THURSDAY, FEBRUARY 5, 1891.

THE BIRDS OF NORFOLK.

The Birds of Norfolk, with Remarks on their Habits, Migration, and Local Distribution. By Henry Stevenson, F.L.S. Continued by Thomas Southwell, F.Z.S. In 3 Vols. (Norwich and London: Gurney and Jackson, 1866-90.)

PRIMACY among all works of its kind has everywhere been accorded to the late Mr. Stevenson's "Birds of Norfolk," from the appearance of its first volume so long ago as 1866. The second, which came out in 1870, surpassed its predecessor in subjects of interest and happy treatment, so that great dismay naturally fell upon ornithologists when they came to learn about 1877 that the author's health had given way, and that, though considerable advance had been made in the third volume, the prospect of the work being completed was imperilled. So matters remained until 1888, when his eyes were closed in death. Thanks to Mr. Southwell, the anticipated danger has been avoided. To him Mr. Stevenson's papers were intrusted, and so admirably have they been used, that but for the narrow "leads" of the continuation, and the constant reference to Mr. Stevenson's own notes, one could hardly detect the change of hand, for that of the continuator is just like that of the original, "only more so"—by which Americanism we mean to imply that the good qualities which especially distinguished the two earlier volumes of "The Birds of Norfolk" from other county ornithologies are intensified in that which ends the work.

What these good qualities are may need some setting forth; but first is the command of his subject shown by each of these gentlemen. Too often it has been our lot, on taking up books of this kind, to find that whenever they depart from the mere catalogue the writer has a tendency to "slop over"—which tendency he generally obeys, and we are indulged consequently in matters which had far better be left to works which have not so limited a scope. It would be easy to name a local ornithology in which the author thought it expedient to include a somewhat elaborate description of each species mentioned—the descriptions being compiled from the standard authority on British birds; while others profess to give a list of the whole British avifauna, leaving the species not found in the particular district to which the book relates without comment, and their less educated readers in bewilderment. Or, again, an author may fill his book with figures that rather caricature than represent the subjects of which he is writing. Mr. Stevenson and his follower have been far wiser. They take for granted that most of their readers will know or be able to find out what the species treated of are like, and they occupy the space thus saved with information much more to the point, and therefore of greater value. It may be said, and truly enough, that Norfolk is an exceptional county. It is not only proud of its birds and of its ornithologists, but it has two Museums that do it credit, and to journey either to Norwich or King's Lynn is no great pilgrimage for any man or woman within its bounds to perform once a year or oftener. As regards local treasures, the Norwich Museum stands probably first in Europe, certainly we have none like it elsewhere in Britain, for they consist in great part not merely of adventitious strangers from afar that have had the ill luck to be immolated on arrival in this inhospitable land (though of these there is good store), but of native examples of species which in old times inhabited the county, though long since driven hence by agricultural operations and the like. It is local specimens of this kind which are of real and not fanciful worth, though the ordinary "collector" almost always overlooks the difference. In the present work it is made very plain to those who know how to read and can appreciate the carefully-written histories given by Mr. Stevenson and Mr. Southwell of species after species which once dwelt in Norfolk, or even yet occur there though in greatly reduced numbers. These histories are often fascinating, and always have an interest which no information subsequently collected is likely to lessen, for in the first place such information is chiefly traditional, so that some portion of it is lost with the death of every ancient inhabitant; and, though much has been saved by the inquiries and exertions of Mr. Stevenson and his friends, there is no doubt that much more would have been obtained had similar efforts been set on foot earlier. The extinction, as regards Norfolk, of several species which has taken place within the lifetime of men who yet survive is still very imperfectly understood, though there is a notable exception in the case of the Bustard; but this bird from its grandeur and certain other qualities attracted unusual attention, at least in East Anglia, though not enough in other parts of England to enable anyone to give the details of its extirpation in such a way as they are given by the authors of this work. One would fain hope that the process of extermination has ceased, but that we believe cannot be, though it is plain, from much that is stated in the third and concluding volume of "The Birds of Norfolk," which we, in our present remarks, have in especial view, that it has been salutarily checked. In the excellent account of the Great Crested Grebe—or Loon, to use its common Norfolk name—which Mr. Stevenson wrote some thirty years ago, the extinction of that fine species was shown to be almost imminent, and certainly there was sufficient ground for entertaining the gloomy anticipations which therein will be found. But a few years after that time, the first of the several Bird Preservation Acts, which the Legislature was induced to pass under the influence brought to bear by the Close Time Committee of the British Association, came into operation; and this species, the ornament of so many of the meres and broad waters of Norfolk, was saved, as Mr. Southwell is able joyfully to record in his picturesque continuation of Mr. Stevenson's mournful history. The Loon has even reappeared, he says, in some of the localities from which it had long ago been shot down—to make ladies' muffs, be it remembered. But this is not the only success of the Acts which he recounts. He does not hesitate to ascribe to recent legislation the establishment or re-establishment as regular and numerous breeders in the county of no fewer than four species of Duck, three of them at least being among those which are most highly esteemed for the table. Yet something is still wanting. All frequenters of the wilder and more desolate parts of our coasts in summer-time know the rapture inspired by the sight of a company of Sea-Swallows or Terns as they pass along the shore with their graceful, dancing flight. Not so very long ago this delightful spectacle might be witnessed in numerous places, and there were many spots to which the observer might be led where he could, if so minded, be entertained for hours by watching their aërial evolutions, for these were the chosen homes of these beautiful and wholly harmless creatures. There, on secluded sand-hills, among the campion or the marram, could be found their nests, with the variously tinted and spotted eggs or the mottled down-clad young; while on the bare shingle itself might be discovered by the trained eye the slight hollow containing the progeny of the smallest and most delicate species of the genus. In days anterior to the Close Time Acts these spots were commonly the scene of useless and brutal outrage on the part of the gun-bearing miscreant; and even now it is evident that their sequestered position tempts the person who miscalls himself a naturalist, but is generally a trafficker in "plumes," to deeds of blood which he would be ashamed to own in decent society. There is at present scarcely any kind of native bird that needs protection more strongly than the confiding Tern and all his kind. Its home is on the shore, which is free to all men—be they honest or murderers—and it enjoys none of the protection which the law of trespass affords to birds which nest on land belonging to some definite proprietor. It is plain, from the caution Mr. Southwell shows in not naming localities, that he believes, and we think with reason, the prolonged existence of Terns on the Norfolk coast to be perilous in the extreme. For ourselves, we cannot see why it should be in the power of any man—be he a blackguard or only a blockhead—to deprive his fellow-men of one of the most delicious sights of the sea-coast, simply because, by the common law of England, the foreshores are the property of the Crown, and he chooses to desecrate them for his own selfish purpose.

Those who study this volume will, however, find in it much more than has been indicated by the preceding remarks. The portions relating to Swans will prove good reading to persons of many tastes. The Swans of Norfolk, if not so widely known as its Turkeys, deserve as much celebrity, as those will admit who have eaten a fatted Cygnet from the St. Helen's Swan-pit—the only Swan-pit, we believe, in England now in working order. Here we have a good description of it, and, more than that, an account of Swan-upping (*i.e.* the taking up of the young Swans) on the Yare—a very much larger affair than that which attracts Londoners to the yearly Swan-upping on the Thames; while the curious subject of Swan-marks, which has so many charms for the antiquary, is duly if not exhaustively treated. Of more strictly ornithological interest, there is a valuable dissertation, by Mr. Stevenson, on that mysterious entity, the so-called "Polish Swan"—a subject on which Mr. Southwell was already a chief authority, as he was on that of decoys. The treatment of this last topic falling to his lot, he naturally refers his readers to his own papers—in the second edition of Lubbock's "Fauna of Norfolk," and in the second volume of the Transactions of the Norfolk and Norwich Naturalists' Society—for the many particulars which it would have been useless here to repeat.

