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A NATURALIST IN NORTH CELEBES.

A Naturalist in North Celebes. By Sydney J. Hickson, M.A. (Cant.), D.Sc. (Lond.), M.A. (Oxon. Hon.Caus.). With Maps and Illustrations. Pp. 392. (London: John Murray, 1889.)

THIS book is the outcome of the residence of a specialist for nearly a year upon a small island off the extreme north point of Celebes. Of books of travel there is in these days no lack, and so beaten are the paths along which authors for the most part lead us, that the reader in search of amusement or instruction not infrequently arrives at the index without having met with either. But Dr. Hickson's is not a book of travel: it is a record of a naturalist's life with an almost boundless submarine field for observation close at hand—albeit terrestrially somewhat limited—and when he leaves his coral-girt island, it is to wander in that little-known archipelago which links Celebes to the Philippines, the Sangir, Nanusa, and Talaut groups, whither few but adventurous Dutchmen have penetrated.

Of the fourteen chapters, three are devoted to Talisse, the island on which Dr. Hickson conducted his observations. Four are descriptive of his wanderings in the groups just mentioned, and the remainder for the most part treat of the Minahassa district, its natives, and their mythology and customs. Of these, the author tells us in his preface that "the greater part of the ethnological portion of the book is borrowed from the valuable writings to be found in many of the reports of missionary and other societies, and in Dutch periodicals."

Dr. Hickson owing his voyage almost entirely to a desire to study the corals of the Malay Archipelago, it is naturally to that part of the book which treats of them that we first turn. No one has ever yet done justice to the wonderful beauties of coral-land, and the author, in common with his predecessors, has failed—as everyone must fail—to convey to the untravelled reader an adequate idea of the appearance of a vigorous reef. Perhaps the very fact of being an authority has lessened his chance of success. The description is nevertheless a good one, and the chapter (vi.) the most important in the book. Dr. Hickson has wisely relegated his technical work to the publications of the various learned societies, but he tells us much of interest. The first sight of a coral reef at close quarters astonished him—specialist as he was:—

"I could not help gazing with wonder and admiration on the marvellous sight. . . . I had expected to see a wonderful variety of graceful shapes in the branching madrepores and the fan-like, feather-like alcyonarians, . . . but I was not prepared to find such brilliancy and variety of colour" (p. 15).

That vexed and most important question, the growth of coral reefs—a question upon which it was to be hoped that Dr. Hickson might be able, from the length of his stay and his varied opportunities, to enlighten us—is left pretty much where it was. We should be able to predict with certainty the direction and the rapidity of growth. As it is now, charts of coral islands and reefs become almost valueless in the course of a few years. But the causes both of growth and erosion are still undetermined. Much, no doubt, depends upon the rapidity of the tides. In strong tide-races no true coral reef is ever formed. "Flowing water, which is neither too swift nor too stagnant, bearing the kind of food necessary for the proper nourishment of the corals," is, as Dr. Hickson justly remarks, a strongly predisposing element to vigorous growth. Yet this is not always the case, neither does the converse always hold good; and we cannot agree entirely with the author when he says, "in deep bays or inlets, where tidal and ocean currents are scarcely felt, there is but little vigour in the reef." The inner harbour of Amboyna displays as rich a "sea garden," perhaps, as any in Malayan seas.

Dr. Hickson's daily work on the reefs led him to the certain conclusion that but one true species of *Tubipora* exists. The size of the tubes and the character of the septa—upon which most of the species are founded—are shown to be utterly without specific value; these differences depending entirely upon the position of the coral on the reefs. The following remarks upon a fact which must have struck most naturalists in tropic seas, but which we do not remember ever to have seen in print before, are worthy of quotation. Talking of sunrise and early morning, he says:—

"Not only are the birds and insects, which disappear as the sun becomes more powerful, particularly visible at that hour, but it is the time of day above all others when the surface of the sea teems with animal life. I remember well my disappointment when I first got into tropical waters at finding that my surface-net invariably came up almost empty. It was not until I had been at work some time that I made the very simple discovery that in the early morning hours every sweep of the net brings up countless pelagic forms of all sizes and descriptions" (p. 58).

The question of the food of corals is yet unsettled; but the author, after careful examination of polypes of various kinds, is inclined to the belief that many of them may be, partially at least, vegetable feeders. No doubt the water in the vicinity of mangrove-swamps is very largely charged with the *débris* of leaves and fruit and wood, some of which, sinking to the bottom, must enter the mouths of the polypes. Upon the mesenterial filaments of the Alcyonarians, indeed, particles of vegetable fibre are frequently found. It is suggested that the vigorous reefs frequently seen near extensive swamps, may be explained by such an hypothesis. Upon Darwin's theory of the formation of atolls, Dr. Hickson had little opportunity of forming an opinion—little, at least, until he visited the archipelagos already mentioned. He ultimately came to a disbelief in the general subsidence theory, and is not opposed to Mr. Murray's view—that coral reefs can, under favourable circumstances, grow out into deep sea-water upon the talus of their own *débris*.

Among many references to birds occurs an account (p. 41) of the existence of the maleo, or brush-turkey, in Ruang Island. Unfortunately, we are not told whether this is *Megacephalon maleo*, or the smaller *Megapodius gilberti*. They were most probably the latter; but it would be interesting to know, for the true Megacephalon of Celebes has never, we believe, been recorded as occurring in the smaller islands. Meyer's story of the whimbrels nesting on trees (probably *Numenius uropygialis*, Gould, by the way—not *N. phæopus*) is quoted, but without comment, and it is worthy of remark that no naturalist has as yet confirmed it. Dr. Hickson is not quite accurate in his statement that there are only two Celebean birds which are likewise English. He must often have noticed, in his rambles along shore, not only the common sandpiper, but also the wide-ranging *Strepsilas interpres* and one or more of the genus *Totanus*, which are not unfamiliar to us at home.

Perhaps one of the best passages in the book is that describing a mangrove-swamp, where the extraordinary conditions of life obtaining within its limits, and the interdependence of that tree and the coral reef, are well illustrated. The scenery of Talisse Island is not particularly beautiful, although the author does not tell us so; but that of the district of Minahassa on the mainland is strikingly lovely, and he describes the view of the Tondano Lake as one without an equal. It was unspoilt to him even by the thought of the "*heerendienst*"—that system of compulsory service which has acted as a red rag to so many Englishmen. Dr. Hickson is not so prejudiced, and is wise enough to recognize—as did Wallace—the enormous advantage which it has conferred upon the people.

"I cannot help thinking," he says (p. 208), "that everyone who is really acquainted with the circumstances of these colonies and the character and condition of the people must admit that it is a service both necessary and just. The Dutch Government has brought to the people of Minahassa not only the blessings of peace and security, but also the possibilities of a very considerable civilization and commercial prosperity. . . . In return for all this, it is only just that every able-bodied man should be compelled to lend a hand in maintaining this happy condition of affairs. In a land where the necessities of life are so easily obtained, . . . it would be impossible for the Government to obtain a sufficient number of them to labour on the roads at a reasonable wage."

The consequence is that they would be neglected. The *heerendienst*, then, as Dr. Hickson shows, is the only system possible, without overburdening the Exchequer, or increasing the taxation beyond the endurance of the people.

We have not space to dwell upon the description of the Sangir Islands, or on the mythology and customs of the natives of Minahassa, which Dr. Hickson has done well to put within the grasp of those who are unacquainted with the Dutch language. Among the folk-lore it is interesting to notice (p. 241) the story of Lumimuüt's impregnation by the west wind—a story which, if we mistake not, is almost identical with one of Egyptian source. The "swan-maiden" tale—which, perhaps, has as wide a distribution over the surface of the globe as any other—again occurs in Celebes. Enough has been said to show that "a naturalist in North Celebes" had a varied interest in his surroundings, which he has contrived to communicate to his readers with success. A little more care, perhaps, would have purged the volume of several misprints, and one or two instances of involved diction.

The woodcuts with which the book is furnished are well enough. We wish that anything could be said in favour of the "process" illustrations. That at p. 33 is bad, and another at p. 137 still worse. But anything more muddy and meaningless than that facing p. 45 we confess never to have seen.

F. H. H. GUILLEMARD.

SAINT-VENANT'S ELASTICAL RESEARCHES.

The Elastical Researches of Barré de Saint-Venant. (Extract from Vol. II. of Todhunter's "History of the Theory of Elasticity.") Edited, for the Syndics of the University Press, by Karl Pearson, M.A., Professor of Applied Mathematics, University College, London. (Cambridge: At the University Press. London: C. J. Clay and Sons. 1889.)

OUR fears lest this "History of the Theory of Elasticity" should, like Thomson and Tait's "Natural Philosophy," remain a magnificent mathematical torso have been agreeably falsified by the early appearance of this instalment of the second volume. It is devoted entirely to the work of Saint-Venant, the distinguished French mathematical engineer.

Saint-Venant is one of the rare examples of a writer who is equally popular with the mere mathematician and with the practical engineer. To quote from the author's preface to this part of the "History of Elasticity," "we live in an age when the physicist awaits with not unreasonable excitement for greater revelations than even those of the past two years about the ether and its atomic offspring; but we live also in an age when the engineer is making huge practical experiments in elasticity, and when true theory is becoming an absolute necessity for him, if his experiments are to be of practical as well as of theoretical value." This is the opinion of the theorist; but the engineer points to his work as magnificent experiments on a gigantic scale, to which he invites the theorist to an inspection, for him to deduce his theoretical laws.

So far as pure theory is concerned, the engineer trusts only to Hooke's law, and Euler's theory of the beam, which neglects the warping of the cross-sections. But Hooke's law is shown by the testing-machine to be only a working hypothesis within very narrow limits of extension and compression, after which the baffling phenomena of plasticity make their appearance, and destroy all the simple mathematical harmony; while as to Euler's theory of the flexure of the beam, the editor, Prof. Pearson, is at present engaged on the mathematical discussion of the permissible limits of the application of the ordinary theory, and, so far, the result of his investigations (in the *Quarterly Journal of Mathematics*) is such as to strike dismay in the heart of the practical man who would be willing to apply his conclusions.

The purely mathematical theory of Elasticity is, at the present moment, in a very curious condition, for a subject in the exact science *par excellence*. Not only are elasticians divided into opposite camps of *multi-constancy* and *rari-constancy*, but we find a war of opinion raging among the most recent investigators—Lord Rayleigh, Chree, Love, Basset, and others. All are compelled to violate apparently the most fundamental rule of mathematical approximation; and, in considering the elasticity of a curved plate, to begin by neglecting the terms depending on the stretching of the material, which involve the first power of the thickness of the plate, in comparison with the terms depending on the bending, involving the cube of the thickness; thus apparently neglecting the first power compared with the third power of small quantities. But, if we take a thin sheet of brass or iron in our hands, we shall find it quite easy to bend, but apparently impossible to stretch or shear in its own plane, showing that the stretching stresses may be considered as non-existent, by reason of requiring such large forces to produce them.

Before pure mathematical treatment can make much progress in Elasticity, much more experimental demonstration is required of the behaviour of pieces of metal of mathematical form under given applied forces; and such experiments can be carried out in testing-machines, now forming an indispensable part of a physical laboratory.

Saint-Venant's memoir on torsion, analysed in Section I., is familiar to us through its incorporation by Thomson and Tait, and shows that Saint-Venant carried out, with the comparatively crude methods at his disposal, valuable experiments, from which much theoretical deduction has been made; the analogues of the mathematical analysis in the problem of the torsion of the cylindrical beam of given cross section, and of the flow of viscous liquid through a pipe of the same section, or of the rotational motion of a frictionless liquid filling the cylinder being very striking. Prof. Pearson introduces great elegance and interest into the series which arise by a free use of the notation of hyperbolic functions, and we think there is still some interesting work for pure mathematicians in the identification of those series which are expressible by elliptic functions. But it certainly looks curious to find in § [287] the old familiar polar co-ordinates treated as mere conjugate functions, without reference to their geometrical interpretation.

Section II. is occupied with the analysis of Saint-Venant's memoirs of 1854 to 1864, in which he attacks such questions in practical elasticity as the longitudinal impact of bars, illustrated by very ingenious graphic diagrams, and also the conditions of stress of a cylindrical shell, in equilibrium under given applied internal and external pressures. This is the problem required in the scientific design of modern built-up artillery; and it is noticeable that Saint-Venant's solution differs materially from Lamé's, subsequently popularized by Rankine, the theory employed, as far as it will go, by scientific gun-designers all over the world.

The researches in technical Elasticity of Section III. arose in the annotations of Navier's "Leçons sur la Résistance des Corps solides"; the mantle of Navier descended on the shoulders of Saint-Venant, and ultimately the notes of Saint-Venant overwhelmed the original text of his master Navier; and, according to Section IV., Saint-Venant has practically done the same thing with Clebsch's "Elasticität."

Being the mathematical referee for all the difficult theoretical problems arising with the extensive use of the new materials iron and steel in architecture and engineering, Saint-Venant was provided with a number of useful problems on which to exercise his ingenuity; such as the impact of bars, the flexure of beams due to a falling weight or a travelling load, the critically dangerous speeds of fly-wheels and piston-rods, and so on; all problems hitherto solved by practical rule of thumb, the practical constructor encountering and opposing the difficulties without knowing why and how they arose.

Saint-Venant's investigations urgently need extension and application to the critically dangerous conditions which can arise in the stresses in artillery, when the dynamical phenomena are analysed, due to the sudden and periodic application of the powder pressure, and to the wave-like propagation and reflection of the stresses in the material. At present, we can only investigate the theoretical strain set up in the material of the gun by a steady hydrostatic pressure equal to the maximum pressure of the powder, employing Lamé's formulas, and then employ an arbitrary factor of safety, say 10, in the design of the gun, to provide against the contingencies of the dynamical phenomena we have not yet learnt how to discuss.

In the old times, before the Cambridge Mathematical Tripos was reduced to its present meagre curriculum, the examiner would have found the present volume very useful in suggesting good ideas, capable of testing reasonably the mathematical power of the candidates; at present, the chief class to profit by the present work are the practical constructors, who will learn where to look for the useful information on the narrow technical point which concerns them.

Prof. Pearson has brought his onerous task one step nearer to completion in this interesting volume, a monument of painstaking energy and enthusiasm.

A. G. GREENHILL.

GLOBES.

Hues's Treatise on the Globes (1592). Edited by Clements R. Markham, C.B., F.R.S. (London: Reprinted by the Hakluyt Society, 1889.)

THE Hakluyt Society has for its object the reprinting of rare or unpublished voyages and travels, and few are worthier of this honour than the "Tractatus de Globis" of Robert Hues. The author of this work was an intimate friend of Sir Walter Raleigh, and combined book-learning with practical knowledge gained by joining in some of the voyages to the New World with navigators whose names have made the sixteenth century famous. He strongly urged that his countrymen would have still further surpassed their Spanish and Portuguese rivals if they had "but taken along with them a very reasonable competency and skill in geometry and astronomy." In those days logarithms were unknown, and the solution of the problems of nautical astronomy required advanced mathematical knowledge. It was hoped that this difficulty would be overcome by the extended use of globes, which at once reduces these complex questions to approximate solution by inspection. After the construction of the Molyneux globes, Hues's treatise came into very general use, and no doubt played an important part in the explorations of the succeeding century.

It seems strange in these days, when a globe can be purchased for a few shillings, to read that only three centuries ago the construction of globes entailed such great expense that the liberal patronage of a merchant prince was required before such an undertaking could be entered upon. Readers of Kingsley's masterpiece will not need to be reminded that the funds were supplied by "Alderman Sanderson, the great geographer and setter forth of globes." Emery Molyneux, a mathematician of whom little is known, was entrusted with the construction of the globes, but although several were manufactured and sold, only one set has been preserved, and this has found a strange resting-place in the library of the Middle Temple.

From the admirable introduction by the editor, we learn that the celestial preceded the terrestrial globe by many centuries. It has been asserted that Atlas, of Libya, discovered the use of the globe, and thus gave origin to the fable of his bearing up the heavens on his shoulders. There are several allusions to globes by the ancient writers, and on the medallion of the Emperor Commodus a celestial globe is clearly represented. None of the Greek or Roman globes, however, have been preserved. Amongst the oldest in existence are those made by the Arabian astronomers, dating from the thirteenth century. These are made of metal, on which the stars are engraved, and five of them are still with us, one belonging to the Royal Astronomical Society. The oldest globe, now at Florence, was constructed in 1070; and, though it is only 7·8 inches in diameter, 1015 stars are engraved upon it.

The terrestrial globe apparently dates from 1492. Baron Nordenskiöld points out that this is the first adoption of the notion of antipodes, and the first to show a sea-passage from Europe to India. The first map on which the name of America appears was found amongst the papers of Leonardo da Vinci at Windsor Castle; it is drawn on eight gores, and was probably intended for a globe. The next terrestrial globe of interest was that completed by Mercator in 1541, having a diameter of 16 inches. Others succeeded, and finally we come to the enlarged and improved globes constructed by Molyneux. These are twenty-six inches in diameter, and differ little in construction from our modern globes, but the geography, of course, differs very considerably.

The original work of Hues was in Latin, and went through several editions. Nine editions in Dutch and French followed, the most important being the Dutch one annotated by Isaac Pontanus. The latter was translated into English by John Chilmead in 1638.

The treatise is divided into five parts, the first dealing with things common to both globes, the second with planets and stars, the third with the geography of the terrestrial globe, the fourth with the use of the globes for purposes of navigation, and the fifth is a treatise on the use of rhumb lines, by Thomas Herriot. The book is especially interesting on account of the many references to the theories of the ancients and contemporaries, the whole forming a valuable history. The discussions of the size and shape of the earth are particularly striking. After giving the diverse opinions as to the length of a degree, the measures varying from 480 to 700 furlongs, the author concludes with the remark: "Let it be free for every man to follow whomsoever he please."

A geographical index at the end gives a long list of places, with their latitudes and longitudes, which has been reprinted with the hope that it may be of use in identifying old names. Longitudes in those days were measured from a point in the Azores, London thus having a longitude of about 26°.

Two other indices have been added, one a biographical index, and the other an index to the names of stars and constellations. Both of these are very complete, and will be of great interest to those wishing to learn a little about ancient astronomers and the origins of astronomical names. A. F.

THE PSYCHOLOGY OF ATTENTION.

The Psychology of Attention. By Th. Ribot. Authorized Translation. (Chicago: The Open Court Publishing Company, 1890.)

IN this neat little volume of little more than a hundred pages we have a very careful and lucid consideration of *attention* from the standpoint of scientific psychology. Adopting the division of attention into two well-defined forms—the one spontaneous or natural (non-voluntary or reflex of Mr. Sully's "Outlines"), the other voluntary or artificial—Prof. Ribot devotes his first chapter to the former and his second to the latter. In a third he deals with "morbid forms of attention." These, with a short introduction and a short conclusion, constitute the compact little work. Although there is not very much that is, strictly speaking, new—and is this to be expected?—there is scarcely a page without some apt illustration, some pithy epigram, or some well-expressed generalization. It is a closely-reasoned and luminous exposition of a genuine piece of psychological work.

The four points on which the author lays most stress are the following:—(1) Attention is caused by, or has its origin in, emotional states. (2) Under both its spontaneous and voluntary manifestations it is, "from its origin on, bound up in motory conditions." (3) Intellectually it is a state of relatively perfect monoideism. (4) It has a biological value. Of these, the second is the most essential. The motor element in attention is the keynote of the whole argument. The emotions from which we start are not merely complexes of pleasurable or painful elements floating free in a purely mental atmosphere. They are the psychological accompaniments of certain activities or tendencies to activity. The pleasure and pain associated with these activities are "the hands of the clock, not its works"—or, to change the analogy, "they follow tendency as the shadow follows the body."

