable one to fix on any part of the great treatise as his special work. Its authors always spoke of it and quoted it in an oddly distant way, as if it had been the work of some third person. The two distinguished coadjutors were compelled, by diverging spheres of activity, to dissolve their partnership in T and T′; but, however divided their spheres, they were in scientific aim, as in friendship, undivided to the last.

Since the last paragraph was written, Lord Kelvin has favoured the writer with a note on Tait's early intimacy with himself, and on their collaboration in T and T′. This we reproduce verbatim for the readers of NATURE.

"I first became personally acquainted with Tait a short time before he was elected professor in Edinburgh; but, I believe, not before he became a candidate for the chair. It must have been either before his election or very soon after it that we entered on the project of a joint treatise on natural philosophy. He was then strongly impressed with the fundamental importance of Joule's work, and was full of vivid interest in all that he had learned from, and worked at with, Andrews. We incessantly talked over the mode of dealing with energy which we adopted in the book, and we went most cordially together in the whole affair. He gave me a free hand in respect to new names, and warmly welcomed nearly all of them.

"We have had a thirty-eight years' war over quaternions. He had been captivated by the originality and extraordinary beauty of Hamilton's genius in this respect, and had accepted, I believe, definitely from Hamilton to take charge of quaternions after his death, which he has most loyally executed. Times without number I offered to let quaternions into Thomson and Tait, if he could only show that in any case our work would be helped by their use. You will see that from beginning to end they were never introduced."

Tait's contributions to our text-book literature began with Tait and Steele's "Dynamics," already mentioned. His friend Steele (second wrangler and second Smith's Prizeman in his own year) died early, and wrote but a few chapters of the book. It was so much altered in successive editions that the retention of his name on the title-page became simply a pious tribute to the memory of a friend. The "Elements of Quaternions," begun in 1859, but, in deference to Hamilton, not published till 1867, went through three editions, and along with the "Introduction to Quaternions," by Kelland and Tait (1873), formed, and still forms, the best approach to the science of S, T and ∇. The "Sketch of Thermodynamics" (1868), originating in articles in the *North British Review* (1864), and Balfour Stewart's "Heat" (1866), were for long the only readily available source of information for English readers on the theory of energy, and both contributed powerfully to the growth of the "energetic" school of natural philosophy. "Recent Advances in Physical Science" (1876), a series of popular lectures for professional men, is one of the raciest of his books, and the most useful for the general reader. "Light" (1884), "Heat" (1884) and "Dynamics" (1895), republications of articles written for the "Encyclopædia Britannica," are all models of their kind, clear, forcible and concise, like everything he wrote. Those who wish to have an idea of how Tait taught should read "Properties of Matter," which embodies a considerable part of the course he usually gave to his elementary class.

Although Tait rarely spoke on matters relating to the Unseen, and in general avoided theological controversy, his intimate friends were well aware that he held decided views on such matters. The writer well recollects the grim humour of a Homeric battle at the Edinburgh Evening Club between him and Thomas Stevenson (father of Robert Louis), occasioned by the introduction into the conversation, by some malicious friend, of the

[1] The writer of an excellent notice in the *Scotsman* has estimated the number at about 10,000.
[2] See an admirable appreciation of Tait in the *Glasgow Herald*.
[3] This is almost the only point on which we differ from the writer of the *Scotsman* article.

subject of the Shorter Catechism. It was, therefore, no surprise to some when he and Balfour Stewart proved to be joint authors of "The Unseen Universe" (first printed privately in 1875). This remarkable book reflects the extraordinary width of Tait's knowledge and of his interest in things known and unknown; its success, so far as its immediate object was concerned, is best described by Tait himself in an obituary notice of Balfour Stewart.

"It has passed through many editions, and has experienced every variety of reception—from hearty welcome and approval in some quarters to the extremes of fierce denunciation, or of lofty scorn, in others. Whatever its merits or demerits, it has undoubtedly been successful in one of its main objects, viz. in showing how baseless is the common statement that 'Science is incompatible with Religion.' It calls attention to the simple fact, ignored by too many professed instructors of the public, that human science has its limits, and that there are realities with which it is altogether incompetent to deal."

Tait's scientific memoirs are being republished in three goodly volumes by the Pitt Press, two of which have already appeared. It is therefore unnecessary to do more than allude to the most important of them. The subjects range over pure and applied mathematics and experimental physics. The majority of the mathematical papers are written in the quaternion notation, and this has undoubtedly prevented some of them from becoming so well known as they deserve to be. We may mention specially two papers on Fresnel's wave surface (1859); a series of papers on the properties of "nabla" (∇), and on the linear and vector function, extending from 1867 to 1900; on the rotation of a rigid body about a fixed point (1868)—a paper of great power and elegance, which exhibits Tait's mathematical power at its best; on Green's and other allied theorems (1870), on orthogonal isothermal surfaces (1872); on knots (1877, 1884, 1885), a series of three papers suggested by the problem of the possible configurations of a Thomson vortex atom. In the three classical papers last named he virtually creates a new chapter in the geometria situs, and is brought into relation with the work of Listing, for whom he had the greatest respect. To this subject he returns again in two subsequent papers: a note on a theorem in geometry of position (1880), and on Listing's topologie (1884).

His first experimental work was on ozone, in collaboration with Andrews (from 1856 to 1860). He also began to work with the same distinguished investigator on the compression of gases, but this was interrupted by his removal to Edinburgh in 1860. His memoir on thermal and electric conductivity contains the result of an elaborate series of experiments extending over ten years. The original idea of the method was due to Forbes, but the complete theory and the difficult details are the work of Tait and his pupils. The memoir on mirage is a remarkably elegant and effective combination of experimental and mathematical methods, and is, perhaps, the best example of Tait's work as a natural philosopher. His investigation of the pressure errors of the *Challenger* thermometers was an intricate piece of experimental work extending over several years. It led him into the discussion of the compressibility of liquids, to which are devoted five memoirs (1893-1898). This investigation brought him into close relations with the French physicist Amagat, for whom he had a great regard. Much work is embodied in five papers (1886-1892) on the foundations of the kinetic theory of gases, in which he endeavours to analyse into their logically simplest elements the first principles of a difficult and much-debated subject. His interest in the game of golf produced three important papers on impact (1888-1892), and two on the path of a rotating spherical projectile. On this subject he also wrote a series of popular articles which were widely read and appreciated.

Besides his text-books and original memoirs, Tait contributed assiduously to the current scientific literature of his day. We may mention in particular his article "On Energy" in *Good Words* (1863); his memoirs of Hamilton (*North British Review*, 1866) and of Andrews (along with Crum Brown, 1888); his famous lecture "On Force" (British Association, 1876), so cleverly parodied in Maxwell's poem—

"Ye British asses who expect to hear
Ever some new thing, &c.";

his article "On the Teaching of Natural Philosophy" (*Contemporary Review*, 1878); his fine appreciation of Maxwell's scientific work (NATURE, vol. xxi. p. 317, February 5, 1880), and his various contributions to the ninth edition of the "Encyclopædia Britannica."

Limitations of time and space, and others besides, make it impossible to attempt here any appreciation of the relative importance of Tait's original contributions to the science of the Victorian age. For one thing, the sense of bereavement is too near to us to permit of the necessary historical abstraction. Nor is this the time to enlarge on the polemical discussions in which Tait took part. Ready to take a blow, he did not always spare his strength in giving one, and his opponents did not always relish his rough play. It may be doubted whether many of them carried for long any resulting bitterness; but undoubtedly some of them were led, temporarily at least, greatly to mistake his character. Personal contact with him at once dissipated any such misconception. To feel the magic of his personality to the full it was necessary to visit him in the little room at the back of his house, No. 38 George Square, Edinburgh, the Spartan simplicity of whose plain deal furniture and book-shelves, unpainted, unvarnished, ink-spotted, littered with books and pamphlets and with piles of manuscript bristling with quaternion symbols, was so finely in tune with the tall, rugged figure, the loud, hearty greeting and the radiant, welcoming smile of the kindly host. Ten minutes in that sanctum would have made a friend of his bitterest foe, and the conquest would have been mutual and permanent, for it seemed to be an axiom of Tait's that a man who had become his friend could sin no more. Thither came at various times Joule, Andrews, Kelvin, Stokes, v. Helmholtz, Rankine, Clerk-Maxwell, Balfour Stewart, Rowland, the Wiedemanns (father and son), Adams, Newcomb, Huggins, Newton, Lockyer, Hamilton (at least in the spirit), Cayley, Sylvester, Hermite, Cremona, Clifford, Klein, Bierens de Haan and many more, the majority, alas! now departed like their common friend. It has been the main part of our endeavour to indicate, faintly at least, some of the qualities that attracted and retained such a galaxy of friends; the most potent of all was doubtless the oldest, the simplest ground of liking—he was loved so well because he loved so much.

G. CHRYSTAL.

NOTES.

THE Hughes Bennett laboratory of experimental physiology, which has been added to the University of Edinburgh by Mrs. Cox as a memorial of the work of her father, Prof. J. Hughes Bennett, in connection with medical education, was formally handed over to the University on Saturday last. The addition comprises a large laboratory equipped with appliances for practical work in experimental physiology by individual students, and a small lecture theatre for class demonstrations. The memorial character of the new laboratory is indicated by a bronze bas relief representing Hughes Bennett, which has been executed by Mr. MacGillivray. This is fixed to one of the walls of the laboratory, with an inscription below it commemorating the fact that Hughes Bennett was the first teacher in

Scotland to apply the microscope to the clinical investigation of disease. At the opening ceremony on Saturday, Sir J. Burdon Sanderson, Bart., formerly a pupil of Bennett, delivered an address upon his life and work. Referring to the work to be done in the laboratory, he said, "The laboratory is intended for researches in experimental physiology, by which term was meant the application of the methods derived from physics and chemistry to the investigation of vital phenomena—*i.e.* to the processes which were peculiar to the living organisms. Bennett used to teach in the old days that the scientific method of study was always comparative. It consisted in comparing the unknown with the known, the more complicated phenomena of disease with the simpler ones of health, in bringing their imperfect understanding of vital processes into relation with the clearer notions of natural philosophy. It was thus that physiology, which was at first little more than an introductory study to that of medicine, had been built up into an independent branch of natural knowledge which has its own special aim, the elucidation of the nature of vital processes, but derived its methods of investigation from physics and chemistry. He was sure that all present would cordially join with him in wishing Prof. Schafer success in carrying out the noble purpose to which Mrs. Cox has devoted her munificent gift." Prof. J. G. McKendrick, who was an assistant of Bennett's thirty years ago, proposed a vote of thanks to Sir John Burdon Sanderson, and it was seconded by Sir John Batty Tuke. Sir William Muir, in closing the proceedings, expressed the indebtedness of the University to Mrs. Cox for her munificence.

WE regret to see the announcement of the death of Miss E. A. Ormerod, whose studies of injurious insects for many years made her a distinguished authority on agricultural entomology. Miss Ormerod was seventy-four years of age.

THE Paris correspondent of the *Times* announces the death of the eminent zoologist, Baron Henri de Lacaze Duthiers, at the age of eighty years. M. de Lacaze Duthiers began life as a medical student in Paris, and in 1854 became professor of zoology at Lille. After his appointment in 1862 to a mission in the Mediterranean, he wrote his famous book "Le Corail." Three years later he became professor of natural history at the Museum, and in 1868 was given a chair at the Sorbonne. In 1871 he succeeded M. Longet at the Academy of Sciences. His activity in the foundation of marine laboratories at Roscoff and at Banyuls-sur-Mer—institutions which were partially endowed by himself—was not the least of his contributions to science.

THE council of the British Medical Association has awarded the Stewart prize to Dr. Patrick Manson, F.R.S. The prize was founded by the late Dr. A. P. Stewart, to be awarded biennially for the recognition of important work already done, or of researches instituted, and promising good results regarding the origin, spread and prevention of epidemic disease with a view to encourage the continuance of the same. It consists of an illuminated certificate and a cheque for 50*l.* The Scientific Grants Committee of the Association has allowed 350*l.* for scientific grants and 650*l.* for research scholarships. In the latter sum is included the separate scholarship known as the (200*l.*) Ernest Hart memorial scholarship. The total amount which has been spent in scientific research through this committee since its institution in 1874 is 15,998*l.*, independently of 1650*l.* granted to societies and bodies outside the Association.