An opinion has obtained among writers of local faunas that it is advantageous to draw up what they are pleased to designate a "strong list"—meaning thereby to enrol as many species in their work as by any excuse, and a liberal extension of the rules of evidence, they could possibly include. Our present authors have gone upon the very opposite plan, and assuredly it is the right one. Instead of welcoming on the slightest testimony every report of the appearance of a misguided straggler, these naturalists of Norfolk have not only required proof positive of the fact, but that its occurrence should be free from the taint of human complicity. Consequently, the list of so-called Norfolk birds has again and again been weeded of all weak members, and whatever be its number, which we have been no more careful to count than has Mr. Southwell, it is obviously to be accepted without hesitation; even stragglers from the Alps or the Antilles, like the Wall-Creeper and the Capped Petrel—the latter being of more general than special interest—since, after the researches of Mr. Ober and Colonel Feilden, at its ancient homes in Dominica and Guadeloupe, there cannot be much doubt that it must belong to the category of extinct species like the Great Auk, the Labrador Duck, the Phillip-Island Nestor, and many others—while the former will always be remembered for the share which Gilbert White, of happy memory, took in certifying its first occurrence in England nearly one hundred years ago, and a *fac-simile* of the drawing of two of its feathers sent to him by Robert Marsham is here given.

We must not conclude our review without mentioning that this third volume of Mr. Stevenson's work contains three beautiful plates by that unrivalled zoological artist, Mr. Wolf, whose labours have now, alas! practically ceased, and these plates are enough to give the book an especial value. That representing the "Gullery" at Scoulton is a picture on which lovers of Nature will for ever fondly dwell. Clever sketches of similar scenes have before appeared; but nothing of the kind approaching the accuracy, or what is called "feeling," has hitherto been published.

The reviewer's grumble, after all this praise, must be finally stated. This work has three faults. It wants a map, showing the localities mentioned and indicating the natural districts of the county, so well described in Mr. Stevenson's introduction, and an index of the local names of the birds; but worse than all, and absolutely destructive to its existence, the third volume is bound with *wire*—wherefore let all buyers of it take warning, and get it out of its case as speedily as possible to save pages so well worth preserving from the effects of corrosion.

SCIENCE WITHOUT TEARS.

The Threshold of Science. By C. R. Alder Wright, D.Sc., F.R.S. (London: C. Griffin and Co., 1890.)

IT was hardly to be expected that a chemist of such scientific distinction as Dr. Alder Wright would undertake to produce a new edition of a well-known popular work entitled "The Magic of Science," which was intended to amuse rather than to instruct its readers. It s therefore not surprising to find that, instead of preparing a new edition of this work, Dr. Wright has compiled the present volume. It represents a compromise between an ordinary text-book written to instruct and a play-book written to amuse. Like most compromises of the kind it is unsatisfactory. It attempts an impossible combination, which fails to satisfy perfectly either those who wish to learn or those who want to play. Dr. Wright refers in his preface to the change in the school curriculum that has occurred during the last thirty years through the introduction of physical science, and he is in sympathy with those who are anxious to arrange a course of instruction suitable for the mental education of boys and girls, most of whom may not become physicists or chemists, or indeed follow any profession in which physical science has a special application. Dr. Wright quotes with approval a part of the second Report of the British Association Committee on Teaching Chemistry, in which stress is laid on the importance of teaching children the science of common things instead of trying to make them learn systematic chemistry and physics. He thinks that this book, which he has named "The Threshold of Science," will to some extent furnish such a course of instruction, while at the same time it will serve to amuse its readers.

"The object is to provide a kind of 'play-book,' which, in addition to affording the means of amusement, shall also to some extent tend in the direction of that course of mental education advocated by the British Association Committee; so that, whilst the juvenile philosopher finds pastime and entertainment in constructing simple apparatus and preparing elementary experiments, he may at the same time be led to observe correctly what happens, to draw inferences, and make deductions therefrom."

While there is no doubt some truth in this statement, as we shall have occasion to point out later, yet it must be clearly understood that this book is not suitable for use in schools. In certain cases it may serve in leisure time as a useful supplement to the systematic instruction of the school, particularly by arousing interest in experimental work, but it can never in any case form a substitute for it. The fatal objection to the book from the educational stand-point is the want of method in its arrangement. Dr. Wright tells us that "not being written with a view to aid in 'preparing for examinations,' nor in accordance with any particular syllabus of requirements, the subject-matter is not arranged in any specially methodical order." The experiments often have no logical connection with each other, and the explanations given of them are frequently so meagre that their educational value is extremely small. The book (of 390 pages) is divided into nine sections, which nominally relate to the "States of Matter," "Physical Changes of State due to Heat and Pressure and not accompanied by Chemical Action," "Changes of State due to Solution not accompanied by Chemical Action," "Solution and Separation from Solution by Actions involving Chemical Changes," "Chemical Actions producing Change of State without the Employment of Solvents," "Physical Adhesion and Allied Phenomena of Surface Action," "Effects of Heat upon Bodies, other than Change of State and Production of Chemical Action," "Radiant Action—Visible Light," "Radiant Action—Invisible Light." Under these sections are described a variety of experiments, many of them quite popular in the sense that while they are easy to make if the directions given are closely followed, it is impossible for a boy who knows no chemistry or physics to fully comprehend the nature of the changes that have taken place. For example, Experiment 13 (in all 404 experiments are described) enables a boy "to produce a gas smelling like rotten eggs by double decomposition." Iron sulphide is decomposed by hydrochloric acid. Anyone will be able to produce the gas, but if he is ignorant of chemistry he will not be much wiser for the information "that double decomposition will take place, resulting in the evolution of the gas hydrogen sulphide whilst the complementary product iron chloride will remain in solution." If physical science is to serve the purpose of an educational instrument, the principal object of making experiments should be to discover facts and verify suppositions. It is only when the learners are put, as far as possible, in the attitude of discoverers that the scientific method of reasoning is acquired. In schools, at all events, there should be no indiscriminate and haphazard experimenting.

The unmethodical character of the book, which unfits it for scholastic purposes, might seem to recommend it as a play-book. But its style is far too didactic for such a purpose, and some of the experiments are too difficult, others too costly, or for various reasons unsuitable. It would be decidedly unsafe to allow boys, unfamiliar with chemistry, to perform many of the experiments described in this book except under competent supervision, the necessity for which is, however, not alluded to. Experiments with hydrogen sulphide, chlorine, bromine, cyanogen, and other poisonous substances, should be excluded from a book which may be used by irresponsible boys who have previously received no chemical instruction and who are bent on amusement or mischief. The production of luminous writing on a wall by means of a stick of phosphorus "held by a towel or pair of tongs" is an operation by no means to be generally recommended, any more than are other experiments with phosphorus—the smearing of the face and hands with a solution of phosphorus in oil, the manufacture of "Fenian fire," a name given to its solution in carbon disulphide—all of which are attended with considerable danger to the inexperienced. The highly ingenious device for setting a "pond or bucket of water on fire," by means of potassium and ether contained in a jar which is plunged into the water, is another operation not free from danger in unskilled hands. The preparation of dry ammonia gas, its collection over mercury, and the demonstration of its absorptibility by ice, are operations far too difficult for a beginner to perform by himself, even if the cost of the mercury were not a hindrance. The same may be said of many other experiments.

So much by way of criticism. It seemed necessary in the interests of science to insist that the book (for which a less ambiguous title might have been found) is unsuitable for schools, and in the interest of those who may use it as a play-book that some supervision and previous chemical knowledge are desirable.

For a boy who is receiving systematic instruction in physical science at school, and whose experimental performances at home can be to some extent supervised, the book is admirably adapted, and such a boy will find it a fascinating as well as an instructive holiday companion.

The volume, on which Dr. Wright has evidently bestowed great pains, contains an astonishing amount of useful and accurate information about common things, and the extreme ingenuity of many of the experiments deserves the highest praise. Teachers of elementary science will find in it much that is suggestive; and many of the experiments, sometimes slightly modified, might be profitably incorporated in a school course.

A work on the "Threshold of Science" in the educational sense of the phrase has yet to be written. The task is a difficult one, and very few men have the originality, knowledge, and scholastic experience which are alike necessary for its accomplishment. Owing to several circumstances, the value of instruction in the methods of acquiring "natural knowledge" has not been fully recognized in the school curriculum. It cannot be expected that much general progress will be made until teachers are provided with a book of this kind adapted for use in public schools. WYNDHAM R. DUNSTAN.

THE ZOOLOGICAL RECORD FOR 1889.

The Zoological Record for 1889. Edited by Frank E. Beddard. (London: Gurney and Jackson, 1890.)