And as the motor element is present at the emotional initiation of attention so too is it present through every phase of its existence. The motor effect may, however, be manifested under either of two forms: it may be impulsive and produce movement; or it may be inhibitory and withhold movement. Attention accordingly means the concentration or the inhibition of movements; while its converse, distraction, means diffusion of movements. Steadily applied work is the concrete, the most manifest form of impulsive attention; steadily applied thought the ultimate goal of inhibitive attention; for, as Prof. Bain has well said, "To think is to refrain from speaking or acting." Such movements as are still requisite for continued life, such as those of respiration, are under strict control. The master-idea, so far as is possible, drains for its own use the entire cerebral activity.

Attention from the first has had a biological value.

"Any animal so organized that the impressions of the external world were all of equal significance to it, in whose consciousness all impressions stood upon the same level, without any single one predominating or inducing an appropriate motory adaptation, were exceedingly ill-equipped for its own preservation."

Attention has thus been a factor in the progress of life, or, as Prof. Ribot puts it epigrammatically, attention is a condition of life. In the lower animals, under normal conditions, attention is for the most part spontaneous; or, to use the author's alternative term, natural. One may perhaps say that in natural or spontaneous attention the motive or interest is inherent, while in voluntary or artificial attention it is extraneous. And the process by which voluntary attention is developed is by rendering attractive by artifice what is not attractive by nature; by giving an artificial interest to things that have not a natural interest. This, too, is a factor in progress; this, too, has a biological value.

"In the course of man's development from the savage state, so soon as (through whatever actual causes, such as lack of game, density of population, sterility of soil, or more warlike neighbouring tribes) there was only left the alternative of perishing or of accommodating oneself to more complex conditions of life—in other words, going to work—voluntary attention became a foremost factor in this new form of the struggle for existence. So soon as man had become capable of devoting himself to any task that possessed no immediate attraction, but accepted as only means of livelihood, voluntary attention put in an appearance in the world. It originated, accordingly, under the pressure of necessity, and of the education imparted by things external."

We have thought it more just to our author, and more satisfactory to our readers, to give some account of Prof. Ribot's main theses with which we are in full sympathy, than to select minor points, of which there are but few, in which we differ from his conclusions. The translation is, on the whole, satisfactory, but some expressions, such as "the marrow and the bulb" (for the spinal cord and medulla), "moderatory centres," and "the fundament of emotional life rests in tendencies," &c., strike one as somewhat unusual. C. LL. M.

OUR BOOK SHELF.

Handleiding tot de Kennis der Flora van Nederlandsch Indië: Beschrijving van de Families en Geslachten der Nederl. Indische Phanerogamen. Door Dr. J. G. Boerlage. Eerste Deel, Eerste Stuk. "Ranunculaceæ—Moringaceæ." Pp. 312. With an Index. ("Introduction to a Knowledge of the Flora of the Dutch East Indies." (Leyden: E. J. Brill, 1890.)

THIS is the first part of a work consisting of descriptions of the natural orders and genera of flowering plants represented in the Dutch East Indies. A work thus limited must necessarily be of limited utility; but we have Dr. Treub's testimony in a preface thereto that he regards it as a highly useful forerunner of a new Flora of the country. It is nearly five-and-thirty years since Miquel began publishing his "Flora," and the last part of it appeared in 1860, before Bentham and Hooker's "Genera Plantarum" commenced; and systematic botany generally has experienced extraordinary development since then. Further, one of the great advantages claimed for the present work is that it is wholly in Dutch. It is based on Bentham and Hooker's "Genera Plantarum," and we find on comparison that the ordinal, tribual, and generic definitions are to a great extent translations, though later additions to the flora, both in genera and species, have not been neglected. Dr. Boerlage's book will also be useful to the phytographer, as it is already something to have a synopsis of the genera found in the large eastern area under Dutch dominion. Geographically, the next descriptive "Flora" of the region should include the whole of "India aquosa," which means, at least, an examination of the plants of the whole of tropical Asia, of tropical Australia, and of Polynesia. Such a work, on lines similar to Hooker's "Flora of British India," would be of immense value; but it requires qualified men, with sufficient time, money, and ample materials from the whole area. W. B. H.

The Elements of Laboratory Work. By A. G. Earl, M.A., F.C.S. (London: Longmans, Green, and Co., 1890.)

THIS volume is of such a character that the reader is at once tempted to seek for its excellences rather than for its weak points. It aims at presenting "an introduction to all branches of natural science," and is intended to be used as a hand-book in the laboratories of public schools that have well-equipped rooms devoted to practical science. The author says in his preface that such rooms "are nowadays considered a necessary part of all public schools and colleges." Granting that this is the case, that the teacher is good, and that his pupils are already highly trained and anxious to learn pure science for its own sake, this volume might be accepted as an excellent guide. It is marked by a total absence of the "familiar examples" which we have hitherto associated with elementary scientific works. The student is made to accustom himself to technical language from the very first. For example, "a set of *weights*," is, on p. 2, explained as being "a number of bodies so arranged," &c.; and a few paragraphs further on the student is directed to "verify the graduation of a burette," and is introduced to reading telescopes and cathetometers. The first introduction of the student to chemical changes is an experiment consisting of the ignition of silver nitrate with quantitative observations, the second experiment is similar but with silver iodate, and the third is the heating of silver nitrate in a closed tube over a small Bunsen flame. In an explanation of the significance of what are commonly known as atomic weights and molecular weights, the expressions atomic masses and molecular masses are used. We do not see the advantage of this novel nomenclature. If the volume had an index, we should be prepared to recommend it in unqualified terms for the use of school-boys who can carry out such instructions as the following: "Perform experiments illustrating the law that chemical combination takes place between definite quantities of different kinds of matter."

Magnetism and Electricity. Part II. Voltaic Electricity. By Prof. Jamieson, M.Inst.C.E., &c. (London: Griffin and Co., 1890.)

IF the third part of this work prove equal in excellence to the two already published, Prof. Jamieson may claim to have produced one of the best introductory text-books on the subject. Like its predecessor, Part II. treats the subject in an essentially practical way. A competent electrician himself, the author is well able to understand the difficulties which beginners are likely to meet with, and his attempts to make obscure things clear will probably be found highly successful. The theoretical side of the subject is carefully considered, and no important application of a principle is passed over without reference.

Instruments in actual use for what have now become every-day purposes are fully illustrated and described.

The book is well up to date both in the experimental and applied branches. Mr. Shelford Bidwell's apparatus for studying the changes in length of a bar during magnetization is described in such a way as to make the object of the experiment and the method of carrying it out easily understood. More of this kind of thing in our text-books is very desirable as showing that progress in a science is not made by chance, but is the outcome of careful thought on the part of patient investigators.

As a text-book for classes where experimental work is encouraged it is especially suitable, but we recommend it to the notice of all beginners. Numerous questions and specimen answers follow the various chapters, and an appendix gives instructions for making simple apparatus.

Astronomy with an Opera-Glass. By Garrett P. Serviss. (London and New York: D. Appleton and Co., 1889.)

WE are glad to welcome this, the second edition of a popular introduction to the study of the heavens. The author has surveyed, with the simplest of optical instruments, all the constellations visible in the latitude of New York, and carefully noted everything that seemed of interest to amateur star-gazers. In addition to the map and directions given to facilitate the recognition of the constellations and the principal stars visible to the naked eye, many facts are stated concerning the objects described which render the work a compendium of useful and interesting information—an astronomical text-book as well as a star-atlas. Similar combinations are very desirable introductions to every science, and offer the best means of extending true knowledge. To lead the student to Nature, and direct his attention to some of her marvellous works, to make him see natural phenomena intellectually, should be the basis of all scientific instruction, and works constructed on these lines read like story-books. With such works the one before us should be included, and there could hardly be a more pleasant road to astronomical knowledge than it affords; replete with information, elegant in design, easy of reading, and practical throughout, it deserves to rank high among similar guides to celestial phenomena. A child may understand the text, which reads more like a collection of anecdotes than anything else, but this does not mar its scientific value, and if the work multiplies the number of observers, as it is calculated to do, the dearest wish of every astronomer will be gratified.

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.*]

Electrical Radiation from Conducting Spheres, an Electric Eye, and a Suggestion regarding Vision.

I DO not know how far the description of little isolated experiments is serviceable, but I am tempted to communicate a simple plan I use for exciting electric oscillations in dumb-bells, ellipsoids, elliptical plates, spheres, or other conducting bodies of definite geometrical shape unhampered by a bisecting spark-gap. I do it by supplying electricity to opposite ends of the conductor by means of Leyden jar knobs brought near enough to spark to it: said knobs being likewise connected with the terminals of a small Ruhmkorff coil. The charge thus supplied or withdrawn at every spark settles down in the conductor after a few oscillations, and these excite radiation in surrounding space.

There are many ways of arranging the Leyden jars: some more effective than others. The outer coats of the two jars may or may not be connected together. Connecting them in some cases brightens the sparks at short range, but seems to have a tendency to weaken them at long ranges. It is not difficult to surmise why this is so.

Of course, when the outer coats are disconnected, only an insignificant portion of the capacity of the jars is utilized; but unless the thing to be charged has too large a capacity it works perfectly well.

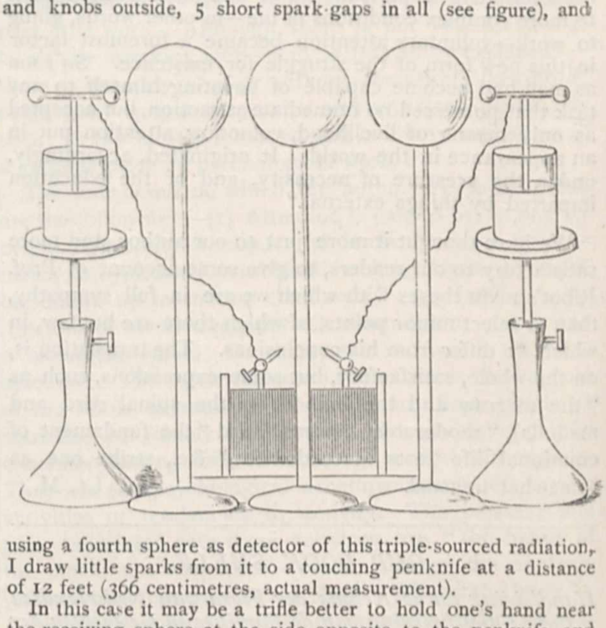
The receiver or detector is a precisely similar conductor touched to earth by a point held in the hand. The distance at which such a receiver responds is surprising. Or one may use a pair of similar conductors and let them spark into each other; but this plan is hardly so sensitive, and is more trouble.

The fact of being able in actual practice to get radiation from a sphere, is interesting, inasmuch as the subject of electrical oscillations in a perfectly conducting sphere has been worked out accurately by Prof. J. J. Thomson in the London Mathematical Society's Proceedings. I have not the volume by me, but I think he reckons the period of oscillation as the time required by light to travel 1·41 diameters of the sphere.

The case of spheres of ordinary metal will not be essentially different, with these rapid oscillations, for the electric currents keep to a mere shell of surface in either case; and in so far as *damping* affects the period, the dissipation of energy by radiation (which is common to both) is far greater than that caused by generation of heat in the skin of a metal sphere.

I happen to have four similar spheres of nickel-plated metal on tall insulating stems; each sphere 12·1 centimetres in diameter. Applying spark knobs to each end of a diameter of one of them, and applying the point of a penknife to another one standing on the same table at a distance of two and a half metres, I am able to get little sparks from it without using any reflector or intensifier.

Or arranging three spheres in a row, with intervals between and knobs outside, 5 short spark-gaps in all (see figure), and



using a fourth sphere as detector of this triple-sourced radiation, I draw little sparks from it to a touching penknife at a distance of 12 feet (366 centimetres, actual measurement).

In this case it may be a trifle better to hold one's hand near the receiving sphere at the side opposite to the penknife, and thus vary its capacity by trial so as to imitate the disturbing effect of the contiguous spheres in the transmitter.

The complete waves thus experimented on and detected are only 17 centimetres (six and a half inches) long, and I imagine are about the shortest yet dealt with.

But we do not seem near the limit set by lack of absolute suddenness in sparks yet, and are going on to try a large number of little globes.

Exciting a lot of little spheres by a coil in this way forcibly recalls to mind the excitation of a phosphorescent substance by a coil discharge.

And a receiver not very unlike the rod-and-cone structure of the retina can likewise be made. My assistant has been experimenting on a sort of gradated receiver which he made himself. I have recently had made a series of long cylinders with diameters ranging above and below 12 centims.; and the length of each which responds to radiation is a kind of measure of specific intensity. They form (speaking sensationally) an electric eye with a definite range of colour sensation. It would be easy to supply it with a pitch or paraffin lens.

There is no need to suppose the retinal bodies to be conducting: a body of high refractive index should be subject to electric vibrations, and its surface to spurious electrifications, when radiation falls upon it; and the optical density of the rods and cones is known to be high. They may, however, be electrolytic conductors; and I find that a liquid sphere—*e.g.* a flask of inky water—responds to radiation, giving a glow to a point touching its glass.

The diameters of the rods, as measured by various physiologists, are not very different from dimensions adapted to respond to actual light-vibration frequency; and if this idea substantiates itself, these bodies can be supposed to constitute a sort of Corti's organ responding to etherial instead of to aërial vibrations, and stimulating in some still unknown, but possibly mechanical, manner, the nerve-fibre and ganglion with which each appears to be associated. OLIVER J. LODGE.

University College, Liverpool, March 11.

"Peculiar Ice-forms."

MAY I add another to the long series of communications which from time to time have been addressed to you under the above heading? Most of them have described and discussed the occurrence of ice in the form of filaments. One signed by J. D. Paul (NATURE, vol. xxxi. p. 264) seems (the description is somewhat vague) to refer to a mode of ice formation which is of somewhat frequent occurrence here, and is the only reference to this mode which I can find in that portion of the literature of physics which is accessible to me.

It happens now and again in our variable climate that a loose porous soil which has been thoroughly soaked with rain is made by a sudden and a sharp frost to produce a crop of little columns of ice. I observed a striking instance lately on a piece of hard compact ground, which, not being quite smooth, had been covered with an inch or so of loose pebbly soil for levelling purposes. Before the loose soil had been rolled or trampled upon, it became saturated with water through two days of continuous rain; and while it was still saturated, a sharp frost set in at night. In the morning the ground, to the extent of 60 square yards, was found to be covered with little columns of ice, some of them about two inches in length. They were roughly circular in section; and each column had approximately the same section throughout. Their diameters ranged from one-tenth to one-third of an inch. They were not transparent, but were whitish in appearance, and carried on their summits pebbles or frozen earth. They were thus obviously not ice crystals, such as Brewster describes in the *Edinburgh Journal of Science*, vol. ix. p. 122, as occurring in similar circumstances. The columns started from the ground at various inclinations to the vertical, and in the great majority of cases they curved upwards to a greater or less extent. I had never noticed this upward curving of the ice columns before, but other persons familiar with the phenomenon assure me they have observed it.

The explanation of this mode of ice formation seems pretty obvious. The sudden frost solidifies the crust of the soil; and it may therefore sometimes happen (in the above case it clearly must happen) that water becomes imprisoned between the frozen crust and the impervious sub-soil. Further freezing enables nature to perform Major Williams's experiment for us. If the crust does not give way as a whole, it must at its weak points; and the internal pressure is relieved by the protrusion of ice columns through apertures formed at these points. These columns would naturally carry portions of the crust on their summits, and during their protrusion might be expected to have innumerable minute fissures or cracks produced in them so as to exhibit a whitish snowy appearance. At the base of any column, at points where the freezing-point has been lowered by the pressure to the actual temperature, melting is continually occurring, and the water thus formed will flow into the fissures referred to. If the axis of the column is inclined to the vertical, and if we assume that the fissures and the points at which melting occurs are pretty uniformly distributed, more water will flow into the fissures of the lower side of the column than into those of the upper side. When the water re-freezes therefore, the lower side must elongate more than the upper, and the column must consequently in general curve upwards. That in exceptional cases the upward curving may not occur is obvious.

J. G. MACGREGOR.

Dalhousie College, Halifax, N.S., March 1.

On a Certain Theory of Elastic After-Strain.

IN a recent paper (Proc. Lond. Math. Soc., April 11, 1889), Prof. Karl Pearson has discussed at some length the possible forms of the additional terms which may be introduced into the general equations of elasticity by a consideration of the mutual action of the molecules and the ether, and has examined what physical phenomena may admit of explanation in this way. In particular, certain terms which thus appear admissible are made to yield a theory of the phenomenon known as "*elastische Nachwirkung*," or "after-strain." The attempt to explain such a comparatively slow process by the intervention of the ether certainly invites scrutiny, and in fact a very slight examination serves, I think, to show that the theory in question rests on a mistake. The author, after writing down the equations which (on his view) represent the steady application of stress to a portion of matter, proceeds to integrate them in the usual way by assuming a time-factor e^{mt}, and arrives at a quadratic in m^2 whose roots are μ/μ' and $(3\lambda + 2\mu)/(3\lambda' + 2\mu')$, where λ, μ are the ordinary elastic constants of Lamé, and λ', μ' are the coefficients of the additional terms referred to. He continues:—"Now m cannot be *positive*, so long at least as we are dealing with elastic-strain. For λ' and μ' are small as compared with λ and μ, the effects we are considering being only of the second order. Hence m^2 is large, and if m were positive the strain would rapidly grow immensely large, which is contrary to experience. Thus, we must give m the negative values $-\sqrt{(\mu/\mu')}$ and $-\sqrt{\{(3\lambda + 2\mu)/(3\lambda' + 2\mu')\}}$." The positive values of m are certainly inconvenient, but they are on the same footing with the negative ones; all are solutions of the author's equations, and all are required for the purpose of satisfying arbitrary initial conditions. The proper inference is surely that the substance is unstable, so long as the constants μ/μ' and $3\lambda' + 2\mu'$ are (as the author has tacitly assumed them to be) positive. If, to avoid this disaster, we change the signs of these constants, we get circular instead of exponential functions, and all analogy to elastic after-strain of course disappears. In its place we have *vibrations* (not molecular, but "molar") whose period is intrinsic to the substance and independent of the dimensions of the portion considered. To what physical reality these may correspond I do not undertake to say. HORACE LAMB.

The Owens College, March 4.

Foreign Substances attached to Crabs.

IF, as Mr. Garstang seems to suppose, the presence of tunicates on a crab is to be regarded as a danger-signal to its enemies, then *Hyas* must belong equally to both his groups α and β. I have found simple tunicates (*A. sordida*) on two small specimens of *H. coarctatus*. In one example they almost completely hid, and several were larger than, the crab. I do not know if anyone has observed *Hyas* "dressing" itself with tunicates. I should think it was an operation of some difficulty, at least in the case of *A. sordida*, which adheres pretty tightly to stones and shells. It cannot be said to be brilliantly coloured, so that its assumption by *Hyas* might be regarded as only an adaptation for concealment, as in the case of *Algæ*—belonging, therefore, to group α. It seems to me, however, very doubtful whether a small *Hyas* would, even if it could, willingly burden itself with such a serious incubus as half a dozen tunicates. Probably their presence is in no way due to any act of the crab's.

The shore-crab, as pointed out long ago by Prof. McIntosh, frequently suffers loss of sight by the usurpation of its orbit by a growing mussel, and the Norway lobster has been found with one eye grown over by a Polyzoan. Such foreign bodies are surely rather hurtful than protective, and the same may perhaps be said of the tunicates on *Hyas*. It is also a question whether the crab likes the smell of tunicates any better than its neighbours.