IN connection with the subject of the subjective lowering of musical pitch, Mr. Harding's theory referring to it (p. 103), and a suggestion made by Mr. E. C. Sherwood (p. 233), Mr. G. W. Hemming thinks the following experiment should be made by some one with the necessary instruments:—"Set siren A to middle C. Set siren B (say) half a tone lower. Sound A loud and B soft. Then by gradually varying the loudness of one of them a point should be reached at which they would appear *to the ear* as a unison. If this cannot be done, there must be some error in Mr. Harding's theory." Mr. Hemming's experiment would test Mr. Sherwood's point, but it does not seem to be able to settle the original statements. "These," writes Mr. Harding, "can easily be tested by means of *one* siren rotating on a table, the ear of the observer being alternately lowered towards, and raised from, the table (which intensifies by its resonance); a point will soon be found beyond which the sound appears flattened."

THE *Revue générale des Sciences* for July 15 contains an interesting article by M. André Blondel on oscillographs. The principles of these instruments have already been described in NATURE (vol. lxiii. p. 142), more particularly in reference to the various types of bifilar oscillographs worked out by Mr. Duddell. M. Blondel gives descriptions of the two types of instrument which he has himself perfected and used with such great success in his researches on the arc, namely a bifilar oscillograph similar to those of Mr. Duddell and an oscillograph in which the moving part consists of a ribbon of soft iron. In a comparison of the relative merits of the two different types, M. Blondel considers that the bifilar instrument is the more suitable for laboratory work on account of its great sensibility and accuracy, but that the soft iron type is to be preferred for industrial purposes as it is less fragile and more portable. None of M. Blondel's instruments seem, however, to be so compact as the small portable pattern recently shown by Mr. Duddell at the Institution of Electrical Engineers. An ingenious point in the design of M. Blondel's instruments is that the vibrating parts for different purposes—projection or research work—are all made to fit into the same magnet, thus allowing a simple and rapid change to be made according as the instrument is required for one purpose or the other. A continuation of the article, dealing with the application of oscillographs, is promised.

IN *Symons's Meteorological Magazine* for this month, Mr. W. H. Dines contributes a paper on the fallacy of one of the explanations given in meteorological works as to the unexplained double diurnal barometer wave. The fallacy referred to lies in assuming that the inertia of the air can act like a containing vessel with only a small hole in it. If a barometer were placed in a sealed vessel, the changes in level of the mercury would follow the changes in the temperature of the air inside, but if a sudden change of temperature occurs in the lower layers of air, or a sudden increase of vapour tension, an oscillation of the barometer would occur, but with only an extremely small period, instead of lasting for hours. The author remarks that warmth reduces the height of the barometer, provided there is time for the upper part of the warmed column to roll off; but could a space be enclosed by a wall reaching to the upper limit of the air, no variations of temperature in the enclosed space could affect the barometer in the slightest degree. A mathematical statement of the question is given for any one who wishes to go into the matter. Dr. Mill gives a short note on the recent extreme heat in New York. The daily maxima do not appear to have exceeded 100° in the shade, but the night minima were frequently more than 80°, so that little difference of temperature was perceptible indoors between day and night. The humidity was also exceptionally high. It is said that special permission was given for people to sleep in the public parks. The worst part of the heat wave was from June 28 to July 4, during which time the deaths in the streets were so numerous that many bodies had to be buried without identification.

WE have received from Mr. J. Elster and Mr. H. Geitel an account of their further experiments on electrical dispersion in closed air spaces (*Physikalische Zeitschrift*, No. 38). They, and Mr. C. T. R. Wilson of Cambridge, had previously arrived independently at the result that the air, notwithstanding the exclusion of all known influences that increase its electric conductibility, is by no means a perfect insulator, owing to the existence of ions, and that the rate of dissipation increased beyond its original amount in the course of a few days. A possible explanation of this behaviour seemed to be that dust-laden air is a worse conductor than air which is dust-free; it might be assumed that the increase of conductibility was due to a gradual self-purification of the air by the deposition of the dust-particles. To a certain extent this assumption is correct, but as it appeared doubtful that the dissipation was due solely to the air becoming dust-free, artificial means of purifying the air were tried. A minute description of the apparatus employed is contained in the article in question. The principal result arrived at is that the gradual increase of electric conductibility observed in closed air-spaces up to a certain limiting value can only be very partially due to the deposition of dust, or to variations of humidity. This is shown in a striking manner in the abnormally high conductibility of the air in cavities, and in cellars which have been closed for some time.

SIR W. J. L. WHARTON, K.C.B., the hydrographer, has presented his report upon the Admiralty surveys made during the year 1900, and it is published as a Blue Book. H.M. surveying vessels were all fully employed and good progress was made in each survey; 1167 miles of coast line were charted, and an area of 10,733 miles was sounded during the year. Dr. Fowler and an assistant were taken on board the *Research* in order to carry out, at the request of the Royal Society, zoological investigations in deep water about 150 miles southwestward of Ushant, the object of the observations being the determination of the vertical limits at which various forms of marine life exist. The surveying vessel, *Gladiator*, was taken to Larne Harbour, Ireland, with the view of ascertaining the truth of reports that the Maiden Rocks cause serious local magnetic disturbances. No such effect was, however, found. A chain of magnetic observations for variation was made at sea by the officers of H.M.S. *Rambler*, on the east coast of Africa off Durban, Beira, Mozambique, Zanzibar, Guardafui and the Arabian coast. The observations are said to show that considerable alteration has taken place of late years in the rate of change of the magnetic declination. During a voyage from Albany to Tasmania, H.M.S. *Penguin* obtained deep-sea soundings at regular intervals 130 miles apart. The greatest depth obtained was 3040 fathoms.

THE composition of alloys employed for bronze medals is referred to by Sir W. C. Roberts-Austen, K.C.B., in the report of the Deputy Master and Comptroller of the Royal Mint. He points out that of late years a change has gradually been effected in the metal used for striking medals which are known by the general name of bronze. Until comparatively recently such medals were invariably struck in copper, which subsequently received a superficial coating mainly consisting of oxide of copper, and the medal was said to be "bronzed." Such a "patina" was formerly imparted to the copper medal by heating it in contact with oxide of iron. The Japanese have long shown their remarkable skill as art-metal workers by employing a wet method, by the aid of which a wide range of shades of brown can be imparted to copper. The solutions are used boiling, and a variety of verdigris, known as "Rokusho," and sulphate of copper are their main constituents. The Japanese, moreover, are very successful in imparting a more or less translucent but permanent coating to the copper, which in fine examples of their art reveals the crystalline structure of the metal beneath the "patina." Sir William Roberts-Austen states that in the years 1897–98 more than 28,500 medals, in commemoration of the Jubilee of Her Majesty the late Queen, were so treated, and the specimens which have been preserved in the Mint show no diminution in the brilliancy of the tints which were originally imparted to them. Many European mints are following the Paris Mint in efforts to replace pure copper by copper alloyed with other metals. Analyses of coins of the reign of Hadrian and Trajan show that the alloys contained about 87 or 88 per cent. of copper and 7 to 11 per cent. of zinc, the remainder being made up of tin, lead, iron and silver, with traces of arsenic and antimony. Sir William Roberts-Austen remarks that modern medallists are working with alloys which resemble those from which the coins mentioned were struck, so that the medallist of to-day is returning to the ideas developed in ancient Rome.

A NEW rangefinder, invented by Prof. G. Forbes, F.R.S., was on view at the Bisley rifle meeting. The want of a rangefinder that is portable and workable, that has not more than two per cent. inaccuracy at 3000 yards, and that does not require a telescope so large as to require a stand, is much felt for infantry work, especially with maxims. All these conditions, says the *Times* correspondent at the meeting, are met by the one in question. It consists of a folding aluminium base, six feet in length, which can be folded in the middle and strapped across the back, and a field-glass carried in the usual fashion. The base is a square tube, hinged at the middle. Each half has at each end a doubly reflecting glass prism. The rays of light from a distant object strike the outer pair of these four prisms, are reflected at right angles along each tube, and are then reflected at the two middle prisms into the two telescopes of the binocular, which can be easily fixed to the centre of the base when in use in directions parallel to the original rays intercepted by the outer prisms. By the measurement of the angle between these rays the distance of the object looked at is determined. This angle is measured by two vertical wires, one in each telescope, seen by the two eyes. One of these wires is fixed, the other moved by a micrometer screw until the two wires appear as one at the same time that the object is seen distinctly. The instrument gives the distance, in the hands of an ordinary observer, at 3000 yards to within 60 yards, at 1500 yards to 15 yards. The 6 ft. base folds to 3 ft. 3 in. and weighs under 3 lb.

IN the *Revue générale des Sciences*, Dr. Guillaume, of the Bureau des poids et mesures, discusses the laws of radiation in reference to their application to incandescent mantles. Dr. Guillaume considers that the high intensity of the Auer light is due partly to the fact that the coefficient of radiation of the mantle is exceptionally high towards the blue end of the flame, partly to the temperature of the flame itself being, as the author shows, higher than has been commonly supposed, and partly to the density of the radiating substance being largely in excess of that of the carbon in an ordinary combustion flame. The high temperature of the mantle is probably attributable to the fact that its coefficient of radiation decreases rapidly towards the red end and infra-red of the spectrum, so that the total radiation is relatively small in comparison with the radiation of rays of short wave-length. Dr. Guillaume quotes the work of Messrs. Le Chatelier and Boudouard, and suggests that the coefficient of radiation of the mantles for infra-red rays presents an interesting field of study. It seems probable that as the wave-length increases, the coefficient may decrease to a minimum and may increase again in a region considerably distant from the visible spectrum. The substances used by von Welsbach thus exhibit gaps in an easily explored region of their emission-spectrum, and we may expect to obtain, with little difficulty, results differing considerably from those furnished by the study of substances whose radiation is more nearly uniform.

THE skin of the okapi, the new mammal discovered by Sir Harry Johnston in the Semliki Forest between Lakes Albert and Albert Edward, has been mounted for the Natural History branch of the British Museum by Mr. Rowland Ward, of Piccadilly. For a time it will be exhibited in the North Hall, among the domesticated animals, but will eventually be placed alongside its nearest living relatives, the giraffes, in the lower mammal gallery. The skin and two skulls were recently exhibited by the Director of the Museum at an evening meeting of the Zoological Society, on which occasion the name Okapia was proposed for this very remarkable mammal, the specific title *johnstoni*, previously suggested by Mr. Sclater on the evidence of two fragments of skin, being adopted. As now mounted, the okapi presents a considerable resemblance in form to a small, short-limbed and short-necked giraffe, although furnished with the large ears characteristic of all forest-dwelling animals, and with an absolutely peculiar type of coloration. No such important discovery has occurred since the giant panda (Æluropus) was made known to the scientific world in the 'sixties of last century. Prof. Ray Lankester's description of this most interesting animal will be anxiously awaited by all naturalists.

WITH no less than seven reports and other technical documents before him, the writer of the article on the "Decay of our Sea Fisheries" in the July issue of the *Quarterly Review* takes a very serious, not to say pessimistic, view of the situation, and deplores the lack of interest in the fishing industry exhibited by Parliament. It is urged that, with far larger interests at stake, we spend much less money on inquiries connected with our fish-supply than other nations, and that the case for interference, based on the falling-off in the yield of inshore-grounds, is fully established. In this respect, indeed, we are suffering from an improvidence which would have been absolutely fatal in other industries; and the one excuse that can be made for legislative inactivity is that our knowledge of the life-history of our food-fishes is at present far too incomplete to permit of the drawing-up of really effectual regulations and amendments. Trawling as now practised is unhesitatingly condemned; while the importance of returning to the sea the spawn of newly-caught fish is strongly urged. There is, however, another aspect of the subject which has received too little attention. This is the great increase which, owing to protection, has of late years taken place in the numbers of our sea-birds. "No one," writes the author, "who has any sense of fairness blames the trout-hatcher for dealing summarily with the herons, otters, chub, pike and eels that invade his stews; and, if it becomes clear that there are no longer fish enough for both ourselves and the cormorants, it may be in like manner necessary to decide that charity shall begin, and end, at home." It may be added that attention is drawn to the value and importance of the researches carried on by the Liverpool Marine Biological Association and kindred bodies.