THIS, the twenty-sixth volume of the "Record of Zoological Literature," is published by the Zoological Society of London, and we have to congratulate the Secretary and Editor on the volume having been published well within the year 1890, the literature of which it treats belonging to the year 1889. Possibly this welcome acceleration in publication may be in some measure due to the freshness of the recorders, to whom we would, however, venture to suggest that work of this nature, the value of which depends so greatly upon its accuracy, may be too hastily done. We are too thankful for what we have received to be in a fault-finding mood; yet a very superficial glance over this volume reveals some evidence of a want of care which it would be right, and we think easy, to avoid.

Some changes have taken place in the recorders, the work done last year by Mr. W. E. Hoyle being divided, Mr. P. C. Mitchell taking the Mollusca, Mr. O. H. Latter taking the Brachiopoda and Polyzoa, and Mr. S. J. Hickson the Cœlenterata.

The record of "General Subjects," compiled by Mr. J. A. Thomson, is a feature added to the programme, as carried out under Dr. Günther and the Zoological Record Association, and to a certain extent it supplies a deficiency, nor could it be in better hands than those of the present recorder; but, in order that there shall be as little as possible of duplicate references in the volume, the Editor-in-chief should keep a watchful eye that works that are of right treated of under the special subjects are not unnecessarily referred to here. Thus we think, for an example, that Ecker's "Anatomy of the Frog" need not have been quoted twice, under text-books in the "General Subjects," and under Ecaudata in the record of Reptilia and Batrachia; nor need Mr. A. G. Butler's paper on "Insects supposed to be distasteful to Birds" have been quoted in full three times (General Subjects, Aves, and Insecta), and there are very numerous instances like this. Such records serve little other purpose than to test the powers of the recorders. The "Record" is not a subject catalogue.

A more serious objection may be taken to the departure from uniformity in the arrangement of the memoirs in the record of the Reptiles and Batrachians, and of the Fishes, where, instead of the authors' names being arranged alphabetically, they are printed as they turned up in the recorders' notes; perhaps, as a very trifling blemish, may be mentioned the occurrence of the footnote indicating that the recorder had not seen the work indicated by an asterisk, which notice is not always attached to each record, and in some cases it is attached when not needed. The record of Insecta is a wonderful piece of work, with its 849 references in chief. Here, too, the most useful method of numbering all the papers is adopted, so that a reference is found with a minimum of trouble.

The index to genera recorded as new in this volume is most unfortunately incomplete; by some oversight the whole of the new genera to be met with among the Cœlenterata have been omitted. It may be also noted that the new forms described among the Alcyonaria in the "Narrative of the Cruise of the *Challenger*" have never as yet been alluded to. There was not a column for "Travels and Faunistic" in the volume for 1885, the year in which the "Narrative" was published, and probably the fact that new genera and species of Alcyonaria were described in it escaped the notice of the then recorder of the group; but they were also unnoticed in the "Record" for 1887; and in the volume now under notice they are again passed by, so that no trace of such remarkable genera as Callozostron, Strophogorgia, &c., will be found in the whole series of records.

We have called attention to these defects, as they may be easily rectified in future volumes, and because we think they are of such a nature that the avoidance of them for the future lies in the hands of the Editor. As suggestions, we might add that it is very desirable that, when possible, short but characteristic diagnoses of all the new genera should be given; of course, when these are founded for well-known species, the mere indication of this would suffice, but it would save many a weary search in out-of-the-way journals if such diagnoses of new genera —as, for example, we find in Mr. Hickson's record of the Cœlenterata—were always given, and this used to be the general practice.

OUR BOOK SHELF.

Reports on the Mining Industry in New Zealand. Pp. 209. (Wellington: George Didsbury, Government Printer, 1890.)

THIS volume of reports from the Minister of Mines on the production and condition of mining enterprise in 1889, to both Houses of the General Assembly in New Zealand, is a continuation of similar reports which we have noticed in previous years. As regards the principal items of production there appears to have been a slight increase in gold—203,211 ounces valued at £808,549, against 201,219 ounces and £801,066 in 1888; but the coal raised has diminished by nearly 10 per cent., or from 613,895 tons to 586,445 tons; Kauri gum, which is next in value to gold among the totals, has also diminished from 8482 tons and £380,933 value to 7519 tons worth £329,590. The final result is that the value of minerals raised was £1,493,167 in 1889, or a little less than in 1888, when it was £1,531,614. In addition to the native supply, 128,000 tons of coal are imported, mainly from New South Wales; but about 80,000 tons are exported, 47,115 tons of which are returned as going to the United Kingdom. It is not, however, shown what the latter quantity is, whether it is a special gas coal or merely coal taken by steamers for English ports.

The detailed reports from the different districts contain some matters of general interest, among which may be noticed the use of dredgers for raising auriferous drift from the beds of rivers, which has been successfully carried out by the Waipapa Company on an ocean beach by a Welman centrifugal-pump dredger, about £300 worth of gold per week being saved from sand and gravel, yielding about 3 grains or sixpence in value per ton. This dredger is not suitable for lifting coarse material, and where the stuff contains stones above 3 inches across, the ordinary bucket and ladder system is found to be more advantageous. Among the reducing processes noticed, that of Messrs. Macarthur and Forest, for dissolving out gold and silver by a weak solution of an alkaline cyanide and precipitating by filtering the liquors through granulated zinc, is the greatest novelty. This is described in several places, both under its own name and as the Cassel process, as it has been taken up by the Cassel Company of Glasgow in place of the original, but defunct process of Cassel for chlorinating gold ores by the electrolysis of common salt.

Astronomical Lessons. By John Ellard Gore. (London: Sutton, Drowley, and Co., 1890.)

WE greet with pleasure all works that have for their object the exposition of the principles and facts of astronomy, for this is the science which, perhaps above all others, is pursued for its own sake, and the end of the study of which is knowledge, pure and simple. It is especially satisfactory to meet with works of this character when written by practical men, hence we view with gratification the little book before us. All astronomers are acquainted with Mr. Gore's astronomical labours, and to them the productions of his pen need no recommendation. As might be supposed, the best chapters are on "Double and Binary Stars" and "Variable Stars." Other chapters deal with the figure and motions of the earth, the sun, and planets, and the measurement of time. We note that Mr. Gore, while asserting that the nebulæ are probably masses of glowing gas, does not put forward the now exploded notion that nitrogen is one of the main constituents.

The book may well be said to be an easy introduction to larger and more advanced works on astronomy, and a useful guide to beginners in the study of this fascinating science.

Soap-Bubbles. By C. V. Boys, F.R.S. "Romance of Science Series." (London: Society for Promoting Christian Knowledge, 1890.)

EVERYONE who has attended lectures delivered by Mr. Boys must have been struck by his ingenuity and zeal in designing and performing experiments illustrative of the subject he has under consideration. The present little work consists of a course of three lectures he delivered to a juvenile audience at the London Institution, and the subject dealt with is one in connection with which a great number of experiments can be performed. The author's idea throughout has been, not to display a large number of hard experiments, but to perform, by means of the simplest apparatus (in many cases only a few pieces of glass, india-rubber tubing, and other simple things readily obtained), interesting and instructive experiments that may be easily repeated by young people with a little care and patience. In order to facilitate the repetition of most of them, he has added some practical hints at the end of the volume, by the careful perusal of which the reader will be fully rewarded. It is unnecessary to allude to the special points touched on in the course of these lectures: suffice it to say that the book is written in simple and clear language, and illustrated with a set of excellent woodcuts. We may note that the figure placed at the end can be easily converted into a thaumatrope for showing the formation and oscillations of drops. If the disk, made to rotate, be held up to a looking-glass, the drop will first appear to form; it then gradually increases in bulk, changing its form all the time; at a particular stage a waist is formed, which grows narrower and narrower until the drop falls. The trouble of mounting the illustration in the specified way will be amply repaid by the interesting phenomena mentioned above.

The Canary Islands. By John Whitford, F.R.G.S. (London: Edward Stanford, 1890.)

IN this little book Mr. Whitford records the impressions produced upon him during a tour in the Canary Islands. He has chapters on Grand Canary, Tenerife, La Palma, Gomera, Hierro, Lanzarote, and Fuerteventura; and as he writes clearly, and displays a considerable power of observation, the volume should be of interest even to readers who do not themselves propose to undertake a like journey. In his travels the author always had his camera with him, and some of the results are seen in the pleasant woodcuts with which his descriptions are illustrated.

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.*]

A Remarkable Ice-Storm.