I think Mr. Garstang is wrong in assuming the inedibility of tunicates. Prof. McIntosh, in "The Marine Invertebrata and Fishes of St. Andrews," speaks of *Molgula arenosa* as being found abundantly, and of *Pelonaia corrugata* as occasionally in the stomach of the cod and haddock; and Mr. W. L. Calderwood has found *Pelonaia* in some numbers in the intestine of the common dab.

Amongst anemones, *A. mesembryanthemum* is certainly a favourite food of the cod, and is not uncommon on the carapace of *Cancer pagurus*. It is difficult to see in what way the anemone is there protective to the crab. Both young crabs and anemones (of this and some other species) are equally preyed on by the cod; and though the crab may perhaps be big enough (as in a recent specimen 5 inches broad) to enjoy immunity from the cod's attack, yet, by parading such a gaudy bait, it must at least run the risk of a severe shaking. It may be added that, in the last-named case, the anemone quitted the crab, when moribund, for a more desirable basis.

ERNEST W. L. HOLT.

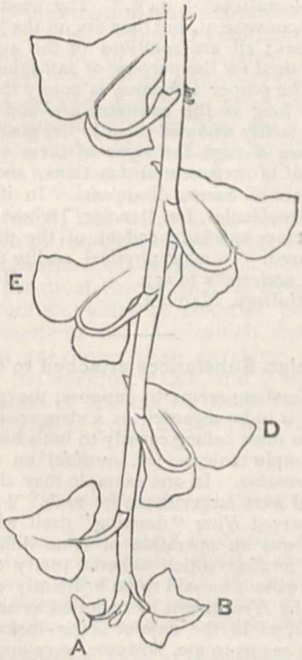
St. Andrews Marine Laboratory, N.B., March 9.

Abnormal Shoots of Ivy.

THE accompanying sketch represents a condition which is exhibited by a certain group of ivy plants in the neighbourhood of Plymouth. The plants are rooted upon the top of a high bank, which bounds the southern side of the road from Mount Edgcumbe to Tregantle; the branches pass downwards from the top of the bank on to its northern side.

The young shoots of each plant are conspicuous, because their leaves appear red, and so contrast strongly with the green of the older leaves. This appearance is due to the fact that the lower surface of each leaf is uppermost.

The sketch represents the terminal portion of a young shoot. The growing point is directed downwards. The three terminal leaves, A, B, C, have their upper surfaces directed upwards. The



leaves beyond these, however (D, E, &c.), are twisted in a twofold way. First, each leaf-stalk is twisted on its own axis, so that the lower side of the leaf is directed upwards; and secondly, the apex of each leaf is rotated through 180°, so that it points away from the growing point of the shoot which bears it, towards the root.

This twisted condition is exhibited by about twelve or fourteen leaves on every young shoot—say, through a dozen inches from the growing point. The older leaves lose both kinds of torsion, so that each old leaf has its upper side uppermost, and its apex is directed towards the growing point of the stem. The under sides of the older leaves have completely lost their red colour.

The condition described is exhibited by all the shoots of a plexus of ivy plants just beyond the fifth milestone from Mount Edgcumbe, on the road above mentioned. It is absent in all the many bushes and creeping masses of ivy which grow on the same bank of the road between this point and Mount Edgcumbe. Whether all the plants composing the abnormal plexus are the offspring of a single parent cannot now be determined.

Plymouth, March 10. W. F. R. WELDON.

Earth-Currents and the Occurrence of Gold.

GOLD has been so large a factor in the prosperity and greatness of Australia, that the interesting subject of the origin of gold drifts and reefs must always possess to us something more than a purely scientific attraction. In the earlier days of the gold-fields there was among the diggers much speculation, of a scientific and semi-scientific nature, as to the processes by which Nature had produced the accumulations of coarse and fine gold dust which it was their business to extract from the alluvial drifts. The most obvious explanation, of course, was that the grains of gold had an origin similar to that of the *débris* and detritus of various characters which made up the alluvium itself; and this explanation seemed to harmonize so completely with the general processes of Nature that at one time it was almost universally accepted as the correct one. But many thoughtful mining authorities had their doubts upon the subject, and these doubts were not founded, as so frequently happens, upon mere prejudice, but were fortified by the fact that certain phenomena characteristic of the occurrence of drift gold were not only not explained by the "detrital hypothesis," as it is called, but were absolutely inconsistent with it. Chief among these objections may be mentioned the undoubted generalization that drift gold is nearly always purer than the gold in the reefs of the neighbourhood in which it occurs. No explanation as to the long distances to which grains of gold might be conveyed, or to the possible purifying effects of natural chemical action, made up any satisfactory explanation of the known facts, and accordingly under the detrital theory these facts had to remain shrouded in mystery. Then, again, it was a frequent occurrence for gold to be found so peculiarly embedded in pieces of wood, or in conjunction with natural crystals of minerals, such as the sulphides, that those who were constantly being brought into contact with such phenomena were firmly convinced that at all events there was a certain proportion of the gold found in alluvial drifts which had its origin in some other source than the breaking down of quartz reefs by the ordinary processes of Nature. The majority of those who held to this belief had at first but little scientific knowledge of natural reactions; and when questioned as to their theory on the subject, they were accustomed to say of the alluvial drift-gold, that it appeared to be actually growing—a statement which sometimes provoked, not unnaturally, a smile of pity for misplaced credulity.

These objectors, however, were right. Of this there is now scarcely the shadow of a doubt. It would be tedious to trace the steps by which such a strange conclusion has come to be virtually established. Suffice it to say that at the present day there are but few scientific men in Australia who have studied the subject who do not hold that by some agency or another the gold that is in our alluvial drifts has been formed, and probably is at present accumulating at the present moment, in its present position. It seems probable, indeed, that drift gold has its origin in the salts held in solution by the water by which it was formerly supposed to have been merely carried from one place to another. The most common salt of the precious metal is chloride of gold; and of this salt there is an appreciable quantity present in sea water along with the common sea salt, which, of course, is mainly chloride of sodium. In geological epochs, when the rocks of our present gold-fields were submerged below the ocean, and later on, when they held upon their surfaces vast imprisoned lakes of salt water, it is probable that they became saturated with sea water and retained large amounts of gold in solution. According to a computation quoted by Mr. Skey, the Government Geological Analyst for New Zealand, it is probable that every cubic mile of rock contains something like a million ounces of gold. Hence the underground streams of Australia, in certain districts, are particularly rich in salts of the precious metal, and there is an enormous area over which slight quantities of gold can always be obtained, while surface streams which are fed by deep-seated springs accumulate gold upon alluvial flats and hollows. Some of the gold found in such streams may undoubtedly be ascribed to the destruction of quartz reefs. It stands to reason that these reefs, like other rocks, must contribute to the *débris* in the beds of rivers and streams. But most of the purer alluvial coarse gold has evidently a different origin.

Up to this point, the new explanation of the origin of drift gold seems feasible, and, indeed, almost conclusive. The gold is present in minute quantities in the water of the drift, and this fact has been conclusively demonstrated experimentally by various investigators, among whom may be mentioned Messrs. Newberry and Skey. But it is one thing to prove that chloride of gold exists in the drift waters, and quite another thing to suggest in what manner and by what agency the precious metal has been reduced from its salt, and deposited in the form of coarse or fine grains or in that of large and strangely-shaped nuggets. Precipitation was the first and most obvious suggestion. The addition, for instance, of a minute quantity of sulphate of iron to a solution of chloride of gold would cause the formation of minute particles of metallic gold, and sulphate of iron, of course, is present in Nature abundantly. But such an explanation would only account for the formation of the very finest gold dust. It would give no solution of the origin of coarse gold and nuggets, nor would it account for any of the many peculiar anomalies of which I shall presently mention some striking examples.

In order to afford a possible extension of this purely chemical theory which might give a clue to the origin of nuggetty gold, it has been pointed out that if a crystal of some sulphide, such as iron pyrites, be immersed in a solution of chloride of gold, it will be covered with a film of metallic gold. Following the track of investigation thus apparently opened up, it has been ingeniously suggested that possibly the material of the metallic sulphide, and that of the golden film, may be regarded as a sort of miniature electric battery, in which the gold would form one anode and the pyrites the other. A current would pass between the two, and the result would be the deposition of metallic gold upon the film, at the same time that the material of the pyrites would continually become decomposed. The electroplater, in his laboratory, places the salt of gold in his bath, and uses an ordinary battery from which to obtain a current sufficiently strong to deposit gold upon the articles to be plated. But in this case it was suggested that the article to be plated, which was the film of gold itself, might be regarded as one of the elements supplying the current. The theory seems from the outset somewhat far-fetched, and it is open to very strong objections on the ground of improbability. The amount of material which the electroplater has to use up in order to deposit an ounce of gold is very considerable, even in the most efficient forms of batteries known to science. It is scarcely conceivable that a piece of pyrites, weighing about two pennyweights, would, by its decomposition, afford sufficient current to deposit an ounce of gold. Yet something of the sort would have to be established before it could be proved that electro-chemical action *in situ* supplies the electric current as a reducing agent.

In seeking for an explanation of the deposition of gold which would afford a surer or more probable basis for conjecture, I was at first mainly influenced by two remarkable facts which could hardly be referred to any imaginable phenomena of a chemical or electro-chemical origin. These were that in a drift supplying gold in abundance it is by no means uncommon to find a patch in which the gold gives out altogether, and is picked up further along the line; and the second was that there has always been observed at many of the leading goldfields a certain correspondence between the richness of the alluvial drifts and reefs and the points of the compass. The direction in which the richest drifts run may vary from one locality to another. But no matter how broken in contour the country may be, there is almost always a marked parallelism between the richest drifts.

Taking these and one or two other facts as a starting-point, I was led to form the hypothesis that the probable origin of the deposition of gold is to be found in thermo-electric earth-currents, probably generated by the unequal heating of the surface of the earth by the sun's rays in passing from east to west. This theory of earth-currents has attracted a good deal of attention in Australia, and it is remarkable how rapidly facts in support of it have been brought forward during the past few months. It would be impossible for me, within brief limits, to refer to all of these; but it will be of interest to summarize a few of the leading points:—

(1) The existence of earth-currents has been frequently demonstrated, and has attracted special attention since the invention of the telephone. In 1880, Prof. Trowbridge, of Harvard, conducted a series of experiments at the Observatory, and recorded it as one of his results that these currents appeared to be most pronounced along the water-courses.

(2) In Victoria remarkable instances of deflection of the compass have been particularly numerous, hinting at the presence of strong currents, more especially at the lines of junction between permeable and impermeable rocks.

(3) There is a remarkable relation between the conductivity of the adjacent rock country and the richness of an alluvial drift. Thus, in passing through slate or below an overhanging mass of basalt, the drift is generally richer than in passing through moist sandstone, suggesting that, where an earth-current is concentrated along the line of the water in consequence of the presence of rocks of low conductivity, the process of deposition has been facilitated.

(4) There are places at which the gold gives out altogether, although no discernible change has taken place in the nature of the country. These places seem to be the localities of a sort of short-circuiting, which we may readily suppose to take place very frequently in earth-currents.

(5) At particular pinched localities the current would be peculiarly strong, and would lead to the formation of nodules or nuggets of gold, the existence of which cannot be satisfactorily explained by any chemical theory hitherto advanced.

(6) Nuggets of an alloy of gold and copper have sometimes been met with, and the two metals have even been found to lie in alternate layers, suggesting that at one time a copper salt, and at another a gold salt, has been subjected to the action of a reducing current.

(7) In presence of a large amount of organic matter, it is almost invariably found that a drift becomes especially rich. The formation of acid by decomposition is what would be peculiarly required to facilitate the passage of an earth-current through the water of an underground drift, the existence of free acid being the requirement for an artificial electro-depositing bath.

(8) Conversely, the vicinity of large masses of calcite has been observed to be most inimical to the richness of a drift, and, of course, this could be explained by the fact that the carbonate of lime would destroy the free acid, and reduce the conductivity of the water so as to impede the transmission of a current.

(9) The peculiar shapes of the grains of what is known as coarse gold, are very suggestive of the action of a feeble current in piling up the metal upon the prominent portions, and leaving deep indentations between. Electric action of an extraneous nature is also strongly indicated by the strange strings and filaments which are constantly being met with.

(10) If we accept the crenitic theory of the origin of quartz reefs, the theory of earth-currents would at once apply with particular force to show how the action of such currents in hot siliceous solutions would produce a formation of gold simultaneous with that of quartz, thus accounting for the finely divided state of the gold in such reefs.

(11) At the same time it is necessary to account for the existence of the large masses of gold which are sometimes found associated with quartz, at places where the reefs become narrow in pinched localities. The theory of precipitation cannot account for these. But that of earth-currents would naturally lead us to expect the phenomenon, because in such a locality, while the formation of quartz would be retarded, the formation of gold would be accelerated by the concentration of the current as already explained.

The hypothesis is thus well supported by *primâ facie* evidence. For the experimental detection of earth-currents on goldfields I have strongly recommended the close observation of the most minute deflections of the magnetic needle, especially in underground workings. I believe also that the use of the telephone, as in Prof. Trowbridge's experiments, will be of great service in indicating the lines of greatest conductivity in the earth's crust, and in enabling us to decide whether these are identical in goldfields with those lines in which the drifts contain the richest gold.

GEORGE SUTHERLAND.
Angas Street, Adelaide, South Australia.

THE PRIMITIVE TYPES OF MAMMALIAN MOLARS.

SO much light has recently been thrown on the origin and mutual relations of the Mammalia by the labours of the Transatlantic palæontologists, that in the case of the limbs we have long since been able to trace the evolution of the specialized foot of the Horse from that of the five-toed *Phenacodus* (see NATURE, vol. xl. p. 57). Till quite lately, however, we have been unable to follow the mode of evolution of the more complicated forms of molar teeth from a common generalized type, although Prof. Cope, by his description of the so-called "tritubercular" type of molar structure, paved the way for the true history of this line of research.

The common occurrence of this tritubercular type of dentition among the mammals of the Lower Eocene at once suggests that we have to do with a very generalized form of tooth-structure; and by a long series of observations Prof. H. F. Osborn, of Princeton, New Jersey, has succeeded, to a great extent, in showing how the more complicated modifications of molars may have been evolved from this generalized type. These observations are of so much importance towards a right understanding of the phylogenetic relationships of the Mammalia that a short summary cannot fail to be interesting to all students of this branch of zoology.

The tritubercular molar (Fig. A, 6), consists of three cusps, cones, or tubercles, arranged in a triangle, and so disposed that those of the upper jaw alternate with those of the lower. Thus, in the upper teeth (Fig. A, 7), there are two cusps on the outer side, and one cusp on the inner side of the crown; while in the lower teeth (Fig. A, 8, 8*a*) we have one outer and two inner cusps. This type, when attained, appears to have formed a starting-point from which the greater number of the more specialized types have been evolved. The Monotremes, the Edentates, perhaps the Cetaceans, and the extinct group of Multituberculata (*Plagiaulax* and its allies), must, however, be excepted from the groups whose teeth have a tritubercular origin.

It appears probable, indeed, that "trituberculism," as this type of tooth-structure may be conveniently termed, was developed from a simple cone-like tooth during the Mesozoic period, and that in the Jurassic period it had developed into what is termed the primitive sectorial

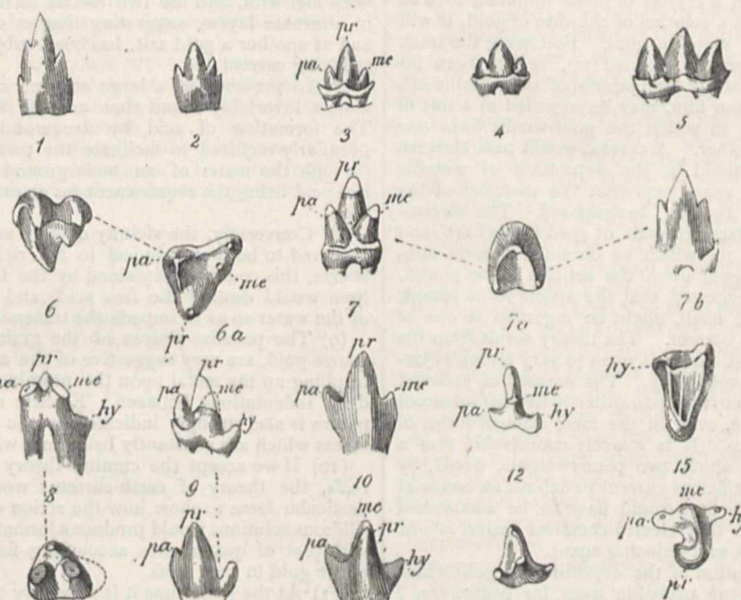


FIG. A.—Types of Molar Teeth of Mesozoic Mammals. 1–5, Triconodont Type (1, *Dromatherium*; 2, *Microconodon*; 3, *Amphilestes*; 4, *Phascolotherium*; 5, *Triconodon*). 6, 7, 10, Tritubercular Type (6, *Peralestes*; 7, *Spalacotherium*; 10, *Asthenodon*). 8–9, 11–15, Tuberculo-Sectorial Type (8, *Amphitherium*; 9, *Peramus*; 11, *Dryolestes*; 12, 13, *Amblotherium*; 14, *Achyrodon*; 15, *Kurtodon*). 6 and 15 are upper, and the remainder lower molars. *pa*, paraconid; *pr*, protoconid; *me*, metaconid; *hy*, hypoconid. In the upper teeth the termination ends in cone.

type (Fig. A, 9). The stages of the development of "trituberculism" may, according to Prof. Osborn, be characterized as follows:—

(1) The *Haplodont* type.—This is a hypothetical type at present undiscovered, in which the crown of the tooth forms a simple cone, while the root is probably in most cases single, and not differentiated from the crown.

(*a*) The *Protodont* sub-type.—This sub-type is a slight advance on the preceding, and is represented by the American Triassic genus *Dromatherium*. The crown of the tooth (Fig. A, 1) has one main cone, with fore-and-aft accessory cusps, and the root is grooved.

(2) The *Triconodont* type.—In this Jurassic type the crown (Fig. A, 4, 5) is elongated, with one central cone, and a smaller anterior and posterior cone situated in the same line; the root being differentiated into double fangs. *Triconodon*, of the English Purbeck, is the typical example.

(3) The *Tritubercular* type.—In this modification the crown is triangular (Fig. A, 7), and carries three main cusps or cones, of which the central one is placed internally in the upper teeth (Fig. A, 6), and externally in the lower molars (Fig. A, 7). The teeth of the Jurassic *Spalacotherium* are typical examples. In the first and second types the molars are alike in both the upper and lower jaws; but in the third or tritubercular type, the pattern is the same in the teeth of both jaws, but with the arrangement of the homologous cusps reversed. These features are exhibited in Fig. B.

These three types are regarded as primitive, but in the following sub-types we have additional cusps grafted on to the primitive tritubercular triangle, as it is convenient to term the three original cusps.

(*a*) *Tuberculo-sectorial* sub-type.—This modification of the tritubercular type is found in the lower molars, like those of *Didelphys*. Typically the primitive tritubercular triangle is elevated, and the three cusps are connected by cross ridges, while a low posterior talon or heel is added (Fig. A, 9). This modification embraces a quinquetubercular form, in which the talon carries an inner and an outer cusp; while by the suppression of one of the primitive cusps we arrive at the quadritubercular tooth, bunodont tooth (Fig. C), like that of the Pigs. In the upper molars the primitive triangle in what is termed the secodont series may remain purely tricuspid. But by the development of intermediate tubercles in both the secodont and bunodont series a quinquetubercular form is reached; while the addition of a postero-internal cusp in the bunodont series gives us the sextubercular molar.

There is no doubt as to the homology of the three primary cusps in the upper and lower molars; and Prof. Osborn proposes the following series of terms for all the cusps above mentioned. The first secondary cusps (hypocone and hypoconid) respectively added to the upper and lower molars are also evidently homologous, and modify the crown from a triangular to a quadrangular form; but there is no homology between the additional secondary cusps of the upper molars termed protoconule and metaconule with the one termed ectoconid in the lower molars.