IN their Report for the year 1900 the executive committee announce that the New York Zoological Society is in a much more satisfactory financial position than it has ever been before, mainly owing to the liberality of the city. It is felt, however, that the Society does not receive adequate support from private citizens, and strenuous efforts are being made to raise the number of members to 3000, the total at the commencement of the present year being just short of 1000. The most important feature in the Report is an illustrated article by Mr. W. T. Hornaday on the wild sheep of America, the main object of this communication being the description of a hitherto unrecognised type inhabiting part of the Yukon valley. For this animal the name *Ovis fannini* is proposed. According to the illustration, it appears nearly allied to the white Alaskan bighorn, but has a large grey saddle on the back.

WE have received from the director of the Missouri Botanical Garden an elaborate paper on garden beans, by Mr. H. C. Irish. It deals with the species cultivated in America of the genera Phaseolus, Dolichos, Vigna, Glycine, and Vicia, and with their very numerous cultivated varieties, which are described in detail. Like so many of our cultivated fruits and vegetables, the scarlet runner and the kidney bean are unknown in the wild state. The broad bean is stated to be a native of Africa, and to be one of the oldest vegetables in cultivation. De Candolle says that it was cultivated in Europe in prehistoric times. The ten plates illustrate the very great variety in the seeds of the same species produced under cultivation.

IN the *Proceedings* of the Royal Academy of Sciences of Amsterdam, Dr. W. Burck has an interesting note respecting a possible provision of nature for preventing hybridisation in plants. He finds from experiment that the pollen-grains of different species vary very greatly in their sensitiveness to the action of the same chemical substance. Thus with some plants a very small quantity of lævulose greatly promotes the emission of the pollen-tubes, while with others it causes the pollen-grains to burst. Saccharose and dextrose have not the same effect as lævulose. He suggests that there may be present in the stigmatic secretion, not only substances which promote the emission of the pollen-tubes in that particular species, but also substances which act injuriously on the pollen of foreign species.

THE interesting discovery by Baron Toll of buried glaciers from the Glacial period, covered with more recent Post-Glacial deposits containing branches and roots of *Alnus fruticosa*, under the 74th degree of latitude, on the Great Lyakhoff Island of New Siberia, has already been mentioned several times in these columns. We have now received the thirty-second volume of the "Memoirs" (*Zapiski*) of the Russian Geographical Society, the first fascicule of which contains Baron Toll's memoir in full, with several interesting photographs. Three of these represent cliffs of glaciers ("fossil glaciers," as Baron Toll describes them), which are masses of ice, not of river ice, or of ice formed in clefts, but undoubtedly of a glacial ice, dating from the Glacial period, and covered with more recent layers of soil; while two other photographs represent layers of soil containing remains of *Alnus fruticosa* and a species of *Salix* deposited above the ice. The branches and the roots of the former are well seen on the photograph, while the catkins which were found by Baron Toll show that these trees, which now do not spread beyond 70° N. lat., grew on the New Siberian islands during the post-Glacial period. As to the mammoth, the rhinoceros and other extinct mammals, it seems impossible, since the researches of Fr. Schmidt, Tcherskiy, Bunge and Toll, not to accept the last author's conclusion, namely: "The mammoths and the other contemporary mammals lived on the spots where we now find their relics; they died out owing to a change in the physico-geographical conditions of the region. The bodies of these mammals, which have not died in consequence of some sudden catastrophe, were deposited in a cold region, partly on river terraces, and partly on the shores of lakes and on the surfaces of the glaciers, and there they were gradually buried in loam. They have been preserved in the same way as have been preserved the masses of ice underneath, owing to a permanent and perhaps increasing cold."

THOSE who are interested in the local antiquities, church and domestic architecture, folklore and antiquarian odds and ends of the counties of London, Middlesex, Essex, Herts, Bucks, Berks, Surrey and Kent, cannot do better than read *The Home Counties Magazine*, in which a number of brightly-written and well-illustrated articles on these various topics will be found.

THE Scottish archæologists should be happy, as they have a very useful bone of contention in the age of the crannog recently discovered at Dumbuck in the estuary of the Clyde. The Rev.

H. J. Dukinfield Astley warmly asserts its Neolithic origin and attacks Dr. Robert Munro for doubting this view. The weighty arguments of Dr. Munro are parried by Mr. Andrew Lang in his characteristic manner. Those who care to see the present position of this pretty quarrel should consult the current number of the *Reliquary and Illustrated Archaeologist*. Doubtless the problem will be threshed out in Section H of the British Association at the meeting in Glasgow in September next.

THE "Picts' houses" of Scotland are a perennial source of discussion to antiquaries, and Mr. David MacRitchie, who has long studied the Pictish question problem, describes in the *Reliquary and Illustrated Archaeologist* (vol. vii. 1901, p. 89) a series of interesting complicated bee-hive huts round which earth has been heaped. Mr. MacRitchie suggests that the series is as follows:—(1) The primitive subterranean "Picts' houses," consisting of one or more chambers and reached by a low narrow gallery. (2) Circular buildings with several chambers round a central one, the walls rising to a height of 12 to 15 feet and culminating in a "bee-hive" roof. (3) Brochs or forts, similar in ground plan to the last, rising as ring-like towers, with staircases in the walls and the central area unroofed.

THE May number of the *Physical Review* contains a good portrait of the late Prof. Fitzgerald, reproduced by photogravure. Dr. Larmor contributes an appreciative notice of the life and work of the lamented investigator, whose death all men of science sincerely deplore.

Feilden's Magazine will celebrate its second anniversary on the first of next month. During its short life it has shown what a good engineering magazine can be, and has maintained a high standard both in its first-class illustrations and in its text, which has been graphic and well up to date. On this account we are glad to express the wish that its future may be long and prosperous.

THE fifth part of "A Manual of Surgical Treatment," by Drs. W. Watson Cheyne, F.R.S. and F. F. Burghard, has been published by Messrs. Longmans, Green and Co. The subject is the treatment of the surgical affections of the head, face, jaws, lips, larynx and trachea, and one of the main divisions is on the intrinsic diseases of the nose, ear and larynx, by Dr. H. Lambert Lack. Dr. A. Whitfield gives an account of the method of removing superfluous hairs by electrolysis. The negative electrode from a battery of about five Leclanché cells is connected with a needle which is introduced into the neck of the hair follicle. The patient is then instructed to grasp firmly the positive electrode, and after a few seconds bubbles of hydrogen can be seen issuing from the mouth of the follicle. Shortly afterwards the needle is withdrawn, and after a moment or two the hair may be pulled out very easily. If the operation has been successful, Dr. Whitfield says that the hair will slide out of the follicle without offering the slightest resistance, and will bring the inner root-sheath with it. About forty hairs can, on the average, be taken out at one sitting.

THE additions to the Zoological Society's Gardens during the past week include a Campbell's Monkey (*Cercopithecus campbelli*) from West Africa, presented by Mrs. Morrell; a Lion (*Felis leo*, ♂) bred in Ireland, presented by Mr. Rowland Ward; an Alligator (*Alligator mississippiensis*) from Southern North America, presented by Mr. W. S. Foster; four Crossed Snakes (*Psammophis crucifer*), a Rough-keeled Snake (*Dasypeltis scabra*), two Rufescent Snakes (*Leptodira hotamboeia*), five Rhomb-marked Snakes (*Trimerorhinus rhombeatus*) from South Africa, presented by Mr. A. W. Guthrie; five Red-headed Weaver-birds (*Foudia madagascariensis*) from Madagascar, two Yellow-rumped Seed-eaters (*Crithagra sulphurata*) from South Africa, six Waxbills (*Estrelda cinerea*) from West Africa, two Nutmeg Birds (*Munia punctularia*) from India, presented by Mr. E. S. Foot; two Antillean Boas (*Boa diviniloqua*) from St. Lucia, presented by Mr. Walter Graham; an Algerian Skink (*Eumeces algeriensis*) from North Africa, presented by the Rev. F. Jervis-Smith, F.R.S.; two Peba Armadillos (*Tatusia peba*), three Brazilian Tortoises (*Testudo tabulata*), a Blue and Yellow Macaw (*Ara ararauna*) from South America, a Short-billed Toucan (*Ramphastos brevicarinatus*) from Central America, a Reticulated Python (*Python reticulatus*) from the East Indies, six Spiny-tailed Mastigures (*Uromastix acanthinurus*), three Grey Monitors (*Varanus griseus*) from North Africa, deposited; a Lion (*Felis leo*, ♂) bred in Ireland, received in exchange; two Crested Screamers (*Chauna cristata*) from Buenos Ayres, two Hoopoes (*Upupa epops*), European, a White-fronted Amazon (*Chrysotis leucocephala*) from Cuba, two Red Under-winged Doves (*Leptoptila rufaxilla*) from Guiana, purchased.

OUR ASTRONOMICAL COLUMN.

THE TOTAL SOLAR ECLIPSE, MAY 18, 1901.—Since the provisional telegraphic reports immediately after the eclipse there has been little further information as to the exact procedure of the various parties, but an article in the *Times* of July 20, 1901, gives a more comprehensive series of particulars.

Considering the adverse meteorological conditions, the observations in general must be classed as successful, as out of the fifteen stations occupied along the line of totality, determinations of some kind were made at thirteen places. In respect to the special investigations based on the unusually long duration of totality, however, the results are practically useless. Chief among these unsuccessful attempts were the large scale photographs of corona by Prof. Barnard, the spectroscopic determination of the rotation of the corona by Messrs. Newall, Wilterdinck and Baume Pluvinel, and the determination of heat radiation from corona by Dr. Abbott and Prof. Julius.

The photographs of the region round the sun for recording stars, &c., to be used in searching for possible intramercurial planet were more successful, good results being obtained by Prof. Perrine at Padang and Mr. Dyson at Auer Gadang.

The polariscopic investigations were only partly successful; visual observations were secured by Prof. Julius, and a series of photographs obtained by Mr. Newall with a Savart camera.

In the case of the chromospheric spectrum, several observers have secured more or less successful photographs. At Fort de Kock Dr. Humphreys has obtained good spectra of the lower chromosphere, using a concave grating, the whole blue and violet range of spectrum being on a film two feet long.

Mr. Newall, assisted by Lieut. Briggs, used an objective plane grating and obtained a series of spectra with high dispersion over a small range.

Dr. Mitchell also obtained a valuable series of spectra of the flash by means of a grating spectroscope.

Good series of photographs with prismatic cameras were obtained by the Dutch party at Fort de Kock, M. de la Baume Pluvinel, M. Donitch, and also by Mr. Maunder at Mauritius.

Numerous photographs of the corona and surroundings were obtained with various forms of cameras, but it is improbable that any of these taken in Sumatra will show any considerable extension of the streamers, and reliance will have to be made in this branch upon the photographs taken under the more favourable conditions at Mauritius. In Sumatra, series of large scale pictures were obtained with 40-feet lenses by Prof. Nyland, Mr. Perrine and Dr. Humphreys. Prof. Todd failed to even see the corona at Singkep on account of heavy clouds.

From an examination of the plates it is stated that they show a remarkable feature indicating a huge local storm in the eastern equatorial regions, and several bright arches apparently related to marked prominences, especially in the S.E. quadrant.

The duration of totality again appears to have been considerably different from the computed ephemeris time, the observed time in most cases being *shorter*. The Dutch astronomers at Painan report it about eleven seconds, and Mr. Dyson about nine seconds shorter than the almanac duration. Other observers, however, including Prof. Burton and the Fort de Kock party, appear to have found the time of totality longer than was predicted.

A noticeable feature of this eclipse has been the misleading effect of meteorological statistics as influencing the observers' choice of sites for their stations. The eclipse was observed under almost perfect conditions from Padang Pandjang, which is regarded as the rainiest and cloudiest region in Sumatra, while those who camped in the old Solok Fort were the least favoured on the entire coast.