IN March 1884 I wrote to you in regard to a heavy ice-storm which we had experienced on the 7th and 8th days of that month, giving some statistics as to the thickness of the ice deposits on trees and as to the weight which the extremities of branches were carrying. I can now report to you a more remarkable storm of the same kind, the effects of which still continue more than sixty hours after the storm has ceased; and there seems to be little hope that the morrow will give us an unclouded sun to loosen the casing under which the trees are labouring.

Before sunrise on the 17th instant, a light snow began, with the wind blowing gently from the north; the storm soon changed to a fine hail, which prevailed throughout the day, and by sunset had covered the ground to the depth of some two inches; then followed a rather heavy rain, the thermometer standing not far from the freezing-point. The rain ceased for a while about eight o'clock, and I found that the amount of precipitation reduced to water was 1·25 inches. Before midnight the rain began to fall again, and the ice formed rapidly on trees, fences, wires, and everything that could hold a drop of water for an instant. The amount of rain in the night, augmented by a little drizzle and a light snow on the following day, was 0·67 inch, making the total precipitation during the entire storm 1·92 inches. In the morning the appearance of everything out of doors needed but bright sunlight to make it beautiful in the extreme, except for the feeling that many trees were maimed or ruined, and that the wires on which the community depends for light and for telegraphic and telephonic communication were in a state of dire confusion. But I can best convey an idea of the effects of the storm by giving the results of some measurements which I made on our College campus.

The fence at the north side of the campus was decorated with icicles about eight inches long; the trees were covered with ice, coating every twig and hanging in icicles, which were formed of course nearly vertically, but which, as the trees bent under the increasing weight of the ice, stood out like fringes in every direction. One English elm, fifteen feet high, touched the ground with its topmost branches; its stem, 1·6 inches in diameter, carried 0·65 of an inch of ice on its most exposed side; the stem of another tree, having a diameter of 1·4 inches, carried 0·60 inch of ice. Twigs at the extremity of the branches of more spreading elms carried enormous loads of ice. One twig having a diameter of 0·07 inch was increased by the ice to 1·12 inches; another of the same diameter was increased to 1·26 inches; and one of 0·09 inch diameter was made 1·32 inches; that is to say, these twigs were carrying respectively fifteen, seventeen, and fourteen times their thickness of ice. Two connected twigs, taken from one of these trees, about sixteen inches long and weighing by themselves less than half an ounce, carried a little over a pound of ice; that is, they supported about thirty-five times their own weight. A few frail stems of weeds standing up from the ground carried relatively still larger amounts of ice. One which had a diameter of 0·05 inch had become increased to 1 inch, or by nineteen times its size; and one of 0·07 inch measured 1·23 inches, showing a gain of about seventeen times its size; and a bush-like weed, which weighed about a quarter of an ounce, was supporting eleven and a half ounces of ice.

When the ice had been on the trees for more than thirty hours, and there may have been a little melting, I made two additional observations as to the weight of the ice. On one twig of an elm-tree, itself weighing a decided fraction less than three-quarters of an ounce, there was found to be ice weighing over twenty-eight ounces; and on another, having a weight of three-eighths of an ounce, there was ice weighing more than nineteen ounces and a half; that is to say, in the one case the extremity of a branch was carrying at least forty times its own weight, and in the other case fifty-two times its own weight of frozen water.

The most beautiful piece of ice work on the College grounds was shown by a wire net running east and west, and placed for a guard at the end of a tennis court on the lower campus. The wire, of about 0·04 inch in diameter, was woven into hexagonal meshes, of which the horizontal sides were about an inch long, those inclined to them being longer. The wire was covered with ice to a thickness of about 1·06 inches; and from each of the horizontal sides hung an icicle curving slightly to the south, owing to the influence of the wind, and so standing free of the wire below, and attaining a length of 2½ or 3 inches. It was a wonderful specimen of the beauty of Nature's work.

The figures given above, compared with those recorded in March 1884, show that this has been a heavier storm than the former. In that case the largest proportional measurement of ice upon the twig of a tree gave an increase of but nine times the original diameter, and the largest amount of ice which I found on an upright weed-stalk was about twenty times its own diameter, while the weight of ice attached to ten ounces of twigs from a tree was less than seventy ounces. This storm, while it has recalled the lesser though remarkable ice-storm of March 1884, has also revived the memory of a storm of the same kind at Christmastide in 1855.

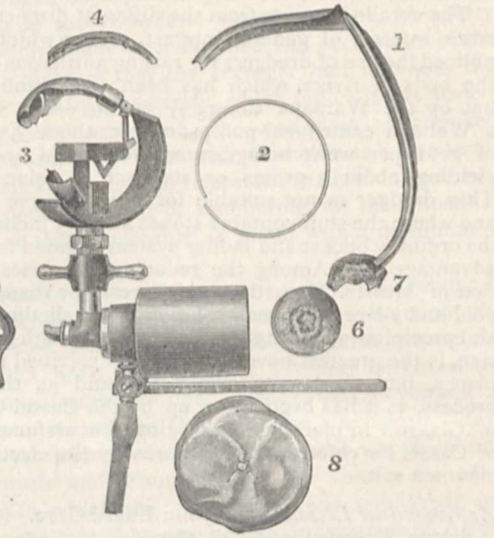
Perhaps I should add that, as the ice did not freeze on twigs, or stalks, or wires so that the cross-sections would be circular, the measurements made were those of the largest diameters in the several instances. SAMUEL HART.

Trinity College, Hartford, Connecticut, U.S.A., January 20.

The Bursting of a Pressure-Gauge.

AN accident caused by the bursting of a pressure-gauge attached to a compressed oxygen cylinder has recently come under my notice. As there are several points connected with it which may be of interest to those who use the oxyhydrogen light in their scientific work, I venture to send you a photograph of the remains of the apparatus, and a short description of the different parts.

The accident appears to have been brought about by the inside of the curved Bourdon tube giving way. The fusion of the metal being caused by the impact of the gas, about 35 cubic feet of oxygen escaped; the initial pressure was 115 atmospheres. The screw valve which formed part of the cylinder was fully open, so that the whole contents must have been discharged very quickly. The particles of metal which were shot out from the apparatus were found to be nearly quite spherical in shape; fragments of glass and metal fused together were also found. The metal seems to have been heated to fusion, in the same way as meteors are, by air-friction. For some time previous to the accident the gauge had been exposed to a far greater pressure than that at which it gave way. The stopcock and rubber tube leading to the jet were uninjured; from this it may be inferred that the hydrogen used in the jet, which was a blow-through one, had nothing to do with the bursting of the gauge. The injury done by the accident was, fortunately, not of a very



1, a part of the brass case, originally circular in shape. 2, the ring which held the dial in its place. 3. the pressure-gauge. The arc-shaped piece at the top is a part of the Bourdon tube; the inner curved surface is blown outwards; the outer surface is but little injured. 4, part of the cast-iron case of the instrument; this was driven edgewise into a pine plank to the depth of about a quarter of an inch. 5, the union nut for connecting the gauge and regulator to the cylinder. This is deeply cut away by fusion. 6, the disk of the regulator, partly fused. 7, a mass of fused brass found attached to the disk. 8, the dial. The gun-metal nose of the cylinder was fused away to the depth of three-eighths of an inch.

serious character, as the larger fragments missed the assistant. Some pieces of the case penetrated a plank to a considerable depth. A similar accident has recently taken place in the north of England, attended with very serious injury to the person using the apparatus. FREDERICK J. SMITH.

Trinity College, Oxford, January 15.

The Darkness of London Air.

LONDONERS need not be surprised to find black fogs when it is a fact that tons of soot float in the atmosphere every day. Hoping to get some *fact* on the subject, I collected a patch of snow, equal one square link, that had lain from November 27 to December 27 last, and from which I obtained two grains of soot. Now, supposing London to cover 110 square miles, it would produce 1000 tons of soot. Imagine a month's allowance being drawn off in a line by 1000 horses! The line would extend to about four miles in length. GEORGE WHITE.

7 Mildmay Grove, Canonbury, N.

A Swallow's Terrace.

AN explanation of the curious construction which I described in NATURE of November 27 (p. 80), has been suggested to me by Mr. Vernon Harcourt, in whose boat-house it was built. It is as singular as the construction itself, and, whether right or not, is probably worth the attention of naturalists.