Terms applied to the cusps of molars:—

Upper Molars.

Antero-internal cusp .	=	Protocone	—pr.
Postero- ,, ,, or 6th cusp	=	Hypocone	—hy.
Antero-external ,, .	=	Paracone	—pa.
Postero- ,, ,, .	=	Metacone	—me.
Anterior intermediate cusp .	=	Protoconule[1]	—ml.
Posterior ,, ,, .	=	Metaconule	—pl.

Lower Molars.

Antero-external cusp .	=	Protoconid	—pr^d.
Postero- ,, ,, .	=	Hypoconid	—hy^d.
Antero-internal or 5th cusp .	=	Paraconid	—pa^d.
Intermediate, or antero-internal cusp (in quadritubercular molars)	=	Metaconid	—me^d.
Postero-internal cusp	=	Entoconid	—en^d.

Having thus worked out the homology and relations of the tooth-cusps, Prof. Osborn gives some interesting observations on the principles governing the development

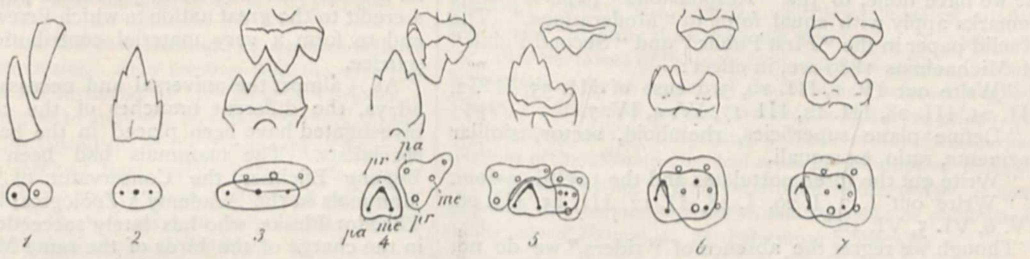


Fig. B.—Upper and Lower Molars in mutual apposition. 1, *Delphinus*; 2, *Dromatherium*; 3, *Triconodon*; 4, *Peralestes* and *Spalacotherium*; 5, *Didymictis*; 6, *Mioclænus*; 7, *Hyopsodus*. Letters as in preceding figure.

of these cusps. It is considered that in the earliest Mammalian, or sub-mammalian, type of dentition (Haplodont), the simple cones of the upper and lower jaws

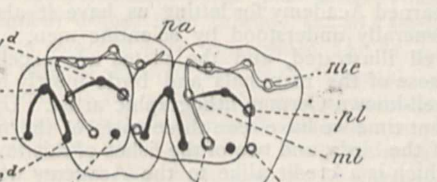


Fig. C.—Diagram of two upper and lower quadritubercular molars in apposition The cusps and ridges of the upper molars are in double lines, and those of the lower ones in black. The letters refer to the table given above. The lower molars are looked at from below, as if transparent.

interlocked with one another, as in the modern Dolphins (Fig. B, 1). The first additions to the primitive protoconid appeared upon its anterior and posterior borders, and the growth of the para- and metaconids involved the necessity of the upper teeth biting on the outer side of the lower (Fig. B, 2), this condition being termed anisognathism, in contrast to the isognathism of the simple interlocking cones. In the typical tritubercular type (Fig. A, 7) it has been suggested that the para- and metaconids were rotated inwards from the anterior and posterior borders of the triconodont type; but it is quite possible that they may have been originally developed in their present position. By the alternation of the primitive triangle in the upper and lower jaws of the tritubercular type, the retention of an isognathous arrangement is permitted, the upper and lower teeth biting directly against one another.

Finally, Fig. C shows the mutual relations of the upper and lower teeth of the complicated quadritubercular molars, with the positions held by the primitive tritubercular triangles.

OXFORD "PASS" GEOMETRY.

ἀγεωμέτρητος μηδεὶς ἐνταυθοῖ εἰσίτω.

WHETHER poultry are to be regarded as descended from a primeval egg or a primeval hen, is a question on which some amount of scholastic ingenuity is supposed to have been exercised, and whether teachers or examiners are responsible for defective training in geometry is a question on which much might, more or less unprofitably, be said, and on which teachers and examiners may be expected to take different views. Happily for the mental equipment of the present generation of students, many teachers and examiners, avoiding barren controversy, have both laboured, as far as in them lies, to encourage soundness and thoroughness.

Probably, the old-world teachers who, hearing a "Euclid" lesson with the open Simson in their hand, looked upon "therefore" as an unwarrantable substitute for "wherefore," and could not be induced to accept "angle CAB" as a legitimate equivalent for what they saw in the text presented as "angle BAC," are fast disappearing, if not already extinct. Unfortunately, we are still under the influence of bad examination papers. Take, for instance, the papers set last year at Responsions. The sole directions from the examiner to the printer, necessary for getting these set up, might have been, and very likely were, as follows:—

Trinity.		Hilary.		Michaelmas.	
(1) I. 4	(6) I. 46	(1) I. 5	(6) I. 48	(1) I. 2	(6) I. 45
(2) I. 14	(7) II. 5	(2) I. 10	(7) II. 3	(2) I. 7	(7) II. 6
(3) I. 21	(8) II. 7	(3) I. 17	(8) II. 6	(3) I. 26	(8) II. 10
(4) I. 22	(9) II. 12	(4) I. 31	(9) II. 9	(4) I. 34	(9) II. 12
(5) I. 42	(10) II. 14	(5) I. 39	(10) II. 14	(5) I. 46	(10) II. 14

[1] The symbols *ml.* and *pl.* should properly apply respectively to the metaconule and protoconule, but since they bear the opposite signification in Fig. C, they are placed as above.

We believe that those qualified to give an opinion will agree as to the tendency of papers like these. They are direct incentives to learning propositions by rote—a practice to which beginners are by nature only too prone, without being encouraged by the grave authority of an ancient University: and they tend to paralyse any efforts a tutor may make to teach his subject intelligently. How is he to get pupils to listen to any discussion of difficulties, or to care for any deductions from the propositions, when they know as well as he does that not a mark can be gained by anything which goes beyond a bare knowledge of the Simsonian text?

Well might the Council of the Association for the Improvement of Geometrical Teaching, in its last Report, "regret to notice that the Euclid papers set for Responsions at Oxford still consist exclusively of bookwork," and remark that "the entire absence of riders or other questions designed to test the real knowledge of the student seems calculated to foster 'cram.'" The Council confined itself, as we have done, to the "Responsions" papers, but its remarks apply with equal force to "Moderations." The Euclid paper in the "First Public" and "Second Public" of Michaelmas 1889 are, in effect:—

"Write out IV. 1, III. 10, 3rd case of III. 35, III. 2, III. 25, III. 28, III. 12, III. 17, IV. 4, IV. 7.

"Define plane superficies, rhomboid, sector, similar segments, ratio, ex æquali.

"Write out the three postulates and the twelfth axiom.

"Write out I. 7, I. 29, I. 48, II. 12, III. 15, III. 26, IV. 6, VI. 5, VI. 18."

Though we regret the absence of "riders," we do not attach so much importance to it as to that of "other" questions arising naturally from the definitions, axioms, postulates, and propositions set to be written out: questions, for instance, on the redundancy of the definitions; on the distinction between the general and the geometrical axioms; on the axioms tacitly assumed by Euclid; on the truth or falsehood of the converse of a given proposition; on the interdependence of two contrapositives; or on the difficulties of Euclid's treatment of parallels.

It is instructive to contrast the Mathematical Responsions papers with those set in the classical part of the same examination. In these the University is by no means satisfied, as in the mathematical, with a knowledge which may be obtained by efforts of the memory alone, but applies the sharp test of prose composition and "unseens." To this inequality we draw the special attention of readers of NATURE. Compare the course open to a classical man with that which lies before one who intends to take his degree in science or mathematics. The classical man appears to have everything in his favour: he most likely knows enough mathematics to feel quite comfortable as to the paltry modicum required at Responsions. The other is in a very different position. If he has attained to anything like scholarship in his own subject, it will only be in rare cases that he can hope to get through Responsions without devoting a large amount of valuable time towards the acquirement of some facility in prose composition. We should like to see a vigorous protest by the science graduates against this anomaly.

PRZEWALSKY'S ZOOLOGICAL DISCOVERIES.[1]

WITH great satisfaction naturalists will observe that a complete account of Przewalsky's zoological observations and discoveries is to be given to the world, and has in fact been for some time in course of publication. The great Russian explorer, although perhaps best known in Western Europe as a geographical traveller, was at heart a naturalist, and one of no mean rank. Those who have read the narratives of his four great journeys will recollect how full they are of notes on the animals and plants met with during his routes. The specimens obtained by him and his companions were carefully preserved, and deposited in the Museum of the Imperial Academy of Sciences at St. Petersburg. Up to the present time these collections have only been made known to the public by various fragmentary accounts of them in scientific journals, and in the appendices to Przewalsky's volumes of travels, which were in many cases of the most unsatisfactory character. The Imperial Crown Prince Nicolas of Russia has now, however, placed at the disposal of the Imperial Academy, in whose Museum Przewalsky's collections are stored, a sum sufficient to cover the cost of the publication of a connected account of them. To no more worthy object could Royalty devote its income, and the resulting volumes promise to be alike a credit to the great nation to which Przewalsky belonged, and to form a very material contribution to zoological science.

As is almost the universal and necessary custom nowadays, the different branches of the collections to be investigated have been placed in the hands of different specialists. The mammals had been undertaken by Eugene Büchner, the Conservator of the Division of Mammals in the Academy's Zoological Museum. Herr Theodor Pleske, who has lately succeeded Herr Russow in the charge of the birds of the same Museum, supplies the portion of the work relating to the objects under his care. Similarly, to Herr S. Herzenstein have been assigned the fishes. Each section is prepared on a similar plan. The text is given in parallel columns of Russian and German. We cannot complain of a great national work like the present being published primarily in the national language, but our thanks should be given to the learned Academy for letting us have it also in a tongue generally understood by scientific men. The work is well illustrated, and the plates are excellently drawn, those of the mammals and birds mostly by Mützel, the well-known German lithographic artist. Up to the present time we have seen three parts of the mammals, one of the birds, and two of the fishes of this important work, which is a credit alike to the Academy which has produced it, and to the distinguished personage who has supplied the necessary means.

[1] "Wissenschaftliche Resultate der von N. M. Przewalski nach Central-Asien unternommenen Reisen: auf Kosten einer von seiner Kaiserlichen Hoheit dem Grossfürsten Thronfolger Nikolai Alexandrowitsch gespendeten Summe." Herausgegeben von der Kaiserlichen Akademie der Wissenschaften. Zoologischer Theil. (St. Petersburg, 1888–89.)

NOTES.

THE Chemical Society will this year for the first time hold its anniversary meeting (March 27) in the afternoon at 4 p.m., and the Fellows and their friends will dine together in the evening at the Whitehall Rooms, Hotel Métropole. It is hoped that the Fellows will signify their approval of this alteration by attending in considerable numbers.

A MEETING was held in Berlin on Monday, March 10, under the auspices of the German Chemical Society, to celebrate the 25th anniversary of the promulgation of Prof. Kekulé's theory of the constitution of the aromatic compounds. A very large number of chemists assembled in the Rathhaus in the afternoon. After an introductory address by the President, Prof. v. Hofmann, Prof. A. Bayer delivered a lecture in which he pointed out how completely modern investigations had confirmed Kekulé's views. A congratulatory address from the German Chemical Society was then presented to Prof. Kekulé. Prof. Armstrong attended on behalf of the London Chemical Society, Prof. Korner on behalf of the Italian chemists, Prof. Bischof on behalf of the Russian chemists; and besides the addresses presented by those representatives, there were very numerous letters and telegrams of congratulation from various sources. Dr. Glover, on behalf of German artificial dye-stuff manufacturers, then presented a most admirable portrait of Prof. Kekulé which had been painted by the celebrated painter Angeli; this is to be placed in the Berlin galleries. Prof. Kekulé returned thanks in an eloquent address. Subsequently a banquet was held which was very numerously attended.

LORD RAYLEIGH has been elected a correspondent of the Paris Academy of Sciences in the department of physics.

THE discourse to be given by Lord Rayleigh at the Royal Institution on Friday evening, March 28, will be on "Foam."

MR. H. CARRINGTON BOLTON, the eminent American bibliographer, wishes to associate himself with those who recommend the system of Russian transliteration, explained lately in NATURE (p. 397). His letter was not received in time to permit of his name being included in the list of signatures.

THE visit of the Iron and Steel Institute to America is likely to be remarkably successful. At a meeting held the other day at New York, upon the invitation of Mr. Andrew Carnegie, a committee was appointed to arrange a reception for the members. The Philadelphia Correspondent of the *Times* says so many invitations have been received from various parts of the country that the belief is that the month given to the visit will be insufficient. The members will meet in New York. There will also be an international session at Pittsburg.

A STATED meeting of the Royal Irish Academy was held in Dublin on the 15th inst., at which the President and Council for the ensuing year were elected. Prof. Sollas, F.R.S., read a paper on the mica which occurs in well-formed crystals in the famous geodes of the Mourne Mountain granite: it was described as a lithium mica of the species Zinnwaldite. Most of the crystals possessed an exquisitely defined zonal structure, and in a single crystal a change in colour, density, composition, and in the magnitude of the angle of the optic axes could be traced on passing from the centre to the surface; this gradual transition from a more ferro-magnesian character near the centre to a more alumino-alkaline one near the surface was compared to the change from a more anorthite-like to a more albitic character, which accompanies the growth of many zonal felspars. This subject is also referred to in Prof. Sollas's paper on the granites of Leinster, which is to appear in the Academy's Transactions. The Report of the Council, giving the details of work done by the Academy during the past year, with notices of deceased members—among these John Ball, F.R.S., Sir Robert Kane, F.R.S., and Robert McDonnell, F.R.S.,—was read and adopted. Dr. E. Perceval Wright, Secretary to the Academy, was elected, in the place of the late Sir R. Kane, a visitor to the Museum of Science and Art, Dublin.

THE Royal Society of Medical and Natural Sciences of Brussels offers a gold medal of the value of 200 francs for the best essay on the influence of temperature on the progress, duration, and frequency of karyokinesis in an example belonging to the vegetable kingdom. The essay must be written in French, and must be sent in before July 1 to Dr. Stiénon, 5 Rue du Luxembourg, Brussels.

MR. J. WERTHEIMER, head master of the Leeds School of Science and Technology, has been elected to the head mastership of the Merchant Venturers' School, Bristol, the largest technical school in the West of England.

RECOGNIZING the difficulty experienced by Western naturalists in following the valuable scientific work now carried on in Russia, a number of influential men of science of that country have arranged for the publication of a monthly review—the *Vyestnĭk Estestvoznaniya.* This will consist of original articles and short reports, with French *résumés*, and an index, in French, to Russian periodical scientific literature; the subjects included will be zoology, botany, physiology, geology, and microscopical technology, with the allied sciences. As, with the exception of Nĭkĭtĭn's admirable geological bibliography, no adequate attempt has been made to record Russian general scientific literature, this review will supply a very general want. The facts that it is published under the auspices of the St. Petersburg Society of Naturalists, and that the list of promised contributors includes most of the leading Russian naturalists, are sufficient guarantee for its value. The bibliographical index commences in the second number. The first consists of eight original articles. W. Wagner treats of the Infusoria of the body-cavity of Sipunculus and Phascolosoma; J. Wagner of some points in the development of Schizopods; Schĭmkevĭch of the alternation of generation in the Hydromedusæ; Borodĭn and Tanfĭl'ev contribute botanical articles, the former discussing the nature and distribution of dulcite, and the latter the causes of the extinction of *Trapa natans.* Geology is represented by an account of the Devonian rocks of Mughodzhares, a criticism of Lévy's classification of the eruptive rocks by Polyenov, and an interesting account of the formulæ and relations of the different chemical types of the eruptive rocks by F. Levinson-Lessĭng. The subscription to the review, it may be added, is 3 roubles 50 kopecks, and the office of publication, the Society of Naturalists, St. Petersburg University.

THE Vienna correspondent of the *Standard* telegraphed as follows on Monday:—"Dr. Eder, Professor of the Photographic Institute of Vienna, has announced that a photographer named Verescz, living in Klausenburg, Transylvania, has succeeded in solving the problem of photographing in natural colours. Up to the present, only the shades between deep red and orange can be retained, and even these, if exposed to the light, fade in from two to three days; but the experiments are being continued, with good prospects of complete success."

RECENTLY Lord Reay, the Governor of Bombay, laid the foundation-stone at Poona of a Bacteriological Laboratory, which is to be annexed to the College of Science in that town. Dr. Cooke, the Principal of the College, to whose efforts the establishment of the Laboratory is due, stated that it was originally intended that the study of the diseases of the lower animals in Poona should be directed to check the losses from anthrax in cattle by the introduction into India of protective inoculation. With this object two Bengal students at the Cirencester Agricultural College underwent a course of study at M. Pasteur's laboratory in Paris. One of these gentlemen devoted his attention entirely to sericulture, the other studied M. Pasteur's system of vaccination against anthrax. He returned to India, and has since conducted some experiments on cattle in Calcutta. Subsequently, Mr. Cooper, of the Veterinary Service, was deputed to M. Pasteur's Institute for instruction in the system of inoculation against anthrax. While in Paris, Mr. Cooper submitted a report, and explained that for the work in question a special laboratory would be required. At the same time he advocated the adoption of artificial gas for the culture-stoves and glass-blowing, and for the purpose of obtaining the high temperature required for sterilizing vessels, instruments, &c. Subsequent inquiry showed that anthrax is not the only contagious disease of a fatal nature with which the Indian cattle-owner has to contend. He has also to take into account rinderpest, tuberculosis, pleuro-pneumonia, and, in a minor degree, foot and mouth disease. It was, therefore, evident that if an institution was established for the preparation of an anthrax vaccine its value would be greatly enhanced if diseases other than anthrax could receive attention. The main objects of the Poona

Laboratory therefore are :—(*a*) The preparation of anthrax vaccine for despatch to districts where anthrax prevails. (*b*) The conduct of experiments in rinderpest with a view to the discovery of the pathogenic micro-organism of the malady, its cultivation in broth and other media, and attenuation, so as to provide a vaccine that shall give immunity to animals in rinderpest-infected districts. (*c*) Experimental research into the epizootic diseases generally of the ox and horse. (*d*) The instruction of trained native veterinarians in a proper method of performing vaccination and of the precautions necessary to avoid risk of septic infection.

ON March 17, at six minutes past 11, a severe shock of earthquake was felt at Bonn, and reports from the surrounding districts on the following morning showed that it was very generally perceived in the vicinity of the town. On March 18, in the morning, a strong shock of earthquake was felt at Malaga and the neighbouring towns. The inhabitants were greatly alarmed, but no damage is reported.

ACCORDING to a telegram sent from New York by Reuter's Agency on March 15, the captain of the steamer *Slavonia* reported having encountered a waterspout during the voyage from Europe. The vessel sustained no damage.