THE TWELVE MOVEMENTS OF THE EARTH.—In the *Bulletin de la Soc. Ast. de France* (1901, pp. 262–266), M. Flammarion gives an interesting review of the various movements by which the terrestrial sphere is known to be affected at the present time. These are due to, or consist of, the following phenomena :—

(1) Rotation, having a period of 24 hours.
(2) Revolution, having a period of 365¼ days.
(3) Precession, having a period of 25,765 years.
(4) Luni-solar gravitation, having a period of 28 days.
(5) Nutation, having a period of 18⅔ years.
(6) Variation of obliquity of ecliptic, about 47″ arc in 100 years.
(7) Variation of eccentricity of orbit.
(8) Change of line of apsides, period about 21,000 years.
(9) Planetary perturbations.
(10) Change of centre of gravity of whole solar system.
(11) General translation of solar system in space.
(12) Latitude variation with several degrees of periodicity.

NEW NEBULÆ.—In the *Comptes rendus* (vol. cxxxiii. pp. 26–28 and 86–88), M. G. Bigourdan gives two further lists of new nebulæ discovered with the west equatorial at the Paris Observatory. The first paper deals with twenty-one objects, observed during the period 1897–1899, copious notes and comparisons with the N.G.C. being appended.

The second list contains similar information regarding nineteen nebulæ observed between 1884 and 1898.

THE SUPPRESSION OF TUBERCULOSIS.[1]

THE task with which this Congress will have to busy itself is one of the most difficult, but it is also one in which labour is most sure of its reward.

I need not point again to the innumerable victims tuberculosis annually claims in all countries, or to the boundless misery it brings on the families it attacks. You all know that there is no disease which inflicts such deep wounds on mankind as this. All the greater, however, would be the general joy and satisfaction if the efforts that are being made to rid mankind of this enemy, which consumes its inmost marrow, were crowned with success.

There are many, indeed, who doubt the possibility or successfully combating this disease, which has existed for thousands of years, and has spread all over the world. This is by no means my opinion. This is a conflict into which we may enter with a surely founded prospect of success, and I will tell you the reasons on which I base this conviction.

Only a few decades ago the real nature of tuberculosis was unknown to us; it was regarded as a consequence, as the expression, so to speak, of social misery, and, as this supposed cause could not be got rid of by simple means, people relied on the probable gradual improvement of social conditions, and did nothing. All this is altered now. We know that social misery does indeed go far to foster tuberculosis, but the real cause of the disease is a parasite—that is, a visible and palpable enemy, which we can pursue and annihilate, just as we can pursue and annihilate other parasitic enemies of mankind.

Strictly speaking, the fact that tuberculosis is a preventible disease ought to have become clear as soon as the tubercle-bacillus was discovered, and the properties of this parasite and the manner of its transmission became known. I may add that I, for my part, was aware of the full significance of this discovery from the first, and so will everybody have been who had convinced himself of the causal relation between tuberculosis and the tubercle-bacillus. But the strength of a small number of medical men was inadequate to the conflict with a disease so deeply rooted in our habits and customs. Such a conflict requires the cooperation of many, if possible of all, medical men, shoulder to shoulder with the State and the whole population; but now the moment when such cooperation is possible seems to have come. I suppose there is hardly any medical man now who denies the parasitic nature of tuberculosis, and among the non-medical public, too, the knowledge of the nature of the disease has been widely propagated.

Another favourable circumstance is that success has recently been achieved in the combating of several parasitic diseases, and that we have learned from these examples how the conflict with pestilences is to be carried on.

The most important lesson we have learned from the said experience is that it is a great blunder to treat pestilences uniformly. This was done in former times; no matter whether the pestilence in question was cholera, plague, or leprosy: isolation, quarantine, useless disinfection were always resorted to. But now we know that every disease must be treated according to its own special individuality, and that the measures to be taken against it must be most accurately adapted to its special nature, to its etiology. We are entitled to hope for success in combating tuberculosis only if we keep this lesson constantly in view. As so extremely much depends just on this point, I shall take the liberty to illustrate it by several examples.

The pestilence which is at this moment in the foreground of interest, the bubonic plague, may be instructive to us in several respects.

People used to act upon the conviction that a plague patient was in the highest degree a centre of infection, and that the disease was transmitted only by plague patients and their belongings. Even the most recent international agreements are based on this conviction. Although, as compared with formerly, we now have the great advantage that we can, with the aid of the microscope and of experiments on animals, recognise every case of plague with absolute certainty, and although the prescribed inspection of ships, quarantine, the isolation of patients, the disinfection of infected dwellings and ships are carried out with the utmost care, the plague has, nevertheless, been transmitted everywhere, and has in not a few places assumed grave dimensions. Why this has happened we know very well, owing to the experience quite recently gained as to the manner in which the plague is transmitted. It has been discovered that only those plague patients that suffer from plague-pneumonia—a condition which is fortunately infrequent—are centres of infection, and that the real transmitters of the plague are the rats. There is no longer any doubt that, in by far the majority of the cases in which the plague has been transmitted by ocean traffic, the transmission took place by means of plague among the ship rats. It has also been found that, wherever the rats were intentionally or unintentionally exterminated, the plague rapidly disappeared; whereas at other places, where too little attention had been paid to the rat plague, the pestilence continued. This connection between the human plague and the rat plague was totally unknown before, so that no blame attaches to those who devised the measures now in force against the plague if the said measures have proved unavailing. It is high time, however, that this enlarged knowledge of the etiology of the plague be utilised in international as well as in other traffic. As the human plague is so dependent on the rat plague, it is intelligible that protective inoculation and the application of antitoxic serum have had so little effect. A certain number of human beings may have been saved from the disease by that, but the general spread of the pestilence has not been hindered in the least.

With cholera the case is essentially different; it may, under certain circumstances, be transmitted directly from human beings to other human beings, but its main and most dangerous propagator is water, and therefore, in the combating of cholera, water is the first thing to be considered. In Germany, where this principle has been acted on, we have succeeded for four years in regularly exterminating the pestilence (which was introduced again and again from the infected neighbouring countries) without any obstruction of traffic.

Hydrophobia, too, is not void of instruction for us. Against this disease the so-called protective inoculation proper has proved eminently effective as a means of preventing the outbreak of the disease in persons already infected, but, of course, such a measure can do nothing to prevent infection itself. The only real way of combating this pestilence is by compulsory muzzling. In this matter also we have had the most satisfactory experience in Germany, but have at the same time seen that the total extermination of the pestilence can be achieved only by international measures, because hydrophobia, which can be very

[1] Paper on "The Combating of Tuberculosis in the Light of the Experience that has been gained in the Successful Combating of other Infectious Diseases," by Prof. Robert Koch, read at the British Congress on Tuberculosis, July 23.

easily and rapidly suppressed, is always introduced again year after year from the neighbouring countries.

Permit me to mention only one other disease, because it is etiologically very closely akin to tuberculosis, and we can learn not a little for the furtherance of our aims from its successful combating. I mean leprosy. It is caused by a parasite which greatly resembles the tubercle-bacillus. Just like tuberculosis, it does not break out till long after infection, and its course is almost slower. It is transmitted only from person to person, but only when they come into close contact, as in small dwellings and bedrooms. In this disease, accordingly, immediate transmission plays the main part: transmission by animals, water, or the like is out of the question. The combative measures, accordingly, must be directed against this close intercourse between the sick and the healthy. The only way to prevent this intercourse is to isolate the patients. This was most rigorously done in the Middle Ages by means of numerous leper-houses, and the consequence was that leprosy, which had spread to an alarming extent, was completely stamped out in Central Europe. The same method has been adopted quite recently in Norway, where the segregation of lepers has been ordered by a special law. But it is extremely interesting to see how this law is carried out. It has been found that it is not at all necessary to execute it strictly, for the segregation of only the worst cases, and even of only a part of these, sufficed to produce a diminution of leprosy. Only so many infectious cases had to be sent to the leper-houses that the number of fresh cases kept regularly diminishing from year to year. Consequently the stamping-out of the disease has lasted much longer than it would have lasted if every leper had been inexorably consigned to a leper-house, as in the Middle Ages; but in this way, too, the same purpose is gained, slowly, indeed, but without any harshness.

These examples may suffice to show what I am driving at, which is to point out that, in combating pestilences, we must strike at the root of the evil, and must not squander force in subordinate ineffective measures. Now the question is whether what has hitherto been done, and what is about to be done, against tuberculosis really strikes at the root of tuberculosis, so that it must sooner or later die.

In order to answer this question it is necessary first and foremost to inquire how infection takes place in tuberculosis. Of course, I presuppose that we understand by tuberculosis only those morbid conditions which are caused by the tubercle-bacillus.

In by far the majority of cases of tuberculosis the disease has its seat in the lungs, and has also begun there. From this fact it is justly concluded that the germs of the disease, *i.e.* the tubercle-bacilli, must have got into the lungs by inhalation. As to the question where the inhaled tubercle-bacilli have come from, there is also no doubt. On the contrary, we know with certainty that they get into the air with the sputum of consumptive patients. This sputum, especially in advanced stages of the disease, almost always contains tubercle-bacilli, sometimes in incredible quantities. By coughing, and even speaking, it is flung into the air in little drops, *i.e* in a moist condition, and can at once infect persons who happen to be near the coughers. But then it may also be pulverised when dried, in the linen or on the floor for instance, and get into the air in the form of dust.

In this manner a complete circle, a so-called *circulus vitiosus*, has been formed for the process of infection, from the diseased lung, which produces phlegm and pus containing tubercle-bacilli, to the formation of moist and dry particles (which, in virtue of their smallness, can keep floating a good while in the air), and finally to new infection, if particles penetrate with the air into a healthy lung and originate the disease anew. But the tubercle-bacilli may get to other organs of the body in the same way, and thus originate other forms of tuberculosis. This, however, is a considerably rarer case. The sputum of consumptive people, then, is to be regarded as the main source of the infection of tuberculosis. On this point, I suppose, all are agreed. The question now arises whether there are not other sources too, copious enough to demand consideration in the combating of tuberculosis.

Great importance used to be attached to the hereditary transmission of tuberculosis. Now, however, it has been demonstrated by thorough investigation that, though hereditary tuberculosis is not absolutely non-existent, it is nevertheless extremely rare, and we are at liberty, in considering our practical measures, to leave this form of origination entirely out of account.

But another possibility of tubercular infection exists, as is generally assumed, in the transmission of the germs of the disease from tubercular animals to man. This manner of infection is generally regarded nowadays as proved, and as so frequent that it is even looked upon by not a few as the most important, and the most rigorous measures are demanded against it. In this Congress also the discussion of the danger with which the tuberculosis of animals threatens man will play an important part. Now, as my investigations have led me to form an opinion deviating from that which is generally accepted, I beg your permission, in consideration of the great importance of this question, to discuss it a little more thoroughly.

Genuine tuberculosis has hitherto been observed in almost all domestic animals, and most frequently in poultry and cattle. The tuberculosis of poultry, however, differs so much from human tuberculosis that we may leave it out of account as a possible source of infection for man. So, strictly speaking, the only kind of animal tuberculosis remaining to be considered is the tuberculosis of cattle, which, if really transferable to man, would indeed have frequent opportunities of infecting human beings through the drinking of the milk and the eating of the flesh of diseased animals.

Even in my first circumstantial publication on the etiology of tuberculosis I expressed myself regarding the identity of human tuberculosis and bovine tuberculosis with reserve. Proved facts which would have enabled me sharply to distinguish these two forms of the disease were not then at my disposal, but sure proofs of their absolute identity were equally undiscoverable, and I therefore had to leave this question undecided. In order to decide it, I have repeatedly resumed the investigations relating to it, but so long as I experimented on small animals, such as rabbits and guinea-pigs, I failed to arrive at any satisfactory result, though indications which rendered the difference of the two forms of tuberculosis probable were not wanting. Not till the complaisance of the Ministry of Agriculture enabled me to experiment on cattle, the only animals really suitable for these investigations, did I arrive at absolutely conclusive results. Of the experiments which I have carried out during the last two years along with Prof. Schütz, of the Veterinary College in Berlin, I will tell you briefly some of the most important.