Let me say beforehand that the "terrace" extends for nearly two feet along the beam at one end of which the nest is placed; that it consists of a layer of mud covered with dry grass; and that it is perfectly neat and finished throughout. No one who has seen it could possibly call it, as Mr. R. H. Read does in your issue of December 25 (p. 176), "an unusually straggling nest of the swallow." I entirely agree with Mr. Harcourt in believing it to have been built for some special and definite purpose.

Mr. Harcourt tells me that last summer the birds used to perch on two tie-beams which cross the boat-house just over his boat, and that their droppings made the boat in such a mess that he had the surface of both beams smeared with tar. Later on, the "terrace" was observed, occupying the surface of the beam alongside of the nest; but it did not strike Mr. Harcourt at the time that there could be any relation between this and the tarring.

The inference, however, is, that the definite object of the "terrace" was either to anticipate the tarring of that particular beam on which the young birds must necessarily perch as soon as they were able to leave the nest; or else to obliterate any traces of tar which they themselves may have left there after perching inadvertently on the tarred beams. In either case, if there is really any relation between the "terrace" and the tarring, it seems likely that the birds, having to meet an emergency, displayed a very unusual degree of reasoning power, and adapted means to end in a very ingenious way.

Oxford, January 29. W. WARDE FOWLER.

The Crowing of the Jungle Cock.

IN the letter in your last issue (p. 295), in which Mr. Forbes endeavours to controvert my statement with reference to the crowing of jungle fowl, his account is extremely vague and indefinite. He admits he did not secure the bird, and omits to name the species; he cannot say it was a pure-bred jungle fowl, and according to his account the voice was "considerably thinner in volume, more wiry, and higher pitched." I have no doubt that there are in Timor plenty of common fowls, and knowing how readily they will cross with the jungle fowl, I think it highly probable that Mr. Forbes may have heard the crow of a hybrid: hybrids are, in some places, as common and wild as the pure breed. Wild caught hybrids are frequently brought here and offered as pure-bred birds.

I have had from time to time in my keeping all the known species of the genus Gallus, and have bred from most, if not all of them, and have had ample opportunities of listening to their various calls and crowing frequently uttered during their breeding season, and I must say none of them can fairly be compared with the loud, fine, clear crow of our common barn-door cock.

A. D. BARTLETT.

Zoological Society's Gardens, Regent's Park,
London, N.W., February 2.

On the Flight of Oceanic Birds.

THE very interesting letter of Mr. David Wilson-Barker under the above title in NATURE of January 8 (p. 223) leads me to say that during a recent voyage to Ivigtut, Greenland, I very often observed in the flight of the Arctic tern the same use of wings and tail which Mr. Wilson-Barker saw in the flight of the sooty albatross. I further noticed that the terns very frequently made use of their feet in steering a course through the air.

It was a common thing for a tern to poise itself on a windy day directly above the taffrail, and hold that position, regardless of the speed of the vessel, for from eight to ten minutes, examining, the while, everything abaft the house, apparently with a critical eye. When satisfied with the inspection, it would with a quick motion lower one of its black-webbed feet down with the web across the line of flight. The effect of this was exactly like that of a ship's rudder. When the left foot was drooped, the bird turned to port; when the right, to starboard. If the foot were lowered but a trifle, as sometimes was done, the bird turned but slightly; when lowered straight down and spread wide out, the bird turned almost as if on a pivot.

When the bird was sailing beside the ship, a foot was sometimes used to correct the course, which had been altered apparently by a flaw or eddy in the wind caused by the sails. Of course, the wings and the tail were very often used in conjunction with the foot, but I never saw the foot used when the bird was flying by flapping its wings continually.

New York, January 21. JOHN R. SPEARS.

A Rare Visitor.

JUST before the recent thaw I observed a water-rail searching for food in my garden. It approached within a few yards of the house, and showed very little timidity. It reappeared on two subsequent days, and was also seen in adjacent gardens; but it finally left when the frost was completely gone.

It is so very unusual to be visited by so shy a bird that I have thought the incident worth recording as an indication of the severity of the recent frost.

My house is in the suburbs of Reading.

Craven Road, Reading, January 30. O. A. SHRUBSOLE.

The Erosive Action of Frost.

A SOMEWHAT striking illustration of the erosive action of frost was to be seen on a reservoir (North Wales Paper Company's) near here a few days ago. The reservoir—a fairly large one—is supplied by a stream entering at its upper end, and during the late severe frost was covered with ice to a thickness of about 8 inches, the ice being firmly attached to the mud and soil of the banks, especially in the narrower parts. With the thaw, about ten days ago, came a very heavy fall of rain, which resulted in the depth of water in the reservoir being raised some 2 feet. The sheet of ice then floating on this increased surface area tore away for long distances the adjacent mud and soil to which it was attached, and to such an extent that the contour of the banks at the narrower portion of the reservoir was completely reproduced by a band of soil from one to two feet wide fringing the sheet of ice, and upon which were growing many plants, grasses, &c. As the ice melted, this material would seriously assist the silting up of the reservoir, and no doubt similar action has taken place in other cases. H. T. M.

Flint, North Wales, January 31.

Skeleton of Brachycephalic Celt.

LAST November, whilst some excavations were going on in the back premises of a house in Albion Road, Dunstable, a human skeleton was lighted on, resting on the right side, with the right hand to the face, and the knees drawn up in a crouching manner.

It fortunately happened that the tenant of the house had, some time before, seen two contracted skeletons of Celts in my possession, and he saw that the skeleton newly uncovered was probably of the same class with mine. He therefore called upon me at once, and as I happened to be at Dunstable, I returned with him to the spot and superintended the recovery of the bones.

The grave was about 5 feet deep, dug into the chalk rock; the head of the skeleton was to the north-east; the grave was filled in with clean, white, small, chalk rubble containing a considerable number of non-human broken bones and a few teeth.

Close to the femora of the man, on the inferior side, were two horn-cores of *Bos longifrons*, each attached to part of the skull, and taken from different individuals. Near the horn-cores were two whitish oval pebbles about the size of a bantam's egg, and a small piece of Romano-British pottery. No flint implements or flakes were in the grave.

As the interment was in chalk rock, with the body covered with fragments of clean chalk, the bones when found were perfect in form to a remarkable degree. Of course, however, the remains were quite flat, with the skull crushed in and the lower jaw and most of the larger bones broken. On touching the maxillary bones, all the teeth dropped out. All the pieces of bone were brittle, and somewhat soft. After careful cleaning, drying, soaking in thin hot gelatine, and conjoining with shellac dissolved in spirit, it became possible for me to repair and replace nearly every bone—including all the vertebræ—in position.

Virtually the skeleton is perfect; no bones are missing, except one clavicle, a few of the small bones of the hands and feet, and the small terminal bones of the sacrum. Only one or two teeth are deficient. The skeleton represents a man of early middle life, and of considerable muscular strength; the height of the man when alive, as deduced from the femora, was 5 feet 7¾ inches.

Mr. A. Smith Woodward, of the British Museum, South Kensington, has kindly looked over and compared some of the small pieces of non-human bone and the teeth found in the grave covering; many of these he has determined as belonging to *Bos longifrons*, others to Equus, &c.

The two other Celtic skeletons mentioned at the beginning of this note were dug up by me in 1887, by permission of a farmer, from two ruined, round tumuli in a field on Dunstable Downs.

One is the crouching skeleton of a girl from 18 to 25 years of age; height when alive, 4 feet 11½ inches; interred on right side; in front of the girl were the fragmentary bones of a child under 5 years of age. Arranged round the body of the girl—one of the Bronze Age dolichocephali—were 158 chalky fossil Echini (86 of these were perfect, the remainder were broken examples), together with a stone muller, several scrapers, a few chevron-marked fragments of a British pot, and other articles.

The other skeleton is that of a boy or girl—one of the brachycephali—interred on the left side with knees drawn towards chin; age about 14 years; height when alive, 3 feet 7½ inches. A few flint flakes, and many fragments of British pottery were in the grave. Near the right hand was a nodule of iron pyrites.

Numerous bone fragments belonging to *Bos longifrons* were in the covering material of both the latter graves.

I have a femur, humerus, and a few other bones of a fourth Celt from the floor of a British hut on Blow's Downs, Dunstable; several flakes and a scraper were with the skeleton, together with a block of pyrites and a metatarsal bone of a horse. The human femur shows the height of the living individual to have been 5 feet 10 inches. I was not in time to secure all this skeleton; more than one-half, including the skull, was shovelled with chalk into a lime-kiln.