THE Pilot Chart of the North Atlantic Ocean for the month of March states that the weather during February was much more moderate than during the two preceding months. An area of very high barometer extended over nearly the entire length of the Transatlantic steamship routes during the first five days. After this date the pressure fell, and gales of varying force were experienced from time to time. The most important of these storms was one south of Newfoundland on the 21st, whence it moved rapidly eastward. The storm on the 11th in about lat. 49° 30′ N., long. 22° W., was also of considerable energy. The most extensive fog bank reported during the month occurred on the coast from the 24th to the 26th, from Boston to Norfolk. The unprecedentedly large amount of ice this season has been the cause of considerable delay and damage to vessels ; there are not only vast fields of ice, but also a very large number of bergs, some of which are of enormous dimensions. The importance of the knowledge of ice movements to navigation is recognized to be so great, that the Navy Department has, at the request of the U.S. Hydrographer, despatched an officer to Halifax and St. John's to collect information upon the ice movements during this season and past years, for the purpose of facilitating predictions of the general movements in future. A petition is also being drawn up for transmission to the Canadian Government to take such steps as they may deem advisable to obtain as thorough a knowledge as possible of the currents in the Gulf of St. Lawrence and adjacent waters, on account of their dangerous character during thick weather.

IN the summary of a meteorological journal kept by Mr. C. L. Prince, at his observatory, Crowborough, Sussex, during 1889, he draws attention to the great preponderance of north-east wind over all other wind currents, and more particularly over that from the south-west, which has obtained during the last five years. He has examined his registers for the thirty-one years ending with 1889, and finds that between 1859 and 1883 there were only two years, viz. 1864 and 1870, in which the north-east wind has been in excess. In 1884 the north-east and south-west winds were nearly balanced, but during the last five years the average frequency has been north-east 102, south-west 72. Comparative observations would be interesting with the view of seeing whether this reversal of the ordinary conditions holds good for other stations. The Greenwich observations show that this great preponderance of north-east wind is not borne out there, at all events in all of the years mentioned.

TECHNICAL instruction, according to the *Times of India*, now takes a leading place in the educational programme of the Central Provinces. A year ago an entirely new curriculum was devised, whereby, among other changes, agricultural and engineering classes were established at Nagpore ; the scholarship rules were revised with special reference to technical education ; drawing-masters were appointed at a large number of schools, and every encouragement was given to the study of that subject ; and new subjects of a technical and scientific character were grafted on to old school programmes. When the fact is taken into consideration that the year was one of transition, the progress made may be pronounced most satisfactory. Eleven students out of thirty who applied were admitted into the engineering class after a test as to general education. These did well, and most of them have entered on a second year's course. The agricultural class had an average strength of twenty-five throughout the year, the pupils working on the model farm and in the laboratory established in connection with this technical education scheme. No fewer than seventeen of the lads came through the ordeal of a strict examination at the end of the session. When it is remembered how largely the economic future of India will depend on the development of her agricultural resources, the value of this work, now fairly initiated in the Central Provinces, cannot be over-estimated.

IN the current number of the *American Naturalist* Mr. R. E. C. Stearns continues his interesting series of papers on the effects of musical sounds on animals. One of his correspondents writes :—"Some time since I had an ordinary tortoise-shell cat, which had a peculiar fondness for the tune known as 'Rode's Air.' One day I chanced to whistle it, when, without any previous training, she jumped on my shoulder, and showed unmistakable signs of pleasure by rubbing her head against mine, and trying to get as near my mouth as possible. I have tried many other tunes, but with no avail." Captain Noble, of Forest Lodge, Maresfield, England, testifies that he formerly had a cat which displayed a corresponding sensitiveness, but it was only by plaintive tunes that she was affected. When such an air was whistled, she would climb up, and try to get her mouth as close as possible to that of the whistler. "I used as a rule," says Captain Noble, "to whistle the 'Last Rose of Summer,' when I wished her to perform. I never could satisfy myself as to her motive in putting her mouth to mine. The most feasible conjecture that I was able to make seemed to be that she imagined me to be in pain, and in some way tried either to soothe me, or to stop my whistling."

A PAPER on forestry in India and the colonies was read last week by Dr. W. Schlich before the Royal Colonial Institute. He said that for 700 years a gradual destruction of the forests of India had gone on. Under British rule the process had been hastened by the extension of cultivated and pasture land, and by the laying down of railways. After a time difficulty was experienced in meeting demands for timber, and in the early part of the century a timber agency was established on the west coast, while, in 1873, a teak plantation on a large scale was made at Nilambur. Through the energy of a few officials the matter was kept before the public, and in 1882 the Forests Department of Madras was entirely reorganized. Several Acts were passed to provide for the management of the forests under the protection of the State, and a competent staff of officers was provided, to be reinforced from time to time by those educated at Cooper's Hill College. Under the charge of the Department were some 55,000,000 acres of forest lands, and the figures relating to the cost of the work done were very satisfactory. Dr. Schlich then gave an account of the action of the Australian colonies with regard to the regulation of wooded lands by the State, contending that in no case had sufficient steps been taken to ensure a lasting and continuous supply of timber.

We print to-day a review of Dr. Sydney J. Hickson's valuable work, "A Naturalist in North Celebes." It may be well at the same time to call attention to an "Album" which has been sent to us, containing reproductions of photographs taken in Celebes. The collection has been formed by Dr. A. B. Meyer, director of the Zoological and Ethnographical Museum of Dresden, and includes 37 plates, on which about 250 reproductions are printed. In 1870 and 1871 Dr. Meyer spent some time in Celebes, and the greater number of the photographs which have been reproduced he brought back with him. Others he has received from friends. We cannot say that the process employed has always yielded perfectly satisfactory results; nevertheless, the "Album" contains many representations that cannot fail to interest students of anthropology and ethnography. There are groups of portraits from northern, central, and southern Celebes, and any one who carefully studies them will find that they give him a very vivid idea of the various types of the native population. The tables are accompanied by short explanatory notices, some of the best of which are by Dr. J. G. F. Riedel, Utrecht. The work is edited by Dr. Meyer, and issued by Messrs. Stengel and Markert, Dresden.

Messrs. Macmillan and Co. have published a second edition of Sir John Lubbock's well-known "Scientific Lectures." The author includes in this edition the Presidential address read by him before the Institute of Bankers in 1879. The address contains many interesting suggestions as to the development of coinage, and is illustrated by two excellent plates representing ancient coins.

We have received the fifth volume of "Blackie's Modern Cyclopædia," edited by Dr. Charles Annandale. The volume includes words from "Image" to "Momus," and the articles, so far as we have tested them, are, like those of the preceding volumes, concise and accurate.

The Literary and Philosophical Society of Liverpool has published Nos. 41, 42, and 43 of its Proceedings. Among the papers printed, we may note "Life and Writings of the Hon. Robert Boyle," by Mr. E. C. Davies; "An Ideal Natural History Museum," by Prof. Herdman; "On the Remains of Temperate and Sub-Tropical Plants found in Arctic Rocks," by the Rev. H. H. Higgins: "Notes on the Cooke Collection of British Lepidoptera," by Mr. J. W. Ellis; "Lake Lahontan, an Extinct Quaternary Lake of North-West Nevada, U.S.A.," by Mr. R. McLintock; "On the Individuality of Atoms and Molecules," by the Rev. H. H. Higgins; note on the foregoing, by Prof. Oliver J. Lodge; "The Complete Analysis of Four Autopolar 10-Edra," by the Rev. T. P. Kirkman; and "On the Cradle of the Aryans," by Principal Rendall.

Mr. Fletcher, the well-known manufacturer of gas appliances, has just issued a little work of 70 pages on "Coal Gas as a Fuel" (Warrington: Mackie and Co.). Perhaps no one has given more attention to the subject than Mr. Fletcher, and his book is therefore of considerable importance. He gives an account of the precautions necessary to obtain the greatest efficiency in every case where coal gas can be applied—in the kitchen, bath-room, greenhouse, workshop, and laboratory. There is a useful chapter giving instructions to fitters with respect to flues and dimensions of service pipes. All who consume gas for purposes other than ordinary house illumination, will do well to read Mr. Fletcher's book.

A curious observation relating to influenza is quoted in *La Nature* from a Copenhagen journal. At the Royal Institution for education of deaf-mutes there, the pupils (about 70 boys and girls) have for seven years been regularly weighed every day in groups of 15 and under. This new experiment has yielded some interesting results. Thus it has been found that the children's growth in weight has occurred chiefly in autumn and in the first part of December; there is hardly any in the rest of winter and in March and April, and a diminution then occurs till the end of summer. Last year proved an exception. The curves of weight were quite like those of previous years till November 23. In the four weeks thereafter, while each child has usually gained on an average over 500 grammes, the girls last year gained nothing, and the boys only 200 grammes each (less than two-fifths of the normal amount). The contrast with 1888 was even more remarkable, 700 grammes having been the average four-weeks' gain in that year. There was no modification as regards food or other material conditions. Now, the influenza epidemic appeared in Copenhagen towards the end of November. While six of the professors at this institution were attacked, there were no pronounced cases among the pupils; but it is supposed that germs of the disease having entered the place, the struggle with these on the part of the children absorbed so much vital force that the organs of nutrition failed to give the normal increase of weight after November 23.

A remarkable fall of a miner down 100 metres of shaft (say 333 feet) without being killed, is recorded by M. Reumeaux in the *Bulletin de l'Industrie Minérale*. Working with his brother in a gallery which issued on the shaft, he forgot the direction in which he was pushing a truck, so it went over and he after it, falling into some mud with about 3 inches of water. He seems neither to have struck any of the wood *débris*, nor the sides of the shaft, and he showed no contusions when he was helped out by his brother after about ten minutes. He could not, however, recall any of his impressions during the fall. The velocity on reaching the bottom would be about 140 feet, and time of fall 4·12 seconds; but it is thought he must have taken longer. It appears strange that he should have escaped simple suffocation and loss of consciousness during a time sufficient for the water to have drowned him.

An extremely useful piece of apparatus has been devised by Prof. Lunge, and is described in the current number of the *Berichte*, by use of which all the troublesome reductions to standard temperature and pressure in the measurement of gas volumes may be avoided, the volume being actually read off corrected to 0° C. and 760 mm. pressure. The arrangement is at once simple and capable of adaptation to any form of gas apparatus. It consists essentially of three glass tubes, A, B, and C, arranged parallel to each other vertically, and all connected with each other below by means of a glass T tube and stout caoutchouc tubing. A is the measuring vessel, graduated in cubic centimetres; any gas measuring vessel, such as that of a nitrometer, or of a Hempel or other gas analysis apparatus, may be used for this purpose. It is closed at the top by the usual well-fitting stopcock, through which the gas to be measured is introduced in the ordinary manner. Below, the gas is enclosed by mercury which is poured down the tube C; Prof. Lunge terms this latter the pressure tube. The pressure tube is simply an ordinary straight glass tube of similar diameter and length to the measuring tube A, and open at the top. The tube B, called the reduction tube, is of about the same length, but of somewhat greater diameter in its upper half. This cylindrical expansion narrows again at the top, and terminates with a well-greased stopcock. A is firmly clamped to the stand, while B and C are held in spring clamps which permit of ready lowering or raising. The reduction tube B is then prepared as a reference tube, once for all, in the following manner. The stopcocks of A and B are opened, and mercury is poured down C until it rises nearly to the expanded portion of B. A drop of water is then introduced into B so that the enclosed air is saturated with aqueous vapour. The thermometer and barometer are next observed, and the apparent volume calculated of 100 c.c. of gas at 0° and 760 mm. A mark is then made upon the reduction tube B so that the volume of the tube between this mark and the stopcock is the calculated apparent volume of the standard 100 c.c. The size of the tube is so arranged that this mark falls on the narrower portion of the tube, just below the expanded part. The pressure tube C is then raised or lowered until the mercury in B stands at the mark, when the stopcock at the top of B is closed. Thus a volume of air is enclosed which at 0° and 760 mm. and in the dry state would occupy exactly 100 c.c. In order to determine the corrected volume of a gas it is then only necessary to introduce it into the measuring tube A, allow it to cool to the temperature of the room, and then adjust B until the mark is a little higher than the mercury meniscus in A; C is next raised until the mercury in B rises to the mark, when B and C are finally simultaneously lowered until the level of the mercury in A and B is the same. The gas in A and the air in B are evidently equally compressed, and thus the volume read off upon the measuring tube A represents the corrected volume at 0° and 760 mm. The simplicity of the arrangement and the rapidity with which it can be worked are sure to recommend it for general use; and its applicability to the estimation of nitrogen in organic substances, which Prof. Lunge discusses in detail, will doubtless be especially appreciated by those who employ the volumetric method.

THE additions to the Zoological Society's Gardens during the past week include two Red Tiger Cats (*Felis planiceps* jv.) from Malacca, a —— Fish Eagle (*Polioaëtus ichthyaëtus*) from the Himalayas, deposited; a Gayal (*Bibos frontalis* ♀), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich at 10 p.*m.* on March 20 = 9h. 53m. 31s.

Name.	Mag.	Colour.	R.A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) G.C. 2008	—	—	9 59 44	− 7 11
(2) π Leonis	5	Yellowish-red.	9 54 24	+ 8 34
(3) α Ursæ Majoris ...	2	Yellow.	10 57 0	+62 21
(4) β Ursæ Majoris ...	2	White.	10 55 12	+56 59
(5) D.M. + 68° 617 ...	6	Red.	10 37 26	+67 59
(6) R Virginis	Var.	Red-yellow.	12 32 55	+ 7 35·6
(7) U Boötis	Var.	—	14 49 15	+18 8·6

Remarks.

(1) This nebula is described in the General Catalogue as "Very bright; large; very much extended in a direction 45°; at first very gradually, then very suddenly much brighter in the middle to an extended nucleus." The spectrum of the nebula was observed by Lieut. Herschel in 1868, but his observations are not quite complete. He states that a continuous spectrum was suspected, and that there were probably no lines present. Further observations are obviously required.

(2) A star of Group II. Dunér states that the bands 2–8 are well seen, but that 4 and 5 are somewhat feeble. The spectrum is not strongly marked. The star is probably approaching the temperature at which the bands will be replaced by lines, and affords an opportunity of studying the order of the appearance of the lines.

(3) A star of the solar type (Gothard). The usual differential observations are required.

(4) A star of Group IV. (Gothard). The usual observations are required.

(5) One of the finest examples of stars with spectra of Group VI. Dunér states that the four bright zones and all the bands which he has numbered 1–10 are visible. In this star, band 6 is weaker than the other carbon bands. Band 5 is strong; 1, 2, and 3 are weaker; and 7 and 8 are visible with difficulty.

(6) This variable will reach a maximum on March 28. The period is about 146 days and the magnitudes at maximum and minimum 6·5–7·5 and 10–10·9 respectively (Gore). The spectrum is a remarkable one of the Group II. type, and the great range suggests the possible appearance of bright lines at maximum, as in R Andromedæ, &c., observed by Mr. Espin. Mr. Espin has noticed that in the variables, where F is very bright, the bright lines do not appear until some time *after* the maximum. It is therefore important to continue observations for a considerable period.

(7) No record of the spectrum of this variable appears to have been published. The period is about 176 days. The magnitude at maximum is 9–9·5, and that at minimum 13·5 (Gore). A maximum will be reached about March 23.

A. FOWLER.

THE MÉGUÉIA METEORITE.—This meteorite was observed to fall at Méguéia, in Russia, on June 18, 1889, and a short account of Prof. Simaschko's analysis of it is found in the current number of *L'Astronomie*. It is noted that the meteorite belongs to that remarkable division containing carbon in combination with hydrogen and oxygen. The meteorites of this class are Alais, 1806, Cold Bokkeveldt, 1838, Kaba, 1857, Orgueil, 1864, and Nogoya, 1880. The Méguéia meteorite is covered with a thin (0·5 mm.) crust, is black, partly dull and partly shiny, and somewhat friable. A microscopical examination showed dark grey specks distributed through the black mass, varying in size from a mustard-seed to a hemp-seed. These grey specks have a more or less chondritic structure, and are different in composition from the mass of the meteorite. Besides these chondrules, the greenish, semi-transparent particles of olivine are seen as in almost all other meteorites, whilst nickel-iron is disseminated through the mass in small grains, and occurs in a half-fused state on the crust. Account is also given of white angular scales, much resembling certain fossils, but this is not the first time that the chondrules with their eccentrically radiating crystallization have been mistaken for organisms. Like other carbonaceous meteorites, that of Méguéia has a bituminous smell.

THE VELOCITY OF THE PROPAGATION OF GRAVITATION.—M. J. Van Hepperger, in a paper read before the Vienna Academy of Science, has assigned an inferior limit to the velocity of propagation of gravitation. It results from this limit that the time taken by gravitation to travel the radius of the earth's orbit does not exceed a second.

THE VATICAN OBSERVATORY.—The work to be undertaken at this new Observatory will be in connection with meteorology, terrestrial magnetism, seismology, and astronomy. The astronomical portion will mainly be directed to the photography of the sun and other celestial bodies, and to take part in the construction of the photographic map of the heavens, under the direction of the International Committee.

DOUBLE-STAR OBSERVATIONS.—Mr. S. W. Burnham, of the Lick Observatory, gives his sixteenth catalogue of double-stars in *Astronomische Nachrichten*, Nos. 2956–57. The observations were made in May, June, and July 1889, and 62 new pairs have been discovered and measured during this period.

SUN-SPOT IN HIGH LATITUDES.—The *Comptes rendus* of the Paris Academy of Sciences for March 10 contains a short note by M. G. Dierckx, in which he states that he observed a sunspot on March 4 in N. lat. 65°. If this were substantiated, it would be an almost unprecedented observation. But the photograph of the sun taken at the Royal Observatory, Greenwich, on that day, shows no trace of a spot in so high a latitude. A fine group did indeed appear on the sun on March 4, but its latitude was only 34°. This, however, is a very interesting circumstance, for though spots have been observed at considerably greater distances from the equator, they have usually been only small, and have lasted but a few hours, or two or three days at most. It would seem probable, therefore, this is the group which M. Dierckx observed, but that he made some error in determining its latitude.

GEOGRAPHICAL NOTES.

THE limits of the ever-frozen soil in Siberia are the subject of a paper by M. Yatchevsky, in the *Izvestia* of the Russian Geographical Society (vol. xxv. 5). It is now generally admitted that Karl Baer's criticism of Middendorff's measurements in the Sherghin shaft at Yakutsk—from which measurements Middendorff concluded that the depth of frozen soil at Yakutsk reaches 600 feet—are well founded. The walls of the shaft, which was pierced seven years before Middendorff came to Yakutsk, had cooled in the meantime through the free access of cold air, and therefore a smaller increment of increase of temperature with depth was found by Middendorff than would have been found if the measurements had been made in a shaft immediately after its being pierced. Nevertheless, the fact of the frozen soil extending to a great depth, especially in the valley of the Lena, is not to be contested ; nor can there be any doubt as to the extension of frozen soil over large parts of Siberia. M. Yatchevsky attempts to determine its limits from general considerations about the average yearly temperature of separate regions, and the thickness of their snow-covering ; and he gives a map of the probable southern limits of the frozen soil in Siberia, which do not differ much from the yearly isotherm of $-2°$ C. It must, however, be remarked that though the map approximately shows where the ever-frozen soil *may* be found beneath the thin layer of soil which thaws every summer, it ought not to be concluded that ever-frozen soil *will* be found everywhere within those limits. For instance, the granite rocks on the surface of the Vitrin plateau being immediately covered with immense marshes, the water from these marshes infiltrates into the rocks, and, while the marshes are covered during the winter with a crust of ice, their depths remain unfrozen. It may thus be considered certain that immense spaces will be found within the theoretical limits marked on the map, where no ever-frozen soil will be discovered. The Russian Geographical Society is sending out a series of questions, in the hope of obtaining accurate information, and it would be well if the same thing were done in Canada.