A number of young cattle which had stood the tuberculin test, and might therefore be regarded as free from tuberculosis, were infected in various ways with pure cultures of tubercle-bacilli taken from cases of human tuberculosis; some of them got the tubercular sputum of consumptive patients direct. In some cases the tubercle bacilli or the sputum were injected under the skin, in others into the peritoneal cavity, in others into the jugular vein. Six animals were fed with tubercular sputum almost daily for seven or eight months; four repeatedly inhaled great quantities of bacilli, which were distributed in water and scattered with it in the form of spray. None of these cattle (there were nineteen of them) showed any symptoms of disease, and they gained considerably in weight. From six to eight months after the beginning of the experiments they were killed. In their internal organs not a trace of tuberculosis was found. Only at the places where the injections had been made small suppurative foci had formed, in which few tubercle-bacilli could be found. This is exactly what one finds when one injects dead tubercle-bacilli under the skin of animals liable to contagion. So the animals we experimented on were affected by the living bacilli of human tuberculosis exactly as they would have been by dead ones; they were absolutely insusceptible to them.

The result was utterly different, however, when the same experiment was made on cattle free from tuberculosis with tubercle-bacilli that came from the lungs of an animal suffering from bovine tuberculosis. After an incubation period of about a week the severest tubercular disorders of the internal organs broke out in all the affected animals. It was all one whether the infecting matter had been injected only under the skin or into the peritoneal cavity or the vascular system. High fever set in, and the animals became weak and lean; some of them died after a month and a half to two months, others were killed in a miserably sick condition after three months. After death extensive tubercular infiltrations were found at the place where the injections had been made, and in the neighbouring lymphatic glands, and also far advanced alterations of the internal organs, especially the lungs and the spleen. In the cases in which the injections had been made into the peritoneal cavity the tubercular growths which are so characteristic of bovine tuberculosis were found on the omentum and peritoneum. In short, the cattle proved just as susceptible to infection by the bacillus of bovine tuberculosis as they had proved insusceptible to infection by the bacillus of human tuberculosis. I wish only to add that preparations of the organs of the cattle which were artificially infected with bovine tuberculosis in these experiments are exhibited in the Museum of Pathology and Bacteriology.

An almost equally striking distinction between human and bovine tuberculosis was brought to light by a feeding experiment with swine. Six young swine were fed daily for three months with the tubercular sputum of consumptive patients. Six other swine received bacilli of bovine tuberculosis with their food daily for the same period. The animals that were fed with sputum remained healthy and grew lustily, whereas those that were fed with the bacilli of bovine tuberculosis soon became sickly, were stunted in their growth, and half of them died. After three months and a half the surviving swine were all killed and examined. Among the animals that had been fed with sputum no trace of tuberculosis was found, except here and there little nodules in the lymphatic glands of the neck, and in one case a few grey nodules in the lungs. The animals, on the other hand, which had eaten bacilli of bovine tuberculosis had, without exception (just as in the cattle experiment), severe tubercular diseases, especially tubercular infiltration of the greatly enlarged lymphatic glands of the neck and of the mesenteric glands, and also extensive tuberculosis of the lungs and the spleen.

The difference between human and bovine tuberculosis appeared not less strikingly in a similar experiment with asses, sheep and goats, into whose vascular system the two kinds of tubercle-bacilli were injected.

Our experiments, I must add, are not the only ones that have led to this result. If one studies the older literature of the subject, and collates the reports of the numerous experiments that were made in former times by Chauveau, Günther and Harms, Bollinger and others, who fed calves, swine, and goats with tubercular material, one finds that the animals that were fed with the milk and pieces of the lungs of tubercular cattle always fell ill of tuberculosis, whereas those that received human material with their food did not. Comparative investigations regarding human and bovine tuberculosis have been made very recently in North America by Smith, Dinwiddie and Frothingham, and their result agreed with that of ours. The unambiguous and absolutely conclusive result of our experiments is due to the fact that we chose methods of infection which exclude all sources of error, and carefully avoided everything connected with the stalling, feeding and tending of the animals that might have a disturbing effect on the experiments.

Considering all these facts, I feel justified in maintaining that human tuberculosis differs from bovine, and cannot be transmitted to cattle. It seems to me very desirable, however, that these experiments should be repeated elsewhere, in order that all doubt as to the correctness of my assertion may be removed.

I wish only to add that, owing to the great importance of this matter, the German Government has appointed a commission to make further inquiries on the subject.

But, now, how is it with the susceptibility of man to bovine tuberculosis? This question is far more important to us than that of the susceptibility of cattle to human tuberculosis, highly important as that is too. It is impossible to give this question a direct answer, because, of course, the experimental investigation of it with human beings is out of the question. Indirectly, however, we can try to approach it. It is well known that the milk and butter consumed in great cities very often contain large quantities of the bacilli of bovine tuberculosis in a living condition, as the numerous infection-experiments with such dairy products on animals have proved. Most of the inhabitants of such cities daily consume such living and perfectly virulent bacilli of bovine tuberculosis, and unintentionally carry out the experiment which we are not at liberty to make. If the bacilli of bovine tuberculosis were able to infect human beings, many cases of tuberculosis caused by the consumption of alimenta containing tubercle-bacilli could not but occur among the inhabitants of great cities, especially the children. And most medical men believe that this is actually the case.

In reality, however, it is not so. That a case of tuberculosis has been caused by alimenta can be assumed with certainty only when the intestine suffers first—*i.e.*, when a so-called primary tuberculosis of the intestine is found. But such cases are extremely rare. Among many cases of tuberculosis examined after death, I myself remember having seen primary tuberculosis of the intestine only twice. Among the great *post-mortem* material of the Charité Hospital in Berlin ten cases of priminary tuberculosis of the intestine occurred in five years. Among 933 cases of tuberculosis in children at the Emperor and Empress Frederick's Hospital for Children, Baginsky never found tuberculosis of the intestine without simultaneous disease of the lungs and the bronchial glands. Among 3104 *post mortems* of tubercular children, Biedert observed only sixteen cases of primary tuberculosis of the intestine. I could cite from the literature of the subject many more statistics of the same kind, all indubitably showing that primary tuberculosis of the intestine, especially among children, is a comparatively rare disease, and of these few cases that have been enumerated, it is by no means certain that they were due to infection by bovine tuberculosis. It is just as likely that they were caused by the widely propagated bacilli of human tuberculosis, which may have got into the digestive canal in some way or other—for instance, by swallowing saliva of the mouth. Hitherto nobody could decide with certainty in such a case whether the tuberculosis of the intestine was of human or of animal origin. Now we can diagnose them. All that is necessary is to cultivate in pure culture the tubercle-bacilli found in the tubercular material, and to ascertain whether they belong to bovine tuberculosis by inoculating cattle with them. For this purpose I recommend subcutaneous injection, which yields quite specially characteristic and convincing results. For half a year past I have occupied myself with such investigations; but, owing to the rareness of the disease in question, the number of the cases I have been able to investigate is but small. What has hitherto resulted from this investigation does not speak for the assumption that bovine tuberculosis occurs in man.

Though the important question whether man is susceptible to bovine tuberculosis at all is not yet absolutely decided, and will not admit of absolute decision to-day or to-morrow, one is nevertheless already at liberty to say that, if such a susceptibility really exists, the infection of human beings is but a very rare occurrence. I should estimate the extent of infection by the milk and flesh of tubercular cattle, and the butter made of their milk, as hardly greater than that of hereditary transmission, and I therefore do not deem it advisable to take any measures against it.

So the only main source of the infection of tuberculosis is the sputum of consumptive patients, and the measures for the combating of tuberculosis must aim at the prevention of the dangers arising from its diffusion. Well, what is to be done in this direction? Several ways are open. One's first thought might be to consign all persons suffering from tuberculosis of the lungs, whose sputum contains tubercle-bacilli, to suitable establishments. This, however, is not only absolutely impracticable, but also unnecessary. For a consumptive who coughs out tubercle-bacilli is not necessarily a source of infection on that account, so long as he takes care that his sputum is properly removed and rendered innocuous. This is certainly true of very many patients, especially in the first stages, and also of those who belong to the well-to-do classes, and are able to procure the necessary nursing. But how is it with people of very small means? Every medical man who has often entered the dwellings of the poor, and I can speak on this point from my own experience, knows how sad is the lot of consumptives and their families there. The whole family have to live in one or two small, ill-ventilated rooms. The patient is left without the nursing he needs, because the able-bodied members of the family must go to their work. How can the necessary cleanliness be secured under such circumstances? How is such a helpless patient to remove his sputum, so that it may do no harm? But let us go a step further and picture the condition of a poor consumptive patient's dwelling at night. The whole family sleep crowded together in one small room. However cautious he may be, the sufferer scatters the morbid matter secreted by his diseased lungs every time he coughs, and his relatives close beside him must inhale this poison. Thus whole families are infected. They die out, and awaken in the minds of those who do not know the infectiousness of tuberculosis the opinion that it is hereditary, whereas its transmission in the cases in question was due solely to the simplest process of infection, which do not strike people so much, because the consequences do not appear at once, but generally only after the lapse of years.

Often, in such circumstances, the infection is not restricted to a single family, but spreads in densely inhabited tenement-houses to the neighbours, and then, as the admirable investigations of Biggs have shown in the case of the densely peopled parts of New York, regular nests or foci of disease are formed. But, if one investigates these matters more thoroughly, one finds that it is not poverty *per se* that favours tuberculosis, but the bad domestic conditions under which the poor everywhere, but especially in great cities, have to live. For, as the German statistics show, tuberculosis is less frequent, even among the poor, when the population is not densely packed together, and may attain very great dimensions among a well-to-do population when the domestic conditions, especially as regards the bedrooms, are bad, as is the case, for instance, among the inhabitants of the North Sea coast. So it is the overcrowded dwellings of the poor that we have to regard as the real breeding-places of tuberculosis; it is out of them that the disease always crops up anew, and it is to the abolition of these conditions that we must first and foremost direct our attention if we wish to attack the evil at its root, and to wage war against it with effective weapons.

This being so, it is very gratifying to see how efforts are being made in almost all countries to improve the domestic conditions of the poor. I am also convinced that these efforts, which must be promoted in every way, will lead to a considerable diminution of tuberculosis. But a long time must elapse ere essential changes can be effected in this direction, and much may be done meanwhile in order to reach the goal much more rapidly.

If we are not able at present to get rid of the danger which small and overcrowded dwellings involve, all we can do is to remove the patients from them, and, in their own interests and that of the people about them, to lodge them better; and this can be done only in suitable hospitals. But the thought of attaining this end by compulsion of any kind is very far from me; what I want is that the consumptives may be enabled to obtain the nursing they need better than they can obtain it now. At present a consumptive in an advanced stage of the disease is regarded as incurable and as an unsuitable inmate for a hospital. The consequence is that he is reluctantly admitted and dismissed as soon as possible. The patient, too, when the treatment seems to him to produce no improvement, and the expenses, owing to the long duration of his illness, weigh heavily upon him, is himself animated by the wish to leave the hospital soon. That would be altogether altered if we had special hospitals for consumptives, and if the patients were taken care of there for nothing, or at least at a very moderate rate. To such hospitals they would willingly go; they could be better treated and cared for there than is now the case. I know very well that the execution of the project will have great difficulties to contend with, owing to the considerable outlay it entails. But very much would be gained if, at least in the existing hospitals, which have to admit a great number of consumptives at any rate, special wards were established for them, in which pecuniary facilities would be offered them. If only a considerable fraction of the whole number of consumptives were suitably lodged in this way, a diminution of infection and consequently of the sum total of tuberculosis could not fail to be the result. Permit me to remind you in this connection of what I said about leprosy. In the combating of that disease also great progress has already been made by lodging only a fair number of the patients in hospitals. The only country that possesses a considerable number of special hospitals for tubercular patients is England, and there can be no doubt that the diminution of tuberculosis in England, which is much greater than in any other country, is greatly due to this circumstance. I should point to the founding of special hospitals for consumptives and the better utilisation of the already existing hospitals for the lodging of consumptives as the most important measure in the combating of tuberculosis, and its execution opens a wide field of activity to the State, to municipalities, and to private benevolence. There are many people who possess great wealth, and would willingly give of their superfluity for the benefit of their poor and heavily afflicted fellow-creatures, but do not know how to do this in a judicious manner. Here is an opportunity for them to render a real and lasting service by founding consumption hospitals or purchasing the right to have a certain number of consumptive patients maintained in special wards of other hospitals free of expense.