Towards the end of last month (January), whilst opening four presumed Saxon (English) graves on a hill at Chalton, near here, I noticed that one of the extended skeletons had but one leg; the left leg had been entirely removed at the hip during life, or before burial. I could see no difference in the condition of the two acetabula. I took a small corroded iron knife from the front of two of the skeletons just where a strap would be bound round the waist. Three bodies were interred with the head to the west, the fourth with the head to the north. I have preserved the femora, humeri, and skull of the last mentioned; the skull exhibits every tooth sound and perfect in both jaws.

Dunstable. WORTHINGTON G. SMITH.

TIDAL PREDICTION.[1]

AT most places in the North Atlantic the prediction of high and low water is fairly easy, because there is hardly any diurnal tide. This abnormality makes it sufficient to have a table of the mean fortnightly inequality in the height and interval after lunar transit, supplemented by tables of corrections for the declinations and parallaxes of the disturbing bodies. But when there is a large diurnal inequality, as is commonly the case in other seas, the heights and intervals, after the upper and lower lunar transits, are widely different; the two halves of each lunation differ much in their characters, and the season of the year has great influence. Thus simple tables, such as are applicable in the absence of diurnal tide, are of no avail.

The tidal information supplied by the Admiralty for such places consists of rough means of the rise and interval at spring and neap, modified by the important warning that the tide is affected by diurnal inequality. Information of this kind affords scarcely any indication of the time and height of high and low water on any given day, and must be almost useless.

This is the present state of affairs at many ports of some importance, but at others a specially constructed tide-table for each day of each year is published in advance. A special tide-table is clearly the best sort of information for the sailor, but the heavy expense of prediction and publication is rarely incurred except at ports of first-rate commercial importance.

There is not any arithmetical method in use of computing a special tide-table which does not involve much work and expense. The admirable tide-predicting instrument of the Indian Government renders the prediction comparatively cheap; yet the instrument can hardly be deemed available for the whole world, and the cost of publication is so considerable that the instrument cannot, or at least will not, be used for many ports at remote places. It is not impossible, too, that national pride may deter the naval authorities of other nations from sending to London for their predictions, although the instrument may be used on the payment of certain fees.

The object, then, of the paper was to show how a general tide-table, applicable for all time, may be given in such a form that anyone with an elementary knowledge of the *Nautical Almanac* may, in a few minutes, compute two or three tides for the days on which they are required. The tables are also to be such that a special tide-table for any year may be computed with comparatively little trouble.

Any tide-table necessarily depends on the tidal constants of the particular port for which it is designed, and it is supposed in the paper that the constants are given in the harmonic system, and are derived from the reduction of tidal observations.

The complete expression for the height of water at any time consists of a number of terms, each of which involves some or all of the mean longitudes of moon, sun, lunar and solar perigees; there are also certain corrections, depending on the longitude of the moon's node. The variability of the height of water depends principally on the mean longitudes of the moon and the sun, and to a subordinate degree on the longitude of lunar perigee and node, for the solar perigee is sensibly fixed. There are, therefore, two principal variables, and two subordinate ones. This statement suggests the construction of a table of double entry for the variability of tide due to the principal variables, and of correctional tables for the subordinate ones; and this is the plan developed in the paper.

The tide-table finally consists of the interval after moon's transit, and height of high and low water, together with corrections depending on the longitude of the moon's node and on her parallax, computed for every 20m. of moon's transit, and for about every ten days in the year. Each table serves for the two times of year at which the sun's longitude differs by 180°, and they may be used without interpolation.

It was hoped that less elaborate tables might have sufficed, but it appeared that, at a station with very large diurnal inequality, the changes during the lunation, and with the time of year, in the interval and height are so abrupt and so great, that short tables would give very inaccurate results, unless used with elaborate interpolations. It is out of the question to suppose that a ship's captain would or could carry out these interpolations, and it is therefore proposed to throw the whole of that work on to the computer of the table.

Such a paper as this is only complete when an example has been worked out to test the accuracy of the tidal prediction, and when rules for the arithmetical processes have been drawn up, forming a complete code of instructions to the computer.

The port of Aden was chosen for the example because its tides are more complex and apparently irregular than those of any other place which has been thoroughly treated.

The arithmetic of the example was long, and was rearranged many times. An ordinary computer is said to work best when he is ignorant of the meaning of his work, but in this kind of tentative work a satisfactory arrangement cannot be attained without a full comprehension of the reason of the method. The author was therefore fortunate in securing the enthusiastic assistance of Mr. J. W. F. Allnutt, and expressed his warm thanks for the laborious computations carried out. After computing fully half the original table, Mr. Allnutt made a comparison for the whole of 1889 of predictions made by the new tables with those of the Indian Government. Without going into the details of this comparison, it may be mentioned that the probable error of the discrepancy between the two tables was 9m. in time, and 1·2 inches

[1] Abstract of the Bakerian Lecture, delivered on January 29, by G. H. Darwin, F.R.S., Plumian Professor and Fellow of Trinity College, Cambridge.

in the height of high water; that there were reasons to expect some systematic difference between the two calculations, and that all the considerable errors of time fall on those very small rises of water which are of frequent occurrence at Aden.

Two other comparisons were also made, one with the Indian predictions of 1887, and the other with actuality of 1884. In the latter case, when a few very small tides were omitted, the probable error was 7m. in the time, and 1·4 inches in height. It is concluded from these comparisons that, with good values for the tidal constants, the tables lead to excellent predictions, even better than are required for nautical purposes.

It is probable that this method may be applied to ports of second-rate importance, where there are not sufficient data for very accurate determination of the tidal constants. Suggestions are made for very large abridgment of the tables in such cases, accompanied, of course, by loss of accuracy.

The question of how far to go in each case must depend on a variety of circumstances. The most important consideration is likely to be the amount of money which can be expended on computation and printing; and after this will come the trustworthiness of the tidal constants, and the degree of desirability of an accurate tide-table. The aim of the paper was to give the tables in a simple form, and if, as seems certain, the mathematical capacity of an ordinary ship's captain will suffice for the use of the tables, whether in full or abridged, the principal object in view has been attained.

THEORY OF FUNCTIONS.[1]

I.

THE papers in Herr Schwarz's "Gesammelte Abhandlungen" range over a wide field. But varied as the subject-matter of the papers is, most of them have an internal connection which lies in profound study of the theory of functions.

Herr Schwarz is a pupil of Weierstrass, but he has been greatly influenced by the writings of Riemann. Both these eminent mathematicians have developed a theory of functions. Whilst Weierstrass starts in all his investigations with analytical expressions and operations, Riemann, following methods borrowed from the theory of potential, bases his theory on certain partial differential equations which express fundamental properties of functions, and by developing general properties of all functions tries to replace calculation by reasoning. Both applied their theories to the Abelian functions, and here Riemann's investigations proved to be more general. His speculations are, however, of such generality, that objections were raised by Kronecker and Weierstrass, as to the validity of his reasoning, and thus it became doubtful whether his most important theorems were actually proved.

In consequence, various mathematicians have attempted to place Riemann's theorems on a more satisfactory basis, to graft Riemann's far-reaching speculations on the more strongly-rooted methods of Weierstrass. These attempts were made, by Neumann and others, in connection with the theory of potential, whilst other mathematicians used purely analytical investigations. Among the latter, Schwarz stands out most prominently, and those of his papers which relate to this subject seem to me to deserve most attention.

As the subject in its great generality and abstractness has received little attention in England, it seems desirable to give an outline of Riemann's theory in order to be the better able to appreciate Schwarz's papers. The notion of a function, originally equivalent to that of a power, was gradually extended till Bernoulli gave a first definition, which was made more concise by Leibnitz. According to them, y is called a function of x if there exists an equation between these variables which makes it possible to calculate y for any given values of x for all (real) values of x from $-\infty$ to $+\infty$. This last condition excludes series which are convergent only for certain values of x. The functions here included will be essentially those which are given by an equation involving a finite number of algebraical, trigonometrical, and logarithmic or exponential terms. Such a function will, as a rule, be continuous—practically the only exceptions being infinite values of y—and it will have a derived function. In fact, these two properties, continuity and existence of a derived function, were considered as identical. Such a function is geometrically represented by a curve, x and y being taken as Cartesian co-ordinates of a point. But not every curve can be taken as representing a function.