ACCORDING to a letter from Iceland, dated Reykjavik, February 5, 1890, a translation of which is printed in the current number of the *Board of Trade Journal*, the population of Iceland during the four years from 1885 to 1888 inclusive has diminished by about 2400, the total number at the close of each of these years having been, in 1885, 71,613 ; in 1886, 71,521 ; in 1887, 69,641 ; and in 1888, 69,224. This diminution was greatest (1880) in 1887, the explanation for which may be sought in the enormous emigration to America which took place in that year. The diminution in the remaining years, though less sensible, must be attributed to the same cause, as in these years the number of births exceeded that of deaths. The chief diminution has been shown by the northern and eastern districts. The prefecture of Hunavatn in particular has fallen off in respect to inhabitants from 4800 in 1885 to 3785 in 1888. In Reykjavik, the capital, the population has risen from 3460 to 3599.

ATMOSPHERIC DUST.[1]

THE infinitely small particles of matter we call *dust*, though possessed of a form and structure which escape the naked eye, play, as you are doubtless aware, important parts in the phenomena of nature. A certain kind of dust has the power of decomposing organic bodies, and bringing about in them definite changes known as putrefaction, while others exert a baneful influence on health, and act as a source of infectious diseases. Again, from its lightness and extreme mobility, dust is a means of scattering solid matter over the earth. It may float in the atmosphere as mud does in water, and blown by the wind will perhaps travel thousands of miles before again alighting on the earth. Thus Ehrenberg, in 1828, detected in the air of Berlin the presence of organisms belonging to African regions, and he found in the air of Portugal fragments of Infusoriæ from the steppes of America. The smoke of the burning of Chicago was, according to Mr. Clarence King (Director of the United States Geological Survey), seen on the Pacific coast.

Dust is concerned in many interesting meteorological phenomena, such as fogs, as it is generally admitted that fogs are due to the deposit of moisture on atmospheric motes. Again, the scattering of light depends on the presence of dust, and you may remember my showing you on a former occasion that beautiful experiment of Tyndall, illustrating the disappearance of a ray of light when made to travel through a glass receiver free from dust, whilst reappearing as soon as dust is admitted into the vessel. There is no atmosphere without dust, although it varies largely in quantity, from the summit of the highest mountain, where the least is found, to the low plains, at the seaside level, where it occurs in the largest quantities.

The origin of dust may be looked upon, without exaggeration, as universal. Trees shed their bark and leaves, which are powdered in dry weather and carried about by ever-varying currents of air, plants dry up and crumble into dust, the skin of man and animal is constantly shedding a dusty material of a scaly form. The ground in dry weather, high roads under a midsummer's sun, emit clouds of dust consisting of very fine particles of earth. The fine river and desert sand, a species of dust, is silica ground down into a fine powder under the action of water.

If the vegetable and mineral world crumbles into *dust*, on the other hand it is highly probable that dust was the original state of matter before the earth and heavenly bodies were formed ; and here we enter the region of theory and probabilities. In a science like meteorology, where a wide door is open to speculation, we should avoid as much as possible stepping out of the track of known facts ; still there is a limit to physical observation, and in some cases we can do no more than glance into the possible or probable source of natural phenomena. Are we on this account to give up inquiring for *causes*? This question I shall beg to leave you to decide, but where we have such an experienced authority as Norman Lockyer, I think the weight attached to possibilities and theories is sufficiently great to warant my drawing your attention for a few moments to the probable origin of the stars and of our earth.

I dare say many of you have read the interesting article in the *Nineteenth Century* of November last, by Norman Lockyer, and entitled "The History of a Star." The author proposes to clear in our imagination a limited part of space, and then set possible causes to work ; that dark void will sooner or later be filled with some form of matter so fine that it is impossible to give it a chemical name, but the matter will eventually condense into a kind of dust mixed with hydrogen gas, and constitute what are called nebulæ. These nebulæ are found by spectrum analysis to be made up of known substances, which are magnesium, carbon, oxygen, iron, silicon, and sulphur. Fortunately for persons interested in such inquiries, this dust comes down to us in a tangible form. Not only have we dust shed from the sky on the earth, but large masses, magnificent specimens of meteorites which have fallen from the heavens at different times, some of them weighing tons, may be submitted to examination. From the spectroscopic analysis of the dust of meteorites we find that in addition to hydrogen their chief constituents are magnesium, iron, silicon, oxygen, and sulphur.

There are swarms of dust travelling through space, and their motion may be gigantic. We know, for instance, some stars to be moving so quickly that, from Sir Robert Ball's calculations, one among them would travel from London to Pekin in something like two minutes. From photographs taken of the stars and nebulæ, we are entitled to conclude that the swarms of dust meet and interlace each other, becoming raised from friction and collision to a very high temperature, and giving rise to what looks like a star. The light would last so long as the swarms collide, but would go out should the collision fail ; or, again, such a source of supply of heat may be withdrawn by the complete passage of one stream of dust-swarms through another. We shall, therefore, have various bodies in the heavens, suddenly or gradually increasing or decreasing in brightness, quite irregularly, unlike those other bodies where we get a periodical variation in consequence of the revolution of one of them round the other. Hence, as Norman Lockyer expresses it clearly, "it cannot be too strongly insisted upon that the chief among the new ideas introduced by the recent work is that a great many stars are not stars like the sun, but simply collections of meteorites, the particles of which may be probably thirty, forty, or fifty miles apart."

The swarms of dust referred to above undergo condensation by attraction or gravitation ; they will become hotter and brighter as their volume decreases, and we shall pass from the nebulæ to what we call true stars.

The author of the paper I am quoting from imagines such condensed masses of meteoric dust being pelted or bombarded by meteoric material, producing heat and light, which effect will continue so long as the pelting is kept up. To this circumstance is due the formation of stars like suns. Our earth originally belonged to that class of heavenly bodies, but from a subsequent process of cooling assumed its present character.

While apologizing for this digression into extra-atmospheric dust, I shall propose to divide atmospheric dust into *organic*, or *combustible*, and *mineral*, or *incombustible*. The dust scattered everywhere in the atmosphere, and which is lighted up in

[1] An Address delivered to the Royal Meteorological Society, January 15, 1890, by Dr. William Marcet, F.R.S., President.

a sunbeam, or a ray from the electric lamp, is of an organic nature. It is seen to consist of countless motes, rising, falling, or gyrating, although it is impossible to follow any of them with the eye for longer than a fraction of a second. We conclude that their weight exceeds but very slightly that of the air, and moreover, that the atmosphere is the seat of multitudes of minute currents, assuming all kinds of directions. Similar currents, though on a much larger scale, are also met with in the air. One day last June, from the top of Eiffel's Tower in Paris, I amused myself throwing an unfolded newspaper over the rail carried round the summmit of the tower. At first it fell slowly, carried away by a light breeze, but presently it rose, and, describing a curve, began again to fall. As it was vanishing from sight, the paper seemed to me as if arrested now and then in its descent, perhaps undergoing again a slight upheaval. Here was, indeed, a gigantic mote floating in the atmosphere, and subject to the same physical laws, though on a larger scale, as those delicate filaments of dust we see dancing merrily in a sunbeam.

I recollect witnessing at one of the Friday evening lectures of the Royal Institution in the year 1870 the following beautiful experiment of Dr. Tyndall, illustrative of the properties of atmospheric dust:—If we place the flame of a spirit-lamp or a red-hot metal ball in the track of a beam of light, there will be seen masses of dark shadows resembling smoke emitted in all directions from the source of heat. At first sight this appears as if due to the dust-particles being burnt into smoke; but by substituting for the spirit-flame or red-hot metal ball an object heated to a temperature too low to burn the motes, the same appearance of smoke is observed, hence the phenomenon is not owing to the combustion of the dust. The explanation, however, is obvious. The source of heat, by warming the air in its contact, and immediate proximity, made the air lighter and the motes relatively heavier, consequently they fell, and left spaces free from dust. These spaces in the track of the electric ray appeared dark, or looked as if full of a dense smoke, because the light of the ray could no longer be scattered in them from the absence of dust.

The motes were next examined by Tyndall, to determine whether they were organic or mineral. This was done by driving a slow current of air through a platinum tube heated to redness, and examining this air afterwards in a beam of light; it was then found to darken the ray, having lost the power of scattering light; therefore the dust had been destroyed or burnt by passing through the red-hot platinum tube, clearly showing its organic nature.

We breathe into our lungs day and night this very finely-divided dust, and yet it produces no ill effect, no bronchial irritation. Tyndall has again shown by the analytical power of a ray of light what becomes of the motes we inhale.

Allow me to return to the experiment with the red-hot metal ball placed in the beam of the electric light. Should a person breathe on the heated ball, the dark smoke hovering around it will at first disappear, but it will reappear in the last portions of the air expired. What does this mean? It means that the first portions of air expired from the lungs contain the atmospheric motes inhaled, but that the last portions, after reaching the deepest recesses in the organs of respiration, have deposited there the dust they contained.

It is difficult to say how much of the dust present in the air may become a source of disease, and how much is innocuous. Many of the motes belong to the class of *micro-organisms*, and the experiment to which we have just referred shows how easily these micro-organisms, or sources of infectious diseases, can reach the lungs and do mischief if they should find a condition of the body on which they are able to thrive and be reproduced. Atmospheric motes, although it has been shown that they are really deposited in the respiratory organs, do not accumulate in the lungs and air-passages, but undergo decomposition and disappear in the circulation. Smoke, which is finely-divided coal-dust, is clearly subjected to such a destructive process; otherwise the smoky atmosphere of many of our towns would soon prove fatal, and tobacco smoke would leave a deposit interfering seriously after a very short time with the phenomena of respiration.

Dust, however, in its physical aspect is far from being always innocuous, and, as you are aware, many trades are liable to suffer from it. The cutting of chaff, for horses' food, is one of the most pernicious occupations, as it generates clouds of dust of an essentially penetrating character. Those engaged in needle manufactures and steel-grinders suffer much from the dust of metallic particles. Stone-cutters, and workmen in plaster of Paris, coal-heavers, cotton and hemp spinners are also engaged in trades injurious to health because of the dust these men unavoidably work in. Those engaged in cigar and rope manufactures, or in flour-mills, hat and carpet manufacturers, are also liable to suffer for the same reason. A number of methods have been adopted, more or less successfully, to rid these trades of the danger due to the presence of dust. I shall not detain you on this subject, which would carry me too far, but merely bring to your notice the fact I observed many years ago, that charcoal has the power of retaining dust in a remarkable degree. I had charcoal respirators made of such a form as to cover both the mouth and nose, and containing about ½-inch thick of charcoal in a granular state. I could breathe through such a respirator in the thickest cloud of dust made by chaff-cutting without being conscious of inhaling any of the dust.

The subject of micro-organisms belongs to the science known as micro-biology. As meteorologists we are chiefly concerned with their distribution in the atmosphere. Micro-organisms are dust-like particles capable of cultivation or reproduction in certain media and at certain temperatures. If a particle of matter known to contain micro-organisms, also called *bacilli*, be placed on a clear surface of gelatine and maintained at a temperature favourable to its development, in a short time the gelatine will be found to contain a colony of those same *bacilli*. A fact so often stated as to become a medical truism is that there can be no infectious disease without the presence of the micro-organism special to that disease. Open cesspools, putrid meat or vegetable matter, accumulations of refuse, have no ill effects on health unless the micro-organisms of a certain disease, as those of typhoid fever or cholera, be present. On such foul decomposing matters these organisms thrive. They are reproduced with great activity, and become virulent in their effects.

Micro-organisms are scattered everywhere in the atmosphere. Dr. Miguel, at the Montsouris Observatory at Paris, has made an extensive inquiry into their distribution in air and water. In this country Dr. Percy Frankland has, with praiseworthy labour and perseverance, investigated the subject of micro-organisms, and ascertained their number in various localities. The result of his inquiry is that in cold weather, especially when the ground is covered with snow, the number of organisms in the air is very much reduced, and presents a very striking contrast with that found in warmer weather. The experiments made on March 9 show that during cold and dry weather, with a strong east wind blowing over London, a large number of micro-organisms may still be present in the air. It is particularly noticeable that even after an exceedingly heavy rain, and within a few hours afterwards, the number of micro-organisms in the air should be as abundant as usual. Taking an average of the experiments made on the roof of the Science Schools of the South Kensington Museum, the mean number of organisms found in 10 litres of air amounted to 35, while an average of 279 fell on one square foot in one minute. Other experiments made near Reigate and in the vicinity of Norwich present a marked contrast with those undertaken in the South Kensington Museum. There was a remarkable freedom from micro-organisms of the air collected on the heath near Norwich during the comparatively warm April weather, when the ground was dry. The air in gardens at Norwich and Reigate was richer in micro-organisms than that of the open country. Again, the number of organisms found in the air of Kensington Gardens, Hyde Park, and Primrose Hill was less than in that taken from the roof of South Kensington, but greater than in the country.

Experiments made in inclosed places, where there is little or no aërial motion, show the number of suspended organisms to be very moderate, but as soon as any disturbance in the air occurs, from draughts or people moving about, the number rapidly increases and may become very great. Experiments made in a railway carriage afford a striking example of the enormous number of micro-organisms which become suspended in the air when many persons are brought together.

Micro-organisms being slightly heavier than air, have an invariable tendency to fall, and on that account frequently collect on the surface of water; hence rivers, lakes, and ponds are constantly being thus contaminated. Micro-organisms in very pure water are not readily disposed to multiply, but traces of decomposing organic matter will induce their reproduction. One remarkable case occurs to me illustrating this fact. In 1884 a severe epidemic of typhoid fever broke out in the town of

Geneva, in Switzerland. The water of the lake in the harbour, which is surrounded by houses on three sides, was then examined by a distinguished micro-biologist, M. Fol, who discovered it to be full of micro-organisms; the water supplied to the town for drinking-purposes was taken from the River Rhone immediately as it flowed out of the harbour. The inquiry was pursued further, and it was found that just outside the harbour, on the surface of the water, there were still a number of micro-organisms, though less than in the harbour; but a few feet below the surface, say 3 or 4 feet, they had greatly diminished in number, indeed to such an extent that there were very few present. The obvious remedy was at once carried out. A wooden aqueduct was constructed, opening into the lake about 150 yards outside the harbour, and some 3 or 4 feet under the surface. As stated by Dr. Dunant, a Geneva physician who has given a very interesting account of this epidemic,[1] eighteen days after the source of the water-supply had thus been altered, a marked decline took place in the epidemic, and it was clearly being mastered. A similar epidemic due to a like cause occurred about the same time at Zurich.

There is one point connected with the properties of dust of organic origin which I think cannot fail to be of interest on the present occasion. I mean its inflammability, and its liability to explode when mixed with air. By *explosion* is meant that the propagation of flame by a very finely-divided material, such as coal-dust, mixed in due proportion with air, may proceed with a rapidity approaching the transmission of explosion by a gaseous mixture.

An interesting lecture was delivered on this subject at the Royal Institution, in April 1882, by Sir Frederick Abel, entitled "Some of the Dangerous Properties of Dust." The lecturer refers to instances of explosions in flour-mills, due in all probability to a spark from the grinding mill-stones, occurring in consequence of a deficient supply of grain to the stones.

Messrs. Franklin and Macadam, who investigated the subject, found that accidents of this nature were of frequent occurrence. In May 1878 a flour-mill explosion, quite unparalleled for its destructive effects, occurred at Minneapolis, Minnesota. Eighteen lives were lost, and six distinct corn-mills were destroyed. Persons who were near the scene of the calamity heard a succession of sharp hissing sounds, doubtless caused by the very rapid spread of flame through the dust-laden air of the passages inside the mill. The nearest mill to that first fired was 25 feet distance, and exploded as soon as the flames burst through the first mill. The explosion of the third mill, 25 feet from the second, followed almost immediately; and the other three mills, about 150 feet distance in another direction, were at once fired. The fire was attributed to a spark from friction of the mill-stones.

Coal-dust in coal-mines is a cause of accident from explosions, which has been closely investigated in this country, in Germany, and other mining districts. Sir Frederick Abel has given this subject especial attention, and brings it prominently forward in his valuable and exhaustive paper on "Accidents in Mines," read to the Institution of Civil Engineers in 1888. Some mines are, of course, more dusty than others, and coal-dusts are not all equally inflammable. That which is deposited upon the sides, top timbers, and ledges in a dry, dusty mine-way is much finer and more inflammable than the coarser dust which covers the floors. The lecture I have referred to alludes to the case of a considerable quantity of coal-dust accidentally thrown over some screens at a pit mouth bursting into flame as the dust cloud came into contact with a neighbouring fire, and burning a man very severely. There appears good ground for believing that fire may travel to a considerable extent through the workings of a mine from the ignition of coal-dust, as will be seen in the following account, extracted from Messrs. W. W. and J. B. Atkinson's book on "Explosions in Mines":—"An appalling accident happened at the Seaham Colliery, in the county of Durham, on September 8, 1880, at 2.20 a.m., causing the death of 24 men. An explosion occurred in the mine, and a loud report was heard at the surface, accompanied with a cloud of dust from the shaft, but no fire was seen. Owing to damage to the shaft it was more than twelve hours before a descent could be effected, and then a scene of destruction was witnessed by the explorers. Doors and air-crossings destroyed; tubs broken to pieces, and hurled one over the other; timber blown out, attended with heavy falls from the roof; and the bodies of men and horses in many cases terribly mutilated. The explosion was found to have extended over roads of an aggregate length of about 7500 yards, the greatest distance between the extreme points reached being about 3800 yards."

When discussing the cause of this terrible accident, Messrs. Atkinson remark that it was apparently impossible to account for the effects of the explosion on the assumption that it was due to fire-damp, as the presence of fire-damp was most unlikely to occur at any part at which the explosion could have happened; and therefore attention must be turned to coal-dust. There was coal-dust on all the roads traversed by the explosion, and there was coal-dust at the supposed point of origin. These facts are of striking significance. After the explosion, all parts of the mine in which its effects could be traced were covered on the bottom and on flat surfaces with a coating of fine dust, which, when examined under the microscope, appeared to have been acted on by great heat. This fine dust covered the surface for a depth of from $\frac{1}{8}$ to $\frac{1}{2}$ an inch and under. Dust of this kind was entirely absent on those roads over which the explosion had not extended. With reference to the original ignition, a shot had been fired apparently simultaneously with the explosion. The road at the place was of stone, and would probably be coated with the finest coal-dust; and, moreover, just above the spot where the fatal shot was fired were large baulks of timber, on which dust was plentifully stored. The shock caused by the explosion would throw the dust into the air, and the flame set fire to it. Thus initiated, the flame would extend through all the roads on which there was an uninterrupted supply of coal-dust to support it.

The second part of this address relates to inorganic or mineral dust. When on the Peak of Tenerife in 1878, engaged in a pursuit mostly of a physiological kind, I had occasion to use a very delicate chemical balance. My object was to determine the amount of aqueous vapour given out of the lungs while in the shallow crater at the summit of the Peak, 12,200 feet above the sea. The heat was intense, as the sun shed its nearly vertical rays at midday on the fine white volcanic sand spread over the floor of the crater. At various places rocks projected, covered here and there with crystals of sulphur, and so hot that the hand could scarcely bear coming in contact with them. Anticipating some difficulty in the use of the balance from the action of the wind, I had brought up with me a hamper and a blanket. After placing the hamper sideways, with the lid off, I proceeded, though not without some little trouble, to dispose the balance satisfactorily inside the basket; then, having thrown the blanket over the hamper, I stretched out at full length on the burning sand, nestling under the blanket, much as a photographer would cover himself and camera with a dark cloth. On trying to use the balance, it refused to act; its beam would not oscillate. A careful examination showed the instrument to be apparently in perfect order, when it occurred to me to wipe the knife-edges at the points of suspension of the beam and pans. The balance then worked quite well, though but for a few minutes only, again most provokingly declining to oscillate; indeed, it was only by constant wiping of the knife-edges that I succeeded with my experiment. The cause of my trouble was clearly the presence of very fine mineral dust in the air, of which my senses were utterly unconscious. Hence it is that extremely fine particles of mineral dust may exist in the atmosphere, while escaping detection by our senses, and such an occurrence is probably more frequent than generally thought.