As, however, unfortunately, the aid of the State, the municipalities, and rich benefactors will probably not be forthcoming for a long time yet, we must for the present resort to other measures that may pave the way for the main measure just referred to, and serve as a supplement and temporary substitute for it.

Among such measures I regard obligatory notification as specially valuable. In the combating of all infectious diseases it has proved indispensable as a means of obtaining certain knowledge as to their state, especially their dissemination, their increase and decrease. In the conflict with tuberculosis also we cannot dispense with obligatory notification; we need it not only in order to inform ourselves as to the dissemination of this disease, but mainly in order to learn where help and instruction can be given, and especially where the disinfection which is so urgently necessary when consumptives die or change their residences has to be effected. Fortunately it is not at all necessary to notify all cases of tuberculosis, nor even all cases of consumption, but only those that, owing to the domestic conditions, are sources of danger to the people about them. Such limited notification has already been introduced in various places, in Norway, for instance, by a special law, in Saxony by a ministerial decree, in New York and in several American towns, which have followed its example. In New York, where notification was optional at first and was afterwards made obligatory, it has proved eminently useful. It has thus been proved that the evils which it used to be feared the introduction of notification for tuberculosis would bring about need not occur, and it is devoutly to be wished that the examples I have named may very soon excite emulation everywhere.

There is another measure, closely connected with notification, viz. disinfection, which, as already mentioned, must be effected when consumptives die or change their residence, in order that those who next occupy the infected dwelling may be protected against infection. Moreover, not only the dwellings but also the infected beds and clothes of consumptives ought to be disinfected.

A further measure, already recognised on all hands as effective, is the instructing of all classes of the people as to the infectiousness of tuberculosis, and as to the best way of protecting oneself. The fact that tuberculosis has considerably diminished in almost all civilised states of late is attributable solely to the circumstance that knowledge of the contagious character of tuberculosis has been more and more widely disseminated, and that caution in intercourse with consumptives has increased more and more in consequence. If better knowledge of the nature of tuberculosis has alone sufficed to prevent a large number of cases, this must serve us as a significant admonition to make the greatest possible use of this means, and to do more and more to bring it about that everybody may know the dangers that threaten him in intercourse with consumptives. It is only to be desired that the instructions may be made shorter and more precise than they generally are, and that special emphasis be laid on the avoidance of the worst danger of infection, which is the use of bedrooms and small ill-ventilated workrooms simultaneously with consumptives. Of course the instructions must include directions as to what consumptives have to do when they cough and how they are to treat their sputum.

Another measure, which has come into the foreground of late, and which at this moment plays to a certain extent a paramount part in all efforts for the combating of tuberculosis, works in quite another direction. I mean the founding of sanatoria for consumptives.

That tuberculosis is curable in its early stages must be regarded as an undisputed fact. The idea of curing as many tubercular patients as possible in order to reduce the number of those that reach the infectious stage of consumption, and thus to reduce the number of fresh cases, was therefore a very natural one. The only question is whether the number of persons cured in this way will be great enough to exercise an appreciable influence on the retrogression of tuberculosis. I will try to answer this question in the light of the figures at my disposal.

According to the business report of the German Central Committee for the Establishment of Sanatoria for the Cure of Consumptives, about 5500 beds will be at the disposal of these institutions by the end of 1901, and then, if we assume that the average stay of each patient will be three months, it will be possible to treat at least 20,000 patients every year. From the reports hitherto issued as to the results that have been achieved in the establishments we learn further that about 20 per cent. of the patients that have tubercle-bacilli in their sputum lose them by the treatment there. This is the only sure test of success, especially as regards prophylaxis. If we make this the basis of our estimates, we find that 4000 consumptives will leave these establishments annually as cured. But, according to the statistics ascertained by the German Imperial Office of Health, there are 226,000 persons in Germany above fifteen years of age who are so far gone in consumption that hospital treatment is necessary for them. Compared with this great number of consumptives the success of the establishments in question seems so small that a material influence on the retrogression of tuberculosis in general is not yet to be expected of them. But pray do not imagine that I wish, by this calculation of mine, to oppose the movement for the establishment of such sanatoria in any way. I only wish to warn against the over-estimating of their importance which has recently been observable in various quarters, based apparently on the opinion that the war against tuberculosis can be waged by means of sanatoria alone, and that other measures are of subordinate value. In reality the contrary is the case. What is to be achieved by the general prophylaxis resulting from recognition of the danger of infection and the consequent greater caution in intercourse with consumptives is shown by a calculation of Cornet's regarding the decrease of mortality from tuberculosis in Prussia in the years 1889 to 1897. Before 1889 the average was 31·4 per 10,000, whereas in the period named it sank to 21·8, which means that, in that short space of time, the number of deaths from tuberculosis was 184,000 less than was to be expected from the average of the preceding years. In New York, under the influence of the general sanitary measures directed in a simply exemplary manner by Biggs, the mortality from tuberculosis has diminished by more than 35 per cent. since 1886. And it must be remembered that both in Prussia and New York the progress indicated by these figures is due to the first beginnings of these measures. Considerably greater success is to be expected of their further development. Biggs hopes to have got so far in five years that in the city of New York alone the annual number of deaths from tuberculosis will be 3000 less than formerly. I take this opportunity of most urgently recommending Dr. Biggs' organisation to the study and imitation of all municipal sanitary authorities.

Now, I do indeed believe that it will be possible to render the sanatoria considerably more efficient. If strict care be taken that only patients be admitted for whom the treatment of those establishments is well adapted, and if the duration of the treatment be prolonged, it will certainly be possible to cure fifty per cent., and perhaps still more. But even then, and even if the number of the sanatoria be greatly increased, the total effect will always remain but moderate. The sanatoria will never render the other measures I have mentioned superfluous. If their number become great, however, and if they perform their functions properly, they may materially aid the strictly sanitary measures in the conflict with tuberculosis.

If now, in conclusion, we glance back once more to what has been done hitherto for the combating of tuberculosis, and forward to what has still to be done, we are at liberty to declare with a certain satisfaction that very promising beginnings have already been made. Among these I reckon the consumption hospitals of England, the legal regulations regarding notification in Norway and Saxony, the organisation created by Biggs in New York, the sanatoria, and the instruction of the people. All that is necessary is to go on developing these beginnings, to test, and if possible to increase, their influence on the diminution of tuberculosis, and wherever nothing has yet been done, to do likewise.

If we are continually guided in this enterprise by the spirit of genuine preventive medical science, if we utilise the experience gained in conflict with other pestilences, and aim, with clear recognition of the purpose and resolute avoidance of wrong roads, at striking the evil at its root, then the battle against tuberculosis, which has been so energetically begun, cannot fail to have a victorious issue.

THE ROYAL HORTICULTURAL SOCIETY'S LILY CONFERENCE.

ON July 16 the Royal Horticultural Society held a conference on "lilies." Although by no means organised upon the same scale as the meeting was two years ago, when hybridisation was discussed, the one under consideration proved, nevertheless, of some importance and much interest.

An exhibition of lilies was also arranged for the same day and the following one, in the Society's Gardens at Chiswick, where the conference took place. The number of plants shown was not large, but taking into consideration the fact that many species had done flowering, while others were not yet in blossom, the series collected together may be put down as a fairly representative one. Possibly more examples might have been displayed if growers had had a little longer notice given to them.

As soon as the inevitable luncheon was cleared away from the tent, the chair was taken by Mr. H. J. Elwes, F.R.S., who had returned from abroad for the purpose. He was also put down upon the programme to give an address on lilies, discovered or brought into cultivation since the issue of his well-known monograph upon these plants.

The chairman, however, deputed this part of his task to Mr. J. G. Baker, F.R.S., and contented himself with making a series of interesting comments upon the various points alluded to by the different speakers. Mr. Baker's contribution being mostly descriptive, he merely alluded briefly in passing to the lilies discovered and in several cases taken up by horticulturists during the last twenty years.

The plants concerned came chiefly from Upper Burma and Central and Western China. Some of the new martagons, however, were discovered in California and North Carolina. Species from the first-mentioned locality were due to the efforts of Sir Henry Collett, while the Chinese ones were collected by French missionaries and by Dr. Henry, who was present and spoke at the conference.

Among the many species and varieties mentioned, one may allude to *Lilium mirabile*, found by one of the missionaries in Western China, and which is unique among lilies in possessing as it does a centrifugal inflorescence; in all others, the lowermost flowers upon the stalk are the first to open. *L. lowei* was shown to be the same thing as *L. bakerianum*, the latter name having priority.

Dr. Henry, who sent home no less than 13 700 specimens of plants, was the next to speak. He was not able to pay special attention to any one kind of plants, so had nothing very particular to say about the habitats of lilies.

He described a day's journey in Western China as up one side of a mountain and down again into the valley on the other side. This speaker also pointed out that there were thousands and thousands of these valleys, each with its own flora, and that there was ample room in the tracts of country he traversed for a hundred collectors of plants.

After several contributions had been made to the meeting, Mr. George Massee had something to say upon the fungoid diseases to which lilies are liable. The chairman had already pointed out how the scientific man was indebted to the professional horticulturist, who introduced and flowered many species that the former would otherwise be unable to figure from living species when monographing a genus, and, again, how the practical man gains through the work of the botanist. Mr. Massee showed very forcibly how the gardener does not profit as much as he might from the labours of the mycologist. Great intelligence was granted to the horticulturist, but within a certain circle; this did not, however, include an appreciation of many simple methods of prevention. For instance, Mr. Massee pointed out that by merely adding a little kainite or Strasburgh fertiliser the most serious "lily disease," which, when it has once taken a hold, is incurable, can be successfully warded off.

When the whole series of papers is printed, growers of lilies should find much information of use to them, while botanists should be grateful to have their knowledge of the species and varieties of lilies brought once more up to date.

WILFRED MARK WEBB.

THE PROPERTIES OF STEEL CASTINGS.

THE first of a series of papers on the result of researches carried out during several years at the Sheffield University College was read by Prof. J. O. Arnold before the Iron and Steel Institute on May 9.

This preliminary paper dealt only with castings composed mainly of iron and carbon. It was shown that such a composition was unsuitable to meet the demands of engineers. The maximum stress recorded in the series was 32·42 tons per sq. in., associated with an elongation of only 2 per cent., whilst the maximum ductility obtained was an elongation of 46 per cent. on two inches, correlated, however, with a maximum stress of only 19·2 tons per sq. in.

A long series of observations revealed the curious fact that no correlation exists between the densities and mechanical properties of steel castings.

The mechanical influence of annealing at 950° C. and slowly cooling from that temperature is, in the case of iron containing about 0·4 per cent. of carbon, exemplified by the following figures:—

Condition of steel	Elastic limit tons per sq. in.	Max. stress tons per sq. in.	Elongation per cent. on 2 in.	Reduction of area per cent.
As cast... ...	17·22 ...	23·41 ...	6·5 ...	8·4
After annealing..	10·08 ...	24·03 ...	24·5 ...	29·0

The micrographic effect of drastic annealing is shown in the drawing, CC 2, which has been reduced from a 6-inch circle magnified 315 diameters.

The constituents of the steel as cast present an irregular trellis-like pattern of pale ferrite or iron and dark pearlite or steel. In addition, small castings, or small parts of large castings, present curious brown-etching lines of a sulphur alloy,

FIG. 1.—Casting CC2. (Reduced from six-inch circle, magnified 315 diameters.)

which arrange themselves almost exclusively along the ferrite, forming lines of dangerous weakness.