The next step forward is chiefly due to the work of Fourier. Physical problems required the study of functions with new characteristics. The initial temperature of a rod, lying in the axis of x, may be supposed arbitrarily given, not for all values of x, but only for those which lie within the interval covered by the rod, and in the trigonometrical series means were found for expressing this arbitrarily given temperature in terms of x. This led Dirichlet to the new definition: y is called a function of x if the values of y are *arbitrarily given*, say by a curve, for all values of x *within a given interval*. This involves a deviation from Bernoulli's definition in two directions: the function is originally not given by a mathematical expression, and not for all values of x; in fact, it exists only as far as it is given. The *expression*, by Fourier's series, is not wanted for the definition of the function; it is needed in order to make the latter amenable to mathematical treatment.

The study of functions thus defined leads to new ideas of possible discontinuities. The curve representing the function may have sharp bends, may even have sudden breaks, the value of y suddenly changing from one value to another, different by a finite quantity. At such points we cannot any longer speak of a derived function, though the expression by Fourier's series is still existing. Further investigations in this direction have clearly established the fact that the existence of a derived function is not at all a necessary consequence of the continuity of the function itself. In connection with this it may be mentioned that Riemann has given a first example of a function which is defined by a process of calculating y from x, such that for every value of x there exists a value of y which has within a finite interval an infinite number of discontinuities, and which therefore has no derived function, though it has an integral. Schwarz gives, in one of his papers, an example of a function which, though continuous, has no derived function.

A much greater revolution in the ideas about function was produced by the introduction of imaginary values of the variables. Cauchy defines, in conformity with the second of the above definitions, that $w = u + iv$ is a function of $z = x + iy$ if for each set of values xy the corresponding values of u and v are given. Here a geometrical representation of the variables becomes very useful, if not absolutely necessary, viz. the variable z is represented by that point z in a plane which has the rectangular co-ordinates x, y; and w by that point in another plane which has the rectangular co-ordinates u, v. This enables us to make use of geometrical conceptions, and thus to become more concise in our language. We shall speak of the value z and of the point z representing this value as equivalent, the one completely determining the other.

If we start with a given value z_0 of z, and vary the latter, then the point z will move from the position z_0,

[1] "Gesammelte Abhandlungen." Von H. A. Schwarz. Two Volumes. Berlin: Julius Springer, 1890.)

describing any curve. To this value z_0 will correspond a value w_0 of w. If z is varied, w will also vary. Let us give z a small change dz; then the point z will move to a point z infinitely near to z_0. If now the corresponding change dw of w is infinitely small of the same order as dz, then the function w will be continuous. To fix the change dz we need not only know its magnitude, but also its direction. A change in either will alter dw, and therefore also the ratio dw/dz. The limiting value of this fraction, obtained by making the magnitude of dz disappear, will thus depend on the direction of dz, and not on the value z_0 only. In other words dw/dz will not be a function of z in Cauchy's sense; w has, in general, no derived function.

If w shall have a derived function, the definition of a function must be narrowed. Geometrically, it is seen at once what the required condition will be: dw/dz shall have the same value for all infinitely small values of dz; hence the magnitude of dw must be proportional to that of dz and independent of the direction of dz. Hence three positions of z near z_0 and the corresponding positions of w must form two similar triangles. Or: If the point z describes any figure, then the point w will describe a figure which in its smallest parts is similar to it.

If this condition is satisfied, then the function is said to be monogen by Cauchy. Weierstrass calls it an analytical function, whilst Riemann and others confine the word function to this case alone. We shall follow Schwarz in using Weierstrass's expression. We may then say that an analytical function establishes a *conform* (*i.e.* similar in the smallest parts) representation in the w-plane of the points in the z-plane; and conversely, if such conform representation between the points in the two planes is given, then also is w determined as an analytical function of z.

It has to be observed that such representation need not extend over the whole planes of w or z. It is also clear that a function as defined by Bernoulli is analytical. The analytical condition for the existence of a derived function is that $\frac{dw}{dy} = i\frac{dw}{dx}$; or, breaking it up in two real equations, that—

$$(1) \qquad \frac{dv}{dx} = -\frac{du}{dy}, \quad \frac{dv}{dy} = \frac{du}{dx}.$$

From these we obtain, by eliminating v,

$$(2) \qquad \frac{du}{dx^2} + \frac{du}{dy^2} = 0, \text{ or } \Delta u = 0.$$

A function u of x and y can therefore be the real part of an analytical function of z only in case that it is a solution of the partial differential equation $\Delta u = 0$. If u is given satisfying this condition, then $\frac{dv}{dx}$ and $\frac{dv}{dy}$ are given by (1), and therefore v itself is known up to a constant. For instance, $u = e^x \cos y$ satisfies (1), and then (2) gives $v = e \ \sin y + C$, and $w = e^z + iC$.

We thus see that w is determined as an analytical function of z if its real part, u, is given as a solution of a certain partial differential equation, and if besides for one value of z the value of v is given in order to determine the remaining arbitrary constant.

Our problem of determining w is therefore reduced to finding solutions of $\Delta u = 0$. The question is, What are necessary and sufficient conditions to determine any special u?

The equation $\Delta u = 0$ is only a special case of Laplace's equation—

$$\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dx^2} = 0,$$

which, on account of its fundamental importance in the theories of potential and of heat, has received a great deal of attention.

If we suppose that u is independent of z, we obtain our equation $\Delta u = 0$. There is thus a close connection between the theory of analytical functions and that of the potential in a plane. The latter has, on account of its concrete meaning, greatly helped the former. In fact, we have here one of the most interesting examples of the reaction of applied on pure mathematics.

Any results obtained for the potential in space can thus by specializing them so as to relate to a plane be applied to the theory of functions. Of such results there is especially one that has to be mentioned. Green has shown that in space the potential due to attracting masses is uniquely determined for all points within a closed surface which incloses no attracting mass if it is known for all points on the surface. His proof, however, is not a mathematical one, but based on the physical meaning of the potential. An analytical proof of the same theorem in a more general form was given by Sir Wm. Thomson. The same theorem, in more or less different form, is found by other authors, and Dirichlet gave it in his lectures on the theory of potential. Riemann, a pupil of Dirichlet's, therefore calls it "Dirichlet's principle," and by this name it is known in Germany, whilst Maxwell has called it Thomson's theorem.

When specified for a plane, the theorem becomes:—There is always one and only one function of x and y which satisfies the equation $\Delta u = 0$, and which is for all values xy within a given area finite and continuous, and which has for points on the boundary of the area arbitrarily given values.

This, in connection with what has been said about the determination of an analytical function, gives the following theorem:—

An analytical function $w = u + iv$ of $z = x + iy$ is uniquely determined for all points within a closed curve if u is arbitrarily given for all points on the curve, whilst v is given for one point within the curve.

The idea of making the partial differential equation $\Delta u = 0$ the foundation of a theory of analytical functions is due to Riemann (in his Inaugural Dissertation, 1851). In his theory of Abelian functions (1857), he gave a fuller account of some special points, and showed in a brilliant example the usefulness of his conceptions.

In this theory the leading theorem is the one just stated. But I have given it in the simplest form possible, leaving out the conditions about continuity and the conditions which must hold if the function w has more values for one value of z. To make it generally applicable, Riemann had first to invent the surfaces known by his name, consisting of a number of sheets spread over the plane of z, which are connected at single points—the branch points. Besides, he had to discuss the connection of that part of the surface at whose boundary u shall have given values, and this led him to what Maxwell has called cyclosis.

The essential part of Riemann's theory is to find criteria which will determine an analytical function by aid of its discontinuities and boundary conditions, and thus uniquely to define a function independent of a mathematical expression. It enables us, for instance, to decide whether a number of conditions which a function has to satisfy, are independent, sufficient, or inconsistent. If a complete set of conditions is given, the theory makes it possible to decide whether a given expression represents the function, or whether two different expressions are identical. According to the old methods, this identity can only be proved by the actual transformation of one expression into the other, and this requires calculations which are generally long and tedious.