Prof. Piazzi Smyth, while on the Peak of Tenerife, witnessed strata of dust rising to a height of nearly a mile, reaching out to the horizon in every direction, and so dense as to hide frequently the neighbouring hills. The Report of the Krakatão Commission of the Royal Society contains the following interesting account, p. 421 (Mr. Douglas Archibald's contribution to the Report):—"In 1881, Prof. S. P. Langley ascended Mount Whitney, in Southern California, with an expedition from the Alleghany Observatory; at an altitude of 15,000 feet his view extended over one of the most barren regions in the world. Immediately at the foot of the mountain is the *Inyo Desert*, and in the east a range of mountains parallel to the Sierra Nevada, but only about 10,000 feet in height. From the valley the atmosphere had appeared beautifully clear, but, as stated in Prof. Langley's own words, "from this aërial height we looked down upon what seemed a kind of level dust ocean, invisible from below, but whose depth was six or seven thousand feet, as the upper portion only of the opposite mountain range rose clearly out of it. The colour of the light reflected to us from

[1] "Epidémie de fièvre typhoide à Genève en 1884," par P. L. Dunant, *Revue Médicale de la Suisse Romande*, 1887.

this dust ocean was clearly red, and it stretched in every direction as far as the eye could reach, although there was no special wind or local cause for it. It was evidently like the dust seen in mid-ocean from the Peak of Tenerife—something present all the time, and a permanent ingredient of the earthy atmosphere."

Dust Storms.—These storms, as suggested by Dr. Henry Cook, from whose paper to the Quarterly Journal of the Royal Meteorological Society, in 1880, I am now quoting, may be considered under three heads, according to their intensity—atmospheric dust, dust columns, and dust storms. Dr. Cook, alluding to occurrences in India, observes that there are some days on which, however hard and violently the wind may blow, little or no dust accompanies it; while on others, every little puff of air or current of wind forms or carries with it clouds of dust. If the wind which raises the dust is strong, nothing will be visible at the distance of a few yards, the sun at noon being obscured. The dust penetrates everywhere, and cannot be excluded from houses, boxes, and even watches, however carefully guarded. The individual particles of sand appear to be in such an electrical condition that they are ever ready to repel each other, and are consequently disturbed from their position and carried up into the air.

Dust columns are considered by Dr. Cook as due to electrical causes. On calm, quiet days, when hardly a breath of air is stirring, and the sun pours down its heated rays with full force, little eddies arise in the atmosphere near the surface of the ground. These increase in force and diameter, catching up and whirling round bits of sticks, grass, dust, and, lastly, sand, until a column is formed of great height and considerable diameter, which usually, after remaining stationary for some time, sweeps away across country at great speed. Ultimately it loses gradually the velocity of its circular movement and disappears. In the valley of Mingochar, which is only a few miles in width, and surrounded by high hills, Dr. Cook, on a day when not a breath of air stirred, counted upwards of twenty of these columns. They seldom changed their places, and, when they did so, moved but slowly across the level tract. They never interfered with each other, and appeared to have an entirely independent existence.

Dr. Cook describes as follows a dust storm which took place at Jacobabad:—"The weather had been hot and oppressive, with little or no breeze, and a tendency for dust to accumulate in the atmosphere. On the evening of the storm heavy clouds gathered and covered the sky. About 9 p.m. the sky had cleared somewhat, and the moon shone. A breeze sprang up from the west, which increased and bore along with it light clouds of sand. At 9.30 p.m. the storm commenced in all its fury. Vast bodies of sand were drifted violently along. The stars and moon were totally obscured. It became pitch dark, and it was impossible to see the hand held close to the face. The wind blew furiously in gusts, and heaped the sand on the windward side of obstacles in its course. Lightning and thunder accompanied it, and were succeeded by heavy rain. The storm lasted about an hour, when the dust gradually subsided. The sky again became clear, and the moon shone brightly. The storm appeared to have entirely relieved the electrical condition of the atmosphere. A pleasant freshness followed, and the oppressive sensation before mentioned was no longer experienced. This, indeed, is the general effect of storms in Upper Scind. The air is cooled, the atmosphere cleared, and the dusty condition of the atmosphere which usually precedes them for several days completely disappears."

In the case of a memorable sand storm which occurred at Aden on July 16, 1878, and recorded by Lieutenant Herbert Russell, there was a remarkable play of light on the objects which remained within sight. The sudden darkness from the storm gave a peculiar and ghastly tint to the white sand and neighbouring plain, while the curling masses of sand drifted before the gale, resembling a dark yellow smoke. The varied lights, quickly changing, were curious and most grand; the sea a clear green, and Slave Island and Shum-Shum, usually of an arid brown colour, became of an ashy white.

In a dust storm I experienced myself at Luxor, on the Nile, the suffocating effect of the sand as it drove into the lungs and air passages was very trying. People rushed to the immediate river side, where some relief was found.

A book on "Whirlwinds and Dust Storms in India," by P. L. H. Baddeley, Surgeon, Bengal Army, 1860, gives some interesting information on the electrical character of dust storms and dust pillars. When at Lahore in 1847, this gentleman was desirous of experimenting on the electrical state of the atmosphere in a dust storm, and with this object he projected into the air, on the top of his house, an insulated copper wire fixed to a bamboo; the wire was brought through the roof into his room, and connected with a gold-leaf electrometer, a detached wire communicating with the earth. A day or two after, during the passage of a small dust storm, he observed the occurrence of vivid sparks from one wire to the other, and, of course, strongly affecting the electrometer. He subsequently witnessed at least sixty dust storms of various sizes, all presenting the same kind of phenomena.

Volcanic Dust.—This dust consists mainly of powdered vitrified substances, produced by the action of intense heat. It is interesting in many respects. The so-called ashes or scories shot out in a volcanic eruption are mostly pounded pumice, but they also originate from stones and fragments of rocks which, striking against each other, are reduced into powder or dust. Volcanic dust has a whitish-grey colour, and is sometimes nearly quite white. Thus it is that, in summer, the terminal cone of the Peak of Tenerife appears from a distance as if covered with snow; but there is no snow on the mountain at that season of the year; the white cap on the Peak is entirely due to pumice ejected centuries ago. It is probably to this circumstance that the island and Peak owe their name, as in the Guelph language the words *Tener Ifa* mean *white mountain.*

The friction caused by volcanic stones and rocks as they are crushed in their collision develops a mass of electricity which shows itself in brilliant displays of branch lightning darting from the edges of the dense ascending column. During the great eruption of Vesuvius, in 1822, they were continually visible, and added much to the grandeur of the spectacle. It not unfrequently happens that dust emitted from Vesuvius falls into the streets of Naples; but this is nothing in comparison with the mass of finely-powdered material which covered and buried the towns of Pompeii, Herculaneum, and Stabiæ in the year 79.

On this occasion, according to the younger Pliny, total darkness from the clouds of volcanic ashes continued for three days, during which time ashes fell like a mantle of snow all over the surrounding country. When the darkness cleared away, the calamity was revealed in all its awful extent, the three towns having disappeared under the showers of dust.

The eruption of Krakatão, a mountain situated on an island in the Straits of Sunda, exceeded, in all probability, in its deadly effects, and as a wonderful phenomenon of Nature, the outburst of Vesuvius in the year 69. The Krakatão Committee of the Royal Society have collected and published in their interesting Report particulars of that memorable eruption, all of them thoroughly authenticated and reliable. The following is extracted from a communication to the Report by Prof. Judd:—"On August 26, 1883, it was evident that the long-continued moderate eruptions of Krakatão had passed into the paroxysmal stage. That day, about 1 p.m., the detonations caused by the explosive action attained such a violence as to be heard at Batavia and Buitzsenborg, about 100 English miles away. At 2 p.m. Captain Thompson, of the *Medea,* then sailing at a point 76 miles east-north-east of Krakatão, saw a black mass like smoke rising into the clouds to an altitude which has been estimated at no less than seventeen miles (nearly six times the height of Mont Blanc)."

If this surmise be correct, some idea of the violence of the outburst can be formed from the fact that during the eruption of Vesuvius in 1872 the column of steam and dust was propelled to a height of from 4 to 5 miles only.

At 3 p.m. the explosions were loud enough to be heard 150 miles away. At Batavia and Buitzsenborg the noise is described as being like the discharge of artillery close at hand. Windows rattled, pictures shook, but there was nothing in the nature of earthquake shocks—only strong air vibrations.

Captain Wooldridge, of the *Sir R. Sale,* viewing the volcano at sunset on the 26th, describes the sky as presenting a most terrible appearance, the dense mass of cloud of a murky tinge being rent with fierce flashes of lightning. At 7 p.m., when from the vapour and dust clouds intense darkness prevailed, the whole scene was lighted up by electrical discharges, and at one time the cloud above the mountain presented the appearance of an immense pine-tree, with the stem and branches formed of volcanic lightning. The air was loaded with excessively fine ashes, and there was a strong sulphurous smell. The steamer *G. G. Loudon,* within 20 or 30 miles of the eruption, passed through a rain of ashes and small bits of stone.

Captain Watson, of the ship *Charles Bal*, at a spot about a dozen miles off the island, records the phenomena of chains of fire appearing to ascend between the volcano and the sky, while on the south side there seemed to be a "continual roll of balls of white fire." These appearances were doubtless caused by the discharge of white-hot fragments of lava rolling down the sides of the mountain. From midnight till 4 a.m. explosions continually took place, the sky one second being intense blackness, the next a blaze of fire.

All the eye-witnesses agree as to the splendour of the electrical phenomena. Captain Woolridge, viewing the eruption from a distance of 40 miles, speaks of the great vapour cloud resembling an immense wall, with outbursts of fork lightning, like large luminous serpents, rushing through the air. After sunset, this dark wall assumed the appearance of a blood-red curtain, with the edges of all the shades of yellow—the whole of a murky tinge, and attended with fierce flashes of lightning. It was reported from the *Loudon* that lightning struck the mast-head conductor five or six times, and that the mud-rain which covered the masts, rigging, and decks was phosphorescent. The rigging presented the appearance of St. Elmo's fire, which the native sailors were busily engaged putting out with their hands, alleging that, if any portion found its way below, a hole would burst in the ship; not that they feared the ship taking fire, but they thought the light was the work of evil spirits, and that if it penetrated the hold of the vessel, the evil spirits would triumph in their design to scuttle the ship.

By these grand explosive outbursts the old crater of Krakatão was completely eviscerated, and a cavity formed more than 1000 feet in depth; while the solid materials thrown out from the crater were spread over the flanks of the volcano, forming considerable alterations in their forms.

The sea disturbance which accompanied the eruption of Krakatão was carefully investigated by Captain Wharton, Hydrographer to the Admiralty:—"The rush of the great sea wave over the land, caused by the violent abrasion in the crater, aided by the action on the water of enormous masses of fallen material, caused great destruction of life and poverty in the Straits of Sunda. By the inrush of these waves on land, all vessels near the shore were stranded, the towns and villages near the coast devastated, two of the lighthouses were swept away, and the lives of 36,380 of the inhabitants sacrificed. It was estimated that the wave was about 50 feet in height when it broke on the shore."

On the morning of the 27th, between 10 and 11 a.m., three vessels at the eastern entrance of the Straits encountered the fall of mingled dust and water, which soon darkened the air, and covered their decks and sails with a thick coating of mud. Some of the pieces of pumice falling on the *Sir R. Sale* were said to have been of the size of a pumpkin. All day on the 27th, the three vessels were beating about in darkness, pumice-dust falling upon them in such quantities as to employ the crew for hours in shovelling it from the decks and in beating it from the sails and rigging. At Batavia, 100 miles from Krakatão, the sky was clear at 7 a.m., but at 11 a.m. there fell a regular dust-rain; at 11.20 complete darkness pervaded the city. The rain of dust continued till 1, and afterwards less heavily till 3 p.m.

The speed and distance attained by the pumice ejected from the volcano may be conceived from the fact stated in Mr. Douglas Archibald's contribution to the Report, that dust fell on September 8, more than 3700 English miles from the seat of the eruption.

The great mass of the pumice thrown out during the eruption presented a dirty greyish-white tint, being very irregular in size. It was undoubtedly due to the collision of fragments of pumice as they were violently ejected from the crater; the noise produced was even more striking than the sound of the explosion.

The dust ejected from Krakatão did not all fall back at the same time upon the sea and earth; as the lightest portions formed into a haze, which was propagated mostly westward. Mr. Archibald states in the Report that most observers agree upon considering this haze as the proximate cause of the twilight glows, coloured suns, and large corona, which were seen for a considerable time after the eruption. The haze was densest in the Indian Ocean and along the equatorial belt, and was often thick enough to hide the sun entirely when within a few degrees from the horizon.

And now, ladies and gentlemen, I must bring this address to a conclusion, and thank you for having followed me over a long, dusty track. I hope I have succeeded in showing that infinitely small objects, no larger than particles of dust, act important parts in the physical phenomena of Nature, just as small and apparently unimportant events occasionally lead to others of the greatest magnitude.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 6.—"The Cranial Nerves of the Torpedo" (Preliminary Note). By J. C. Ewart, M.D. Communicated by Prof. M. Foster, Sec. R.S.

The cranial nerves of the torpedo agree in their general arrangement with those of the skate.[1] The ophthalmicus profundus occupies the usual position, but its ganglion lies in close contact with the Gasserian, and not on a level with the ciliary ganglion. The trigeminus has the usual distribution, for, notwithstanding the statements in the most recent text-books,[2] the trigeminus sends no branch to the electric organ. The facial complex includes the superficial ophthalmic, the buccal, and the hyomandibular nerves, all of which have the same distribution as the corresponding nerves in the skate; but the hyomandibular includes or is accompanied by a large bundle of nerve fibres which supply the anterior and inner portion of the electric organ. This large nerve cord (the first electric nerve) has hitherto almost invariably[3] been described as a branch of the trigeminus. When traced backwards, it is found to spring from the anterior portion of the electric lobe.

The glossopharyngeus, a slender nerve in the skate, is represented in the torpedo by a thick cord which escapes by a large foramen in the outer wall of the auditory capsule. This large nerve consists of two portions, one of which is small and completely covered by the large superficial division. The small deep division, which in its course and distribution closely resembles the glossopharyngeal in the skate, presents on leaving the auditory capsule a distinct ganglionic swelling, beyond which it breaks up into the branchial and other branches. The large superficial division emanates from the electric lobe behind the origin of the first electric nerve, and at once runs outwards to reach and supply the majority of the columns of the anterior half of the electric organ.

The vagus complex consists of the nervus lateralis, the nervus intestinalis, and of five branchial nerves, of which the two anterior are accompanied by the third and fourth electric nerves. The nervus lateralis, lying superficial to all the other nerves, arises on a level with the root of the glossopharyngeus, and then curves backwards dorsal to the posterior electric nerve to reach the canal of the lateral line. Shortly after leaving the cranium it presents a distinct ganglionic swelling, which is crowded with large cells. The four branchial nerves for the four vagus branchiæ, the slender filament which represents a sixth branchial nerve, and the intestinal nerve lie at first in contact with each other under cover of the third and fourth electric nerves. When the branchial and intestinal nerves are carefully examined, they are found to present four, sometimes five, ganglionic enlargements, and in addition ganglionic cells can sometimes be detected at the proximal end of the slender sixth branchial nerve. The third and fourth electric nerves lie over and are especially related to the second and third branchial nerves. These large electric nerves spring from the posterior half of the electric lobe, and find their way outwards partly behind and partly under the auditory capsule, to terminate in the posterior half of the electric organ.

It thus appears that all the electric nerves spring from the electric lobe, that the first accompanies the hyomandibular division of the facial complex, the second the glossopharyngeus, and the third and fourth the first two branchial nerves of the vagus complex. It remains to be seen whether the electric nerves have been derived from motor branches of the nerves with which they are respectively associated by an enormous increase in the number of their fibres, as the muscular fibres were gradually transformed into electric plates.

Physical Society, Feb. 21.—Prof. G. Carey Foster, F.R.S., Past-President, in the chair.—The following communications were read:—On a carbon deposit in a Blake telephone trans-

[1] Ewart, "On the Cranial Nerves of Elasmobranch Fishes," Roy. Soc. Proc., vol. 45, 1889.

[2] *E.g.*, McKendrick, "Text-book of Physiology," 1888, and Wiedersheim, "Grundriss der vergleichenden Anatomie," 1888.

[3] Fritsch is the only author I am acquainted with who does not describe the first electric nerve as a branch of the trigeminus, "Untersuchungen ueber den feineren Bau des Fischgehirns," Berlin, 1878.

mitter, by Mr. F. B. Hawes. The author exhibited photographs of the interior portions of the transmitter on which the deposit had taken place. These portions consist of a metal diaphragm, a highly-polished carbon button, and a platinum contact piece carried by a German silver spring placed between them. The diaphragm presented a mottled appearance due to the deposit, but the part which had been behind the German silver spring seemed comparatively clean. The deposits on the carbon button and German silver spring were much less dense than that on the exposed parts of the diaphragm, and the space near the point of contact between the platinum and carbon was free from deposit. The deposit was fairly adherent, some rubbing being necessary to remove it, and on examination under the microscope particles of copper and metallic crystals could be seen. The author believes the deposit due to some kind of bombardment of carbon particles, but was unable to say why it should occur, or why the varnished diaphragm should receive the greater deposit although it was further from the carbon than the German silver spring. Mr. C. V. Boys said the photographs reminded him of a phenomenon he observed some time ago on a glass sheet against which one terminal of a dry pile had been resting for some weeks. Just as on the carbon button, the glass near the point of contact was clean and had a comet-shaped deposit formed around it. He could offer no explanation of the appearance.—The geometrical construction of direct-reading scales for reflecting galvanometers, by Mr. A. P. Trotter. In a recent paper on galvanometers, by Prof. W. E. Ayrton, F.R.S., T. Mather, and Dr. W. E. Sumpner, read before the Society, the opinion was expressed that proportionality of scale reading to current was very desirable, and the present paper shows how to bend a scale of equal divisions so as to give the required proportionality. Suppose the currents required to produce several deflections have been experimentally determined. A full-size plan of the scale is then drawn, and radial lines from the points on the scale at which the observations were taken are drawn towards the centre of the mirror. Let these radii be numbered 0, 1, 2, 3, &c., commencing from zero azimuth. According to the procedure recommended, distances proportional to the several current strengths are marked off along the edge of a strip of paper, a few inches being left over at each end. Call the marks *a*, *b*, *c*, *d*, &c., *a* being the zero point. Two points on the radii 0, 1, and equidistant from the mirror are now found such that the distance between them is equal to that between *a* and *b* on the strip, and the points marked by fine needles stuck in the board. The zero end of the strip is now fixed so that the marks *a* and *b* lie against the needles, and the strip is swept round until the mark *c* coincides with the radius 2, where also a needle is placed. Repeating the process gives a series of points which on being joined form part of a polygon. A line can then be drawn between the inscribed and circumscribing curves which has the same length as the sum of the straight lines, and this is the curve to which the original scale may be bent so as to give proportional readings. Diagrams showing such curves, constructed from the calibrations of instruments given in the paper above referred to, accompany the paper. The author showed that a family of curves may be drawn, each of which satisfies the required condition. Of the two limiting curves, one is tangential to the usual scale line at zero azimuth, and the other passes through the vertical axis of the mirror. The flattest of the various curves is generally the most convenient. Mr. J. Swinburne asked whether good definition could be obtained when such curved scales not equidistant from the mirror were used, and also whether it was not easier to divide a flat scale unequally so that the readings are proportional to the current. Mr. Trotter, in reply, said Dr. Sumpner thought there would be no difficulty as regards definition with the flat curves shown. He (Mr. Trotter) also added that a curved scale might be advantageous in reading the deflections from one side of a table, as the more distant part of the scale could be more nearly perpendicular to the line of sight. For such an arrangement, however, a parallel beam of light would be required.—A parallel motion suitable for recording instruments, by Mr. A. P. Trotter. This is a modification of Watt's parallel motion, in which the two fixed centres are on the same side of the line described by the "parallel point." The arrangement consists of two vibrating arms, one of which is twice the length of the other, and whose outer ends are jointed respectively to the middle and end of a short lever; the free end of the latter describes an approximate straight line. The motion was arrived at by considering the curve traced out by a point on the radius of a circle, such that its distance from the circumference measured towards the centre is equal to the radial intercept between the circle and a tangent line. The equation to the curve is $r = 2 - \sec\theta$ (conchoid of Nicomedes) and the radius of the osculating circle at the point where the intercept is zero is given as half that of the initial circle. This osculatory circle, the author finds, practically coincides with the curve over a considerable angle (40°), and thus may replace this part of the curve; hence the motion. The author thinks the motion will be useful for recording barometers, ammeters, and voltmeters, as it is more compact than that of Watt, and needs no fixed point beyond the straight path.—Owing to the absence of Prof. S. P. Thompson, his paper on Bertrand's refractometer was not read.