After annealing, the long lines of cleavage between the constituents are broken up, large patches of laminated pearlite and allotrimorphic crystals of iron being formed. At the same time, the dangerous lines of the attenuated sulphur alloy are destroyed, segregating into isolated patches. All the above features are well indicated in the micrograph figured. Steel castings often present mechanical discrepancies very difficult to explain, *e.g.* elongations per cent. and bending angles form measures of ductility which might be expected to be proportional to each other, but often such is not the case.

A remarkable feature of the results recorded is the fact that some of the castings built up of very large crystals have presented great ductility, whilst castings with that minutely crystalline structure usually supposed to give the best mechanical results have given unsatisfactory tests.

Considering the fact that such castings were of identical chemical composition and had been subjected to similar thermal treatment, it is difficult to avoid the conclusion that the initial temperature of the steel on casting may exert a permanent mechanical influence, and that consequently the operation of annealing is not thoroughly effective.

SCIENTIFIC WORK IN EGYPT.

SEVERAL matters of scientific interest are described in Lord Cromer's report upon the finances, administration and condition of Egypt and the Soudan. Particular attention is directed to Sir William Garstin's memorandum on irrigation, and to the value of the work of hydraulic engineers in Egypt. Sir William Garstin brings forward observations showing a continuous fall of level of Lake Victoria Nyanza. His remarks upon this fall and the rainfall observations available are here reprinted.

"*Lake Victoria Nyanza Rain Gauges.*—Information regarding the daily rainfall and the lake levels is now regularly received in Egypt from Uganda. The first series of registers, previous to the rebellion, dates from June 1, 1896, to July 31, 1897. The second series commences on September 1, 1898, and has been carried on to October 31, 1900. Unfortunately, it is impossible to connect the two series, as the gauges erected subsequent to the rebellion are not the same as those which formerly existed. We have, therefore, only twenty-six months of observations upon which to base possible theories. This is not sufficient, more especially as we are still ignorant of many important factors bearing upon the relations of the levels and rainfall of the equatorial lakes with the Nile supply. Information regarding the most important point of all, viz. the Albert Nyanza Lake, is still entirely wanting. This is much to be regretted, as this lake, which drains an enormous catchment area, and through the northern end of which passes the water coming from the Victoria Lake, is probably the most important of the reservoirs which feed the White Nile. It is to be hoped that early measures may be taken to erect gauges upon the Albert Lake and to observe them regularly. The records thus obtained would be invaluable to Egypt.

"The following facts, elicited from the rather meagre information at our disposal, may perhaps be of general interest:—

"Two observing stations now exist on the Victoria Lake, one on either side, viz. at Port Alice or Entebbe and at Port Victoria or Ugowe. Unfortunately, the rainfall register for Entebbe only commences from the month of April 1900, so a comparison between the two for the whole year is impossible.

"The Ugowe rain gauge record shows that 46·28 inches of rain fell in the twelve months ending with October 1900, that there were 131 rainy days, and that the storms invariably took place either in the afternoon or at night. Further, that February was the wettest month of the year and July the driest, 6·45 inches being registered for the former and 1·56 inches for the latter. It would also appear that the period of the heaviest rainfall is from November to May. The total rainfall for the six months in question was 30·73 inches, the remaining six months being responsible for only 15·55 inches.

"The rainfall at Entebbe, on the opposite side of the lake, was, so far as the records go, considerably heavier than at Ugowe. The total fall between April and November 1900 was 30·39 inches at the former place, as against 20·59 inches at the latter. As regards the rise and fall of the water surface of the lake it is possible to make a comparison, as registers have been supplied regularly from both stations. . . .

"The records, as far as they go, seem to prove that the lake is always at its lowest in October, *i.e.* at the end of the dry season, and at its highest in December or January. They also show that the lake level has been steadily falling for the last three years, thus:—

	Port Alice (Entebbe). Ft.	in.	Port Victoria (Ugowe). Ft.	in.
Lake levels on October 1, 1898 ...	3	2 ...	3	2½
,, ,, 1899 ...	2	6½ ...	2	2
,, ,, 1900 ...	1	7 ...	1	1

"It is possible that this fall in the levels may be, in some measure, due to degradation of the bed of the river in the channel whence it issues from the lake; but it seems to be far more probable that it has been caused by a failure of the rainfall over an immense area. All reports go to show, and all travellers who have visited these regions relate, that a severe drought has prevailed over a large portion of Central Africa during the last two years. This drought has extended as far north as the Egyptian Soudan.

"Although it may seem likely that the Nile flood of 1901 will be a poor one if these figures are correct, it would be misleading to attempt to draw any definite conclusions from them. The register of the rainfall only dates from a very recent period, and consequently no comparison can be made with the fall of previous years. Again, the available knowledge of the many factors, which together combine to produce the annual rise of the White Nile, is at present extremely scanty.

"Lastly, as has been already stated, the Albert Nyanza Lake must exercise a most important influence upon the volume of the river, but no attempt has as yet been made to collect information regarding it. It is most desirable that a regular register of its levels and its rainfall should be commenced and maintained as soon as possible."

The Sudd in the Bahr-el-Gebel.—Major Peake's sudd-cutting party removed, in all, fourteen blocks of sudd during 1900. Some of these blocks were, in places, a mile in length and from 15 to 20 feet in thickness. The surface of the river channel was completely closed, and the stream passed underneath the sudd with a high velocity. Sir William Garstin remarks that a visit to the work changed many preconceived ideas as the nature of the obstruction. Instead of the sudd being, as had been supposed, a tangle of weed floating on the water and descending a few feet below the surface, it proved, in most cases, to be a mass of decayed vegetation, papyrus roots and earth, much resembling peat in its consistency, and compressed into such solidity by the force of the current that men could walk over it everywhere, and even elephants could, in places, cross it without danger. The most effectual method of removing it was found to be by cutting deep trenches on the surface, thus dividing it into rectangular blocks of some 10 feet square. These were hauled out, block by block, by means of chains and wire hawsers attached to the gun-boats.

Two portions of the Bahr-el-Gebel still remain uncleared. The one commences at 140 miles south of Lake No, and is some 25 miles in length. The other is some 52 miles further south and about three miles long. In both instances the true channel of the river is blocked by sudd, and it now follows a false channel; in the former instance it passes through a series of broad, shallow lakes.

Survey of the Cataract Region.—Lord Cromer states that the construction of the Nile Reservoirs is now so far advanced that the time has arrived when further studies of the river may usefully be made, so that, should it eventually be found necessary to still further augment the water supply of Egypt, the requisite information for the preparation of the project, or projects, shall be at the disposal of the Ministry of Public Works. One of the first steps necessary to attain this end is to make an accurate survey of the Nile Valley where it passes through the cataract region south of Wady Halfa. It may eventually be decided that a second reservoir is not the best means of supplementing the summer volume of the river, but that it will be more advisable to obtain it by regulating the outlets of the Equatorial and Abyssinian Lakes, by opening up the Bahr-el-Gebel, or some other large scheme. Until, however, a thorough knowledge of the river, as a whole, has been obtained, it would be premature and unadvisable to take any decision whatsoever. The present work is a commencement in this direction, and even should the results obtained, as regards the construction of another dam, prove to be negative, the information thus acquired will be invaluable to those charged with the control of the river.

It is proposed, therefore, to survey the cataract region, at the same time running lines of levels up the river valley. A geological surveyor will accompany the party. It is calculated that three years' work will be required to complete it as far south as the head of the third cataract.

Meteorological Department.—The Observatory, situated in the Abbassieh quarter of Cairo, was greatly improved during the course of last year. The equipment of a first-class meteorological observatory is now working there regularly. The time-ball at Port Said is dropped daily at noon by a current, working automatically, which is sent from the Observatory. Those at Cairo and Alexandria were to commence working early this year. The time of the 30° meridian east of Greenwich has been made civil time for the whole of Egypt, replacing the various local times previously in use.

Eight stations between Alexandria and Omdurman now take regular meteorological observations and send telegraphic weather reports to Cairo daily at 8 a.m. These are printed and published. Arrangements have recently been made by which similar telegraphic reports are daily exchanged at 8 a.m. between Alexandria, Malta, Brindisi, Trieste and Athens. These telegrams are posted for general information at the ports of Alexandria and Port Said.

The observations of all meteorological stations are printed and published monthly. The complete results of the work at the Central Observatory will be published shortly. The observations registered in 1899, together with the mean values of the preceding thirty years, are already printed and ready for publication.

Besides Omdurman, where there is a complete set of instruments, the stations of Rosaires, Fashoda, Wad Medani and Kassala now record rainy days and approximate fall. They have not yet been furnished with proper rain gauges. It is hoped that before long observing meteorological stations may be instituted at different points on the Blue and White Niles.

Funds have been granted for transferring the Central Observatory to Helouan, fifteen miles south of Cairo. The new building will be commenced this year. A set of thermometers has been sent to the base camp at Meshra-er-Rek, in the Bahr-el-Ghazal Province, to be registered and observed there daily.

Geological Survey.—The staff of the Geological Survey has been employed in compiling the results of the previous three years' field work. Reports on the oases of Kharga, Dakhleh and Farafra are on the point of being published; five other reports are ready for printing. Good progress has been made with the preparation of the maps, some of which will shortly be ready for publication. A geological museum is in course of construction, and will probably be completed before the end of the year. The expenditure on this building up to the end of last year was about £E. 2700.

The Preservation of Game.—Captain Stanley Flower, director of the Gizeh Zoological Gardens, is frequently asked questions as to the regulations existing for the preservation of game in the Soudan. The following statement from the report supplies information upon these matters.

A system of licenses for non-native sportsmen has been introduced. The licences are of two kinds: one is issued at £E. 25 and known as licence "A," authorising the shooting of every kind of game except a small class which is absolutely protected, the other issued at £E. 5 and known as licence "B," from which the rarer kinds of game are excluded. In addition to the licence fee of £E. 25, the holder of a licence "A" is required to pay a fee for each animal included in Class 2 which he may kill. A higher charge is made for female animals, but no female animal of the kind included in Class 2 may be knowingly shot. In the case of elephants the royalty upon ivory is also payable.

The Wild Animals Preservation Ordinance, 1900, also provided that natives might be requested to take out licences, but this provision only applies in districts where it is specially brought into force by a notice issued by the Governor-General. The terms of the licences are arranged by the licensing officer. This part of the Act has been brought into force as regards Kassala, and licences have been granted to the Sheikhs of two or three tribes to kill or capture a limited number of the bigger kinds of game. They pay nothing for their licence, but are required to inform the Mudir if they kill or capture any elephant, giraffe, buffalo or certain other kinds of game and to pay a fee varying from £E. 1 to £E. 8; as there is usually a demand at Kassala for specimens of wild animals, it is thought that the natives will readily pay the fees.

Several specimens of wild animals have been exported during the year, and there is also a certain traffic in skins and trophies. There was reason to fear that, unless the trade was controlled, it would lead to unnecessary destruction of the rarer sorts of animals. The Wild Animals Preservation Ordinance, 1901, which has been recently promulgated, places the export of wild animals and birds under Government control.

Section 2 prohibits the export of wild animals and birds, or of their skins, feathers, horns and trophies in an unmanufactured condition other than elephants' tusks, rhinoceros horn and ostrich feathers, except under Government permit. The provision does not apply to animals or birds which are killed under a game licence.

The Governor-General is empowered to permit the export of animals and birds of which there is no reason to fear the destruction and to impose a tax upon the same. Arrangements have been made to establish a special department of the Government under the general superintendence of Captain Flower, the Director of the Gizeh Zoological Gardens, to deal with questions relating to the wild animals and birds of the Soudan. Licences to export live specimens will be issued by this Department at fees to be determined later, and the Department will undertake the supply of specimens to Zoological Gardens, Museums and others.

Zoological Gardens.—Specia attention has been paid to the fauna of the Nile Valley. There were in the Gardens in October last 670 animals, representing 169 species, as compared with 473 animals, of 132 species, at the corresponding date in 1898. The most important acquisitions have been a giraffe, presented by Lord Kitchener, and a white oryx, from Kordofan, presented by Sir Reginald Wingate.

The staff of the Gardens was mainly employed during the year in rebuilding and repairing cages. An elephant-house has been built, and plans are being prepared for a new lion-house.

Nile Fish Survey.—The collecting of fish was, during the early part of the year, extended as far as Abu Hamed, and at present Mr. Loat, the specialist selected by the authorities of the British Museum, is working on the White Nile. A considerable number of plates, which will eventually be published, have been printed, and material from which others may be drawn has been obtained. A severe loss was sustained last year in the death of Dr. John Anderson, F.R.S., whose knowledge and experience made his advice of the greatest value in carrying out a work which was taken in hand owing to his initiative.

Egyptology.—Under the very capable direction of M. Maspero, a great improvement has recently taken place in the working of all branches of the Archæological Department. Notably, the appointment of two English inspectors-in-chief has done much to preserve the monuments, both in Lower and Upper Egypt, from further depredation and mutilation.

Work has been proceeding at Karnak. It will be remembered that eleven columns in the Great Hall fell to the ground during the flood of 1899. Five further columns appeared to be in some danger of falling. Under the direction of MM. Legrain and Ehrlich, these columns have now been dismantled; others have been strengthened and repaired. The *débris* of the stones which had fallen has been removed, labelled and arranged in such a manner as to render it possible, should it ever be decided to rebuild these columns, to replace each separate stone in the precise position which it formerly occupied.

Lord Cromer says he has been informed, on high technical authority, that, in spite of every precaution, the remaining portions of this splendid monument of antiquity will of necessity be exposed to considerable risk every year at the period when the subsoil water is falling. A very heavy expenditure of money would, without doubt, minimise this risk, but it is doubtful whether, under any conditions, it will be possible to obviate it completely.

The bases of the columns are of insufficient strength; the soil is unstable; each column supports an immense weight in the shape of roofing-blocks; and the whole structure has been erected without mortar and without bond of any sort.

The principal tombs at Thebes have been closed by gates. The tomb of Amenophis II. has been so arranged that the Royal mummy remains *in situ*, and can be seen by visitors. M. Maspero is studying a project for lighting these tombs by electricity, so as to obviate the destruction to the wall paintings caused by the candles used by visitors.

Technical Education.—The only important technical school in Egypt is that situated in the Boulac quarter of Cairo. The School of Agriculture is a very popular institution, and is rendering good service to the country, but more institutions of this kind seem to be needed.

Lord Cromer refers particularly to the educational needs of Egypt, and suggests that attention should be given to technical education in all its branches. He has discussed this subject with various authorities in Egypt, and finds a general disposition to do something towards the improvement and extension of technical instruction. Mr. J. Currie, director of education in the Soudan and Principal of the Gordon College, has reported upon the subject, and extracts from his report are given by Lord Cromer. It is proposed to establish a large industrial school at Khartoum, to be worked in connection with the Government dockyards and workshops. It is also proposed to find houseroom for, and supervise, the following institutions at Gordon College, so far as that can be possible: (*a*) A general Soudan reference library; (*b*) an economic museum, to assist in the commercial development of the country; (*c*) a meteorological station and a small observatory; (*d*) a small analytical laboratory.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Miss E. S. Barclay has bequeathed to Bedford College the sum of 1000*l*. without conditions.

We learn from *Science* that Pittsburg will probably soon have a great technical institution, especially adapted to its needs and as complete in the industrial field of education as the Carnegie Institute of that city has become in art and æsthetics. An advisory committee appointed to determine the best plan and most suitable scope of the new institution has just presented its report to Mr. Carnegie. These expert advisers were Dr. R. H. Thurston, Director of Sibley College, Cornell University, Prof. J. B. Johnson, Dean of the College of Engineering, University of Wisconsin, Prof. Thomas Gray, of the Rose Polytechnic School, and Prof. V. C. Alderson, of the Armour Institute. The scheme proposed includes three different and distinct forms of school which may be combined as parts of one complete technical university. If the whole scheme is accepted by Mr. Carnegie, there will be, in the first place, a first-class technical college. "This college," says the committee, "should be made attractive to the greatest scholars in the fields of physical and chemical science. To obtain and hold such men they must be given ample opportunities for research. This college must be supplied, therefore, not only with great experimental shops and laboratories for students' use, but in all departments there should be splendidly equipped laboratories of investigation and research, under the direction of the head of such department, and with a full corps of assistants for the carrying on of all lines of investigation which are now partly or wholly unprovided for in America." There will also be a Technical High School to carry on work above that of the public grammar school, and day and evening classes for the benefit of those who are unable to take advantage of the more complete courses in this school. Mr. Carnegie has now to decide whether he will found a school for artisans, a technical high school or a technical college, or, if his ambition mounts so high, a true technical university including them all.

An article by Mr. J. B. C. Kershaw in the July number of the *Monthly Review* contains a few facts which should be of interest to all who are concerned with educational and national progress. He points out that technical education as at present carried on in this country is chiefly instrumental in giving to great numbers of young people elementary instruction in every subject except the dead languages. In the opinion of practical men, this smattering of science and other subjects is of no value from an industrial point of view, and as a system for bringing the few who possess undoubted ability or genius to the front it is costly and unnecessary. In England the aim has been to educate the rank and file of the workers, but the German aim is to educate thoroughly all who are to occupy posts of authority in manufactures and industries. Herein there is a great difference, and many people are beginning to see that the German method is the best when industrial progress is taken as the criterion. The reason lies in the ability to appreciate new developments, or, as Mr. Kershaw puts it, "a thorough scientific training enables the manufacturer to decide quickly upon the merits of the new processes or inventions, and he is not daunted by the fact that in this newly-chosen path of industrial progress there is no 'practical experience' to guide his steps. The German manufacturer has, therefore, been assisted by his own thorough technical training, and by that of his manager, engineer or chemist, in adapting himself more quickly than his English rival to new conditions of trade, or to the exigencies of new processes and new developments of industry." There is little hope of substantial improvement while our manufacturers and commercial men, as a rule, have so little sympathy with scientific work. Their general attitude is reflected in advertisements of this kind—"Wanted, young man as Chemist at Tar and Vitriol Works in North of England; willing to fill up time at Bookkeeping." While trained chemists are considered to be on about the same level as a clerk and inferior to a skilled operative, how can we expect to make advances similar to those which Germany and the United States are making?

SOCIETIES AND ACADEMIES.

LONDON.

Royal Microscopical Society, June 19.—Mr. William Carruthers, F.R.S., president, in the chair.—Mr. T. H. Powell exhibited *Coscinodiscus asteromphalus* under a new 1/40th-inch apochromatic oil immersion objective.—Mr. J. W. Gordon read a paper entitled "An examination of the Abbe diffraction theory of the microscope," in which he stated that the above long-accepted explanation of the phenomena of high-power microscopic observation had been accepted on insufficient proof and would not bear the test of critical examination. The Abbe theory claimed that pictures formed by the microscope of very minute objects were due to diffraction images originated by the object, and that when the oblique rays of light in which these diffraction images existed were excluded, no image of the object was possible. This theory had been experimentally illustrated by Prof. Abbe by means of a grating on the stage of the microscope and a series of diaphragms behind the microscope object glass with slits to partially exclude oblique rays. Mr. Gordon showed that although in favourable circumstances diffraction effects were produced by fine objects on the stage of the microscope, these effects did not appreciably influence the formation of the image. He also showed that the experimental results produced by the above-mentioned diaphragms, which were adduced to prove the theory, were due to a diffraction effect produced by the diaphragms themselves and not by the grating on the stage of the microscope, the same results being obtained with an aërial image of a grating projected upon the stage by a lens in place of the actual grating. He maintained that in the microscope, as in the telescope, it was necessary to eliminate diffraction effects as far as possible by making lenses of large aperture, and not, as in Abbe's theory, to include as many diffraction phenomena as possible. Diagrams in illustration of the paper were thrown upon the screen, and the various experiments referred to were exhibited under a number of microscopes. In the discussion that followed, Prof. S. P. Thompson agreed with Mr. Gordon in rejecting the presentation of the Abbe theory given by Naegeli and Schwendener, but found himself at variance with Mr. Gordon on almost every other point, and proceeded to discuss several conclusions arrived at in the paper.

PARIS.

Academy of Sciences, July 15.—M. Fouqué in the chair.—Determination of three principal optical parameters of a crystal, in magnitude and direction, by the refractometer, by M. A. Cornu. Though the measurement of the three principal indices of a crystal is relatively easy, the determination of the three principal directions involves calculations too intricate for ordinary work. A geometrical study of the total reflection at a crystalline surface has led the author to some analytical relations upon this application of the refractometer, of unexpected simplicity. Numerous observations of crystals with an Abbe refractometer have shown that the formulæ developed are exact within the limits of error of the experimental results. Large clinorhombic crystals of commercial tartaric acid have been used in the experiments to test the formulæ. The demonstration of the formulæ and the numerical results are reserved for a future communication.—On the morphology and position of flagellated parasites with undulating membrane, by MM. A. Laveran and F. Mesnil. The characteristics of organisms of the two genera Trypanosoma and Trichomonas are described and compared, and the distinctive features are defined. The former genus comprises all the flagellated parasites which have been found in the blood of vertebrates.—Can poisoning be caused, through the skin and mucous membrane, in a medium which has been rendered irrespirable by sulphuretted hydrogen? by M. A. Chauveau. Experiments with dogs have shown that, provided an inhaling apparatus is worn upon the head, no ill effects ensue, even if the body of the animal is in an atmosphere charged with sulphuretted hydrogen so as to be poisonous.—On the sugars from blood, by MM. R. Lépine and Boulud. In the blood of dogs fed upon meat, or fasting, a sugar has been found analogous to saccharose, but differing from it in some properties.—On a new joint with variable angle, by M. G. Koenigs.—On the extension of the Riemann method of integration, by M. J. Coulon.—On the solution of equations of elasticity, in the case where the values of the unknowns at the limit are known, by MM. Eugène and F. Cosserat.—On the movement of a pendulum in a resisting medium, by M. L. Décombe.—On the changes of phase produced in incident rays in the neighbourhood of total reflection, but lower than the limiting angle, by M. J. Macé de Lépinay.—Measures of wave-length in the solar spectrum; comparison with Rowland's scale, by M. Perot and C. Farry. Thirty-three lines in the solar spectrum have been compared directly with the green light of cadmium, and the wave-lengths have been plotted. The observations suggest that Rowland's scale of wave-lengths is not perfect, and indicate where corrections might be made.—On the direction of magnetisation in beds of clay transformed into hard brick by layers of lava, by MM. B. Brunhes and P. David. It is known that clay baked in a furnace acquires magnetisation in the direction of the terrestrial magnetic field at the time when it is transformed into the condition of brick. The authors have examined some beds of hardened clay covered with lava near Clermont, in the Auvergne district, with the idea of finding the magnetic condition. It appears that in general the magnetic condition of the beds is decidedly different from that of the neighbourhood, and the difference is taken to indicate the change which has occurred since the epoch when the clay was baked by the lava flow.—Thermal study of potassium hydrates, by M. de Forcrand. The observations indicate that in addition to the two compounds KOH and $KOH + 2H_2O$ there are two other intermediate hydrates, viz. $KOH + 0{\cdot}5H_2O$ and $KOH + H_2O$.—On some derived phenyl ether compounds, by M. P. Brenans. The author describes some ether-oxides and ether salts of diiodophenol and triiodophenol.—Action of pyridine bases on tetra-chloro-benzo-quinones, by M. Henri Imbert.—New reactions with *c*-butyrylacetylacetate of methyl, by M. A. Haller.—On pyromucic and isopyromucic acids, by M. Chavanne.—Contribution to the study of ortho-xylene bichloride, by M. L. Ferrand.—Precautions to be taken in the study of parthenogenesis in sea-urchins, by M. C. Viguier.—Germination of the spores of Pencillium in humid air, by M. P. Lesage.—Formation of layers of ice, in summer, in the volcanoes of Auvergne, by M. P. Glangeaud.—Action of currents of high frequency and tension on urinary secretion, by MM. Denoyés, Martes and Rouvière.—Observations of a meteor at Floirac (Gironde) on July 5, by M. E. Esclangon.—On the action of the electric current on microbes, by MM. Apostoli and Laquerrière.

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