Linnean Society, March 6.—Mr. Carruthers, F.R.S., President, in the chair.—Mr. Thomas Christy exhibited a dried specimen of *Picramnia antidesma*, the plant from the bark of which a medicine, known as *cascara amarya*, a useful alterative in diseases of the blood and skin, is believed to be prepared.—Mr. J. E. Harting exhibited a series of horns of the American Prongbuck (*Antilocapra americana*), to illustrate the mode in which the shedding and new growth of horn is effected in this animal.—A paper was read by Mr. D. Morris, on the production of seed in certain varieties of the sugar-cane (*Saccharum officinarum*). It was pointed out that, although well known as a cultivated plant, the sugar-cane had nowhere been found wild; nor had the seed (*caryopsis*) been figured or described; it being the generally received opinion that, having been propagated entirely by slips, or cuttings, it had lost the power of producing seed. Spikelets, however, received at Kew, had been carefully examined, and the seed found, which was now for the first time exhibited by Mr. Morris. He anticipated that, by cross-fertilization and selection of seedlings, the sugar-cane might be greatly improved, and much importance was attached to the subject, as it opened up a new field of investigation in regard to sugar-cane cultivation. Mr. J. G. Baker and Mr. Christy concurred.—A paper was then read by Mr. Spencer Moore, on the true nature of *callus*; Part 1, the vegetable-marrow and *Ballia callitricha*. It was shown that the *callus* of sieve-tubes of the vegetable-marrow gives marked proteid reactions; and since it is dissolved in a peptonizing fluid there can be no doubt of its being a true proteid, and not a kind of starchy mucilage, as is usually supposed. The "stoppers" of *Ballia* also yield proteid reactions, but inasmuch as they resist gastric digestion, the substance cannot be a true proteid, and may perhaps be allied to lardacein. Mr. Moore maintained the view of Russow, Strassburger, and others—that *callus* is deposited upon the sieve—to be correct in the case of the vegetable-marrow; since a peptonizing fluid clears the sieve-plates and leaves them in their pristine condition, which would not be the case if *callus* were formed by a swelling up of the sieves. A discussion followed, in which Dr. F. W. Oliver, Dr. D. H. Scott, Prof. Reynolds Green, and Mr. George Murray took part.

Zoological Society, March 4.—Prof. W. H. Flower, F.R.S., President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of February 1890.—Mr. F. E. Beddard exhibited and made remarks on some living specimens of an Indian Earthworm (*Perichæta indica*), obtained from a greenhouse in Scotland.—Mr. A. Thomson exhibited a series of insects reared in the Insect House in the Society's Gardens during the past year, and read a report on the subject. Particular attention was called to specimens of a South African Mantis (*Harpax ocellata*) and of a Canadian Stick Insect (*Diaphemora femorata*).—Mr. Henry Seebohm read a paper on the classification of birds, being an attempt to diagnose the sub-classes, orders, sub-orders, and some of the families of existing birds. The characters upon which the diagnoses were based were almost entirely derived from points in the osteology, myology, and the pterylosis of the groups diagnosed.—A communication was read from Mr. T. D. A. Cockerell, describing some Galls from Colorado, of which specimens were transmitted for exhibition.

EDINBURGH.

Royal Society, February 28.—Sir Douglas Maclagan, Vice-President, in the chair.—Prof. Rutherford communicated a paper on the structure and contraction of striped muscular fibre of crab and lobster.—Prof. Haycraft read a paper on the histology, functions, and development of the carapace of the Chelonia, and also another paper on the rate at which muscles contract when the motor paths are stimulated by interrupted electrical currents.

March 3.—Sir W. Thomson, President, in the chair.—Prof. Tait communicated a note on ripples in a viscous liquid. He investigates in it the motion of a continuous set of ripples, and discusses the effects of gravity, surface-tension, surface-stiffness, and viscosity.—Dr. Thomas Muir communicated a paper by Mr. D. Maver, on a geometrical method based on the principle of translation.—Prof. J. Stuart Blackie read a paper on the phases of the living Greek language.

PARIS.

Academy of Sciences, March 10.—M. Hermite in the chair.—Note on the life and works of George Henry Halphen, by M. Emile Picard.—On the phenomena seen about the sun on March 3, 1890, by M. A. Cornu. Halos and parhelia were seen about the sun on this date, and observations of the aqueous bands of the solar spectrum made at the time when the first halo of 22° appeared, showed that warm and moist currents existed in the higher regions of the atmosphere in spite of the exceptional cold (– 11° C.) at Paris.—Thermal researches on the allotropic modifications of arsenic, by MM. Berthelot and Engel. The amount of heat evolved on treatment with bromine and water was found to be nearly the same in both the forms ; arsenic, in this respect, behaving like carbon.—Second note on the absorption of atmospheric ammonia by soils, by M. H. Schlœsing. From the experiments described in this and the previous note, the author finds that calcareous, acid or neutral, dry or wet soils, absorb atmospheric ammonia. Moist earth, however, favours the fixation of ammonia, and dry earth retards it.—The muscular and elastic elements of the retrolingual membrane of the frog, by M. L. Ranvier. The problems investigated are : the attachment of the elastic fibres to the muscular bundles, and whether a fibril terminates in a thick or thin disc or a clear space, all of which occur in the muscular bundles.—On the microbes of acute osteomyelites called infectious, by MM. Lannelongue and Achard.—Study of the errors of observation, by M. J. E. Estienne.—Sun-spot in very high latitude, by M. Dierckx. To this note we refer elsewhere (p. 472).—On Stirling's formula, by M. E. Rouché.—On regular surfaces which pass through a given curve, by M. Ch. Bioche.—On the compounds of phosphoretted hydrogen and ammonia with boron chloride and silicon hexachloride, by M. A. Besson.—Note on the compounds of the metals of the alkalies with ammonia, by M. J. Moutier.—On the estimation of free halogens and of iodides in presence of chlorine and bromine, by M. P. Lebeau. Iodine is estimated by liberation from its compound in aqueous solution by a standard solution of bromine, the iodine being dissolved out from the water by CS_2 as soon as liberated : the end of the reaction is indicated by the decoloration of the supernatant aqueous solution, to which a few drops of indigo solution has been previously added.—On the formation of thiosulphate of lead, note by M. J. Fogh.—Decomposition of thiosulphate of lead by heat. Trithionate of lead, by the same author. It is shown that, by the prolonged action of boiling water, thiosulphate of lead decomposes according to the equation $2PbS_2O_3 = PbS + PbS_3O_6$.—On a new iodide of bismuth and potassium, M. L. Astre.—Note on the molecular increase of dispersion of saline solutions, by MM. Ph. Barbier and L. Roux. If the constant K given in a previous communication be multiplied by the molecular weight of the dissolved salt, what the authors term the molecular increase of dispersion is obtained. MK for chlorides of the type MCl is shown to have the mean value 0·020, for chlorides MCl_2 the mean value is 0·044.—Researches upon the application of measurements of the rotatory power to the determination of compounds resulting from the action of malic acid upon the neutral molybdates of lithium and magnesium, by M. D. Gernez.—The volumetric estimation of tannin, by M. E. Guenez.—Estimation of acetone in methyl alcohol and in the raw methyl alcohol used for methylation, by M. Léo Vignon.—On the diminution of fermenting power of the ellipsoidal wine-yeast, in presence of salts of copper, by M. A. Rommier.—On a Coleopterous insect attacking the vine in Tunis (*Ligniperda francisca*, Fabricius), by M. A. Laboulbène. —The preparation of crystallized basic nitrate of copper and its identification with gerhardtite, by M. L. Bourgeois.

BERLIN.

Meteorological Society, February 11.—Prof. Schwalbe, President, in the chair.—Dr. Danckelmann spoke on the meteorological conditions which exist on the Gold and Slave Coast. General observations had been started in New Guinea, but were soon reduced to observations of rainfall only ; during the years 1886 to 1889, they had yielded some interesting results on the connection between rainfall and the direction of the monsoons and trade-winds. No trustworthy data are as yet to hand of the meteorological conditions of Southern Africa, Cameroon, and East Africa, but, on the other hand, there is a mass of material accumulated at many stations on the Guinea coast. From the latter it appears that the atmospheric pressure varies but slightly, and shows a maximum in July and August. In Bismarckburg the wind blows from the north and north-east from the Sahara in December, January, and February ; in June, July, and August it blows west and south-west. Variations of temperature are but slight, presenting a maximum in December to February, and a minimum in July and August. The amount of rainfall is very variable, being, in some places, as low as 575 mm. per annum ; in others, 1000, 1500, or even 3500. The speaker concluded by describing the climatic conditions of this region, pointing out that they may be explained with reference to the contiguity of the Sahara Desert.—Dr. Eschenhagen gave a detailed description of the Magnetic Observatory at Potsdam, dealing with its structural arrangements and the internal location of the instruments. While exhibiting the photographically recorded curves of the previous fortnight, he dealt with the breaks in these which result from any more than usually severe shock of earthquake. These he attributed to purely mechanical causes rather than to magnetic, basing his views on observations of the movement of the surface of mercury at the time. He pointed out that the opposite view, urged by French meteorologists, as based upon observation of a copper rod with a bifilar suspension, is inconclusively supported by such observations, inasmuch as the equilibrum of a copper rod is relatively stable, while that of a bifilar magnet is unstable.—The President referred, in conclusion, to the loss which meteorology had sustained in the death of Buys Ballot.

Physiological Society, February 14.—Prof. du Bois Reymond, President, in the chair.—Prof. Zuntz gave an account of experiments conducted in his laboratory by Dr. Katzenstein, on the influence of bodily labour on the metabolism of man. After giving an historical *résumé* of previous researches, he described the methods employed in the present research. The experiments were conducted in a very convenient form of respiration-apparatus, the analysis of the gases being made by Hempel's method. Great stress was laid on the accurate determination of the work done ; the latter consisted in either turning a wheel against a graduated resistance, or else in motion on either a plane or inclined surface. In the latter form of work an apparatus was used which had previously been employed in experiments on a horse. The oxygen consumed in each experiment was taken as a measure of the metabolism. It was found that this was permissible, from the fact that the respiratory quotient was observed to be constant during the three conditions of rest, walking, and climbing. From this it appeared that the energy required for any given work was the outcome of the union of oxygen and carbon in the formation of carbonic acid gas. The increased respiratory interchange which accompanied any extra work fell to the normal some two or three minutes after the work ceased. In each experiment the distance covered and height through which the body was raised was measured in kilogram-metres ; the oxygen simultaneously absorbed was determined, and from this the amount of oxygen which would have been absorbed if no work had been done was subtracted, so that the amount of oxygen required for the given work was obtained. It was found that, as in Smith's experiments, the metabolism might be increased to two or three times the normal during work. The experiment was then repeated, employing a different rate of motion and steepness of ascent, so that it was readily possible to calculate the oxygen, in cubic centimetres, required for a progression of one metre or the raising of one kilogram ; the former was then reduced to a unit of one kilogram of body-weight. The result obtained from the person on whom most of the experiments were made was that the moving of one kilogram of body-weight over one metre of space on the level involved a consumption of 1·11 c.c. of oxygen, and for the raising of one kilogram through one metre, a consumption of 1·438 c.c. In conclusion, the speaker drew some interesting comparisons between the results of these experiments and those previously made on a horse.—Dr. Benda exhibited several preparations of sense-organs of mammals; and Dr. Katz showed some specimens of the organ of Corti.—Dr. Hausemann spoke on unsymmetrical karyokinesis met with in epitheliomata. Ordinarily the chromatin-filaments divide into two equal parts, but in cancer-cells they do not, and from this results the polymorphism of the nuclei.

Physical Society, Febuary 21.—Prof. du Bois-Reymond, President, in the chair.—Prof. von Bezold made a short speech in memory of Buys Ballot, pointing out with chief prominence that he was the first to draw attention to the necessity of co-operation between the meteorologists of different nations, and that he had been chiefly instrumental in establishing the existing International Meteorological Congress. He further showed that Buys Ballot was the first to give a survey of the meteorological conditions existing simultaneously at different places on the earth's surface, the pioneer in the production of the synoptic charts which are now published (see *Poggendorff's Annalen* for 1847), and the first to thoroughly grasp and state with precision the difference between weather and climate.—Dr. E. Pringsheim spoke on Kirchoff's law and gaseous radiation. During the experimental verification of the above, the speaker was chiefly interested in the behaviour of gases and vapours, and selected for his experiments sodium vapour. It was impossible to obtain any answer to the question "Does a gas acquire the power of emitting light-rays when its temperature is raised?" by the mere introduction of sodium or its salts into the non-luminous flame of a Bunsen burner, since it was not possible to exclude the occurrence of chemical changes during such an experiment. Thus he employed rather the method of Lockyer, Liveing, and Dewar, heating the metal in a sealed tube. In this way he verified the appearance of the bright emission-line and of the absorption-line of sodium. The lowest temperature at which they make their appearance was determined and measured thermo-electrically, but the speaker did not deduce any absolute value from his data. He further considered that the radiation of gases when heated is not yet definitely proved, since the nitrogen in which he heated the sodium contained minute traces of oxygen, and the method he employed for closing the ends of his tube permitted of the probable entry of small quantities of air. He had, therefore, additionally made experiments with thallium, and on the introduction of air into the metallic vapours; these experiments yielded a distinctly affirmative answer to the original question, but require further extension. So also do some experiments on the occurrence of a fluted spectrum of sodium, which the speaker had made during the course of the above work.

DIARY OF SOCIETIES.

LONDON.

THURSDAY, MARCH 20.

ROYAL SOCIETY, at 4.30.—The Bakerian Lecture—On the Discharge of Electricity through Gases: Prof. A. Schuster, F.R.S.

LINNEAN SOCIETY, at 8.—The External Morphology of the Lepidopterous Pupæ; Part 2, the Antennæ and Wings: E. B. Poulton, F.R.S.—On the Intestinal Canal of the Ichthyopside with especial Reference to its Arterial Supply: Prof. G. B. Howes.

CHEMICAL SOCIETY, at 8.—The Evidence afforded by Petrographical Research of the Occurrence of Chemical Change under Great Pressures: Prof. Judd, F.R.S.

ZOOLOGICAL SOCIETY, at 4.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.

ROYAL INSTITUTION, at 3.—The Early Developments of the Forms of Instrumental Music (with Musical Illustrations): Frederick Niecks.

FRIDAY, MARCH 21.

PHYSICAL SOCIETY, at 5.—On the Villari Critical Point of Nickel: Herbert Tomlinson.—On Bertrand's Idiocyclophanous Prism: Prof. Silvanus Thompson.

INSTITUTION OF CIVIL ENGINEERS, at 7.30.—Economy Trials of a Compound Mill-Engine and Lancashire Boilers: L. A. Legros.

ROYAL INSTITUTION, at 9.—Electro-magnetic Radiation: Prof. G. F. Fitzgerald, F.R.S.

SATURDAY, MARCH 22.

SOCIETY OF ARTS, at 3.—The Atmosphere: Prof. Vivian Lewes.

ROYAL BOTANIC SOCIETY, at 3.45.

ROYAL INSTITUTION, at 3.—Electricity and Magnetism: Right Hon. Lord Rayleigh, F.R.S.

MONDAY, MARCH 24.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—North American Trans-Continental Pathways, Old and New: Augustus Allen Hayes.

SOCIETY OF ARTS, at 8.—Some Considerations concerning Colour and Colouring: Prof. A. H. Church, F.R.S.

TUESDAY, MARCH 25.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—Exhibition of a Skull, dredged up on the Manchester Ship Canal Works: Isidore Spielman.—The Old British "Pibcorn," or "Hornpipe," and its Affinities: Henry Balfour.—The Ancient Peoples of Ireland and Scotland considered: Hector Maclean.

SOCIETY OF ARTS, at 8.—Engraving in Wood, Old and New: W. J. Linton.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Lough Erne Drainage: James Price, Jun. (Discussion.)—Barry Dock and Railway: John Robinson.

ROYAL INSTITUTION, at 3.—The Post-Darwinian Period: Prof. G. J. Romanes, F.R.S.

WEDNESDAY, MARCH 26.

GEOLOGICAL SOCIETY, at 8.—On a New Species of Cyphaspis from the Carboniferous Rocks of Yorkshire: Miss Coignou. Communicated by Prof. T. McKenny Hughes, F.R.S.—On Composite Spherulites in Obsidian from Hot Springs near Little Lake, California: F. Rutley.—A Monograph of the Bryozoa (Polyzoa) of the Hunstanton Red Chalk; G. R. Vine. Communicated by Prof. P. Martin Duncan, F.R.S.—Evidence furnished by Quaternary Glacial-Epoch Morainic Deposits of Pennsylvania, U.S.A., for a Similar Mode of Formation of the Permian Breccias of Leicestershire and South Derbyshire: W. S. Gresley.

SOCIETY OF ARTS, at 8.—Carriage-Building and Street Traffic in England and France: G. N. Hooper.

THURSDAY, MARCH 27.

ROYAL SOCIETY, at 4.30.—The following papers will *probably* be read:—On Black Soap-films: Profs. Reinold and Rücker, F.R.S.—The Variability of the Temperature of the British Isles, 1869–83 inclusive: R. H. Scott, F.R.S.—Preliminary Note on Supplementary Magnetic Surveys of Special Districts in the British Isles: Profs. Rücker and Thorpe, F.R.S.—The Rupture of Steel by Longitudinal Stress: C. A. Carus-Wilson.—Measurements of the Amount of Oil necessary in order to check the Motion of Camphor upon Water: Lord Rayleigh, Sec. R.S.—On the Stability of a Rotating Spheroid of Perfect Liquid: G. H. Bryan.—A Determination of v, the Ratio of the Electromagnetic Unit of Electricity to the Electrostatic Unit: Prof. J. J. Thomson, F.R.S., and G. F. C. Searle.

CHEMICAL SOCIETY, at 4.—Anniversary Meeting.—Election of Office-Bearers and Council.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.

ROYAL INSTITUTION, at 3.—The Early Development of the Forms of Instrumental Music (with Musical Illustrations): Frederick Niecks.

FRIDAY, MARCH 28.

INSTITUTION OF CIVIL ENGINEERS, at 7.30.—Deflection of Spiral Springs: Alfred E. Young.

ROYAL INSTITUTION, at 9.—Foam: Right Hon. Lord Rayleigh, F.R.S.

SATURDAY, MARCH 29.

SOCIETY OF ARTS, at 3.—The Atmosphere: Prof. Vivian Lewes.

ROYAL INSTITUTION, at 3.—Electricity and Magnetism: Right Hon. Lord Rayleigh, F.R.S.

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