Riemann gives in his dissertation only one application, and that a geometrical one, to which we have also to refer. We have already seen that every analytical function w of z determines a conform representation of the points on the w-plane on the z-plane. If we have two plane surfaces, each bounded by a single curve, then the question arises: Is it possible to find a conform representation of the one on the other? and, if so, what further conditions can be imposed? Riemann gives the theorem that this is always possible and in one way only, in such a manner that a pair of given points of the one figure, one on the boundary and one in the interior, correspond to similarly given points in the other figure. He considers the case when the one figure is a circle, and proves the theorem:—Any simply connected plane figure T can be conformly represented on a circle in such a manner that a given point on the boundary of T corresponds to a given point on the circumference of the circle, and a given interior point of T to the centre of the circle, and this can be done in one way only.

This special case includes the general one, for if two surfaces, T and S, have both been represented on the circle, then also is a representation of one on the other determined.

These and similar important theorems about the general theory of analytical functions were proved by Riemann by aid of "Dirichlet's principle" (Thomson's theorem) already mentioned. This is proved by aid of the calculus of variation. It maintains that a certain definite integral must have necessarily one, and only one, minimum value; its proof, therefore, depends on the calculus of variation.

Whilst the notion and definition of a function were gradually extended, more has also become known about possible discontinuities; and here, again, the theory of potential has greatly helped. In the latter, discontinuities occur which are due to the essentially discontinuous distribution of matter, and which extend over surfaces and lines. Accordingly, we see that an analytical function of z may have discontinuities which extend over lines. Here it must be borne in mind that we know nothing about the possible discontinuities of functions, excepting what we have learned from known functions. Riemann's theory requires that the discontinuities are given, but does not teach us which are possible. Other speculations have shown that the existence of a derived function is not a consequence of continuity; that a function may be integrable without being differentiable, and so on. In fact, of an analytical function in its generality we know almost nothing, and, above all, we do not know how far the methods of the infinitesimal calculus and of the calculus of variations can safely be applied to an unknown analytical function in all its generality. Hence, if, as in the proof of Dirichlet's principle, these methods are used, the functions are endowed with properties which themselves require to be proved. Thus the validity of that principle becomes doubtful, and with it the whole of Riemann's theory. Objections of this kind, first raised by Kronecker and Weierstrass in their lectures, have since been repeated in more specific terms by various mathematicians, and it has long been generally accepted that Riemann's theorems cannot be considered as proved by him.

O. HENRICI.

(*To be continued.*)

HUET'S ANEMOMETER.

THIS instrument is not a new invention. We claim for it rather the honour of being the first of its kind invented. In the article on "Anemometers" in the "Encyclopædia Britannica" mention is made of the efforts of several scientific men in this direction, but neither in this nor in any other such publication can we find any notice of M. Huet's invention. In the said article these instruments are divided into various classes according to the principle upon which they are based, the class to which M. Huet's anemometer would be assigned being described as instruments which "measure the wind force by the difference of level it is capable of producing in an inverted syphon, or U tube, containing water or some other liquid. Lind's anemometer, invented in 1775, is the best known of this type, and is still in common use." Turning to the Philosophical Transactions of the Royal Society for 1775, we find on p. 353 a "'Description and Use of a Portable Wind Gage by Dr. James Lind, Physician, at Edinburgh.' Redde May 11, 1775." Dr. Lind's description of his instrument may be briefly stated as follows:—"This simple instrument consists of two glass tubes . . . connected together like a siphon by a small bent glass tube. . . . The whole instrument is easily turned round upon the spindle by the wind, so as always to present the mouth of the tube towards it. The force or momentum of the wind may be ascertained by the assistance of this instrument by filling the tubes half full of water . . . and observe how much the water is depressed by it in the one leg and how much it is raised in the other."

Now we maintain on behalf of M. Huet's anemometer

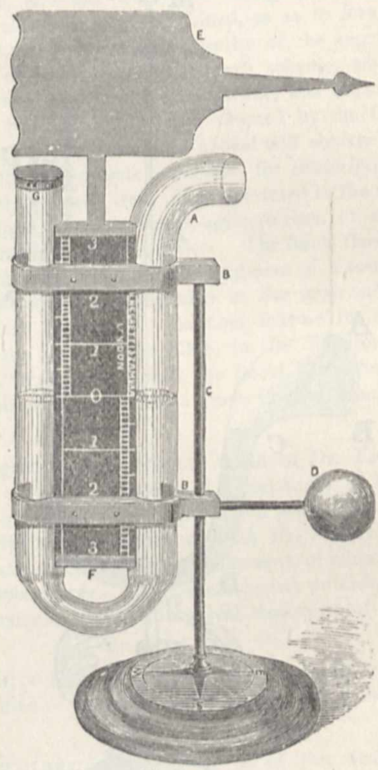


FIG. 1.—Lind's Anemometer.

that it exactly answers this description, and, moreover, that his discovery was given to the world half a century earlier than that of Dr. Lind. It is true that Dr. Lind's description and diagram are much more scientific and business-like than those of M. Huet, nevertheless the principle of the instrument is precisely the same.

Translated, M. Huet's description reads as follows:—

"We have worked with success of late to know exactly the quality of the air, its heat, its humidity and its weight by means of the thermometer, the hygrometer, and the barometer, which is a balance of air. But although we have endeavoured to weigh the air, we have not thought of weighing the wind! I made a suggestion about it to Hubin, an excellent English maker of this kind of instrument. He laughed at it, as of a thing easy to think about, but impossible to execute. I gave him the description of an instrument which I had imagined proper to this effect, and he was so satisfied with it that he left me with the design of making it as soon as possible, but his death frustrated his intention. Here it is in few words.

"It consists of a funnel of white iron, ABC, like a monk's hood. This funnel bends and becomes narrower up to C, where a tube begins and descends to D, where it bends round in DIE, and reascends to K, where it terminates. We fill the tube with quicksilver from CDE up to F. Above F up to G we pour some lye water, of which the rising and falling is perceived by some little dots which are marked on the tube from F to G. The wind entering by the funnel AB strikes the quicksilver at C, and presses more or less according to its force. The quicksilver pressed goes down in proportion, and going down from this side of the funnel it rises in the other branch of the machine above F, and raises the lye water which it supports; and this elevation is noticed and calculated by the dots marked on the tube.

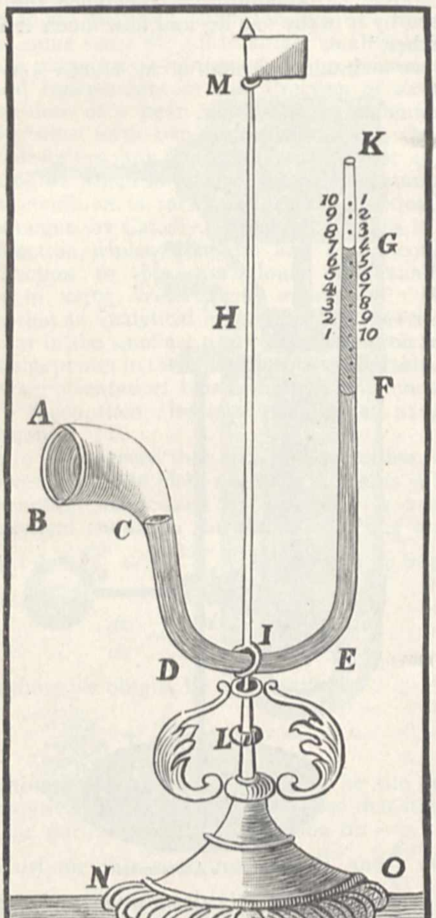


FIG. 2.—Huet's Anemometer.

"And because the instrument may not act if the funnel is not turned towards the wind, it is necessary to adapt a vane M supported by the iron rod MHI. This rod forms a ring at the point I, which encircles and holds firmly the tube. The iron rod below the ring enters a ferrule L, poised on the pedestal LNO, where it turns to the right and left according to the wind which turns the vane, and in turning thus it turns at the same time the whole machine, and holds the funnel always towards the wind."

The instrument, as sketched by the inventor, is extremely toy-like in appearance, and the inevitable result of its first exposure would be its destruction by the very force it was intended to measure. The tube, although encircled by the ring at I, is insufficiently supported, and the vane, M, is not large enough effectually to turn the machine. Lind's anemometer is an improvement on Huet's chiefly in these two particulars—the tubes being brought closely and bound firmly together, and the instrument itself acts as a vane by being set in a spindle. It must, however, be remembered that Huet's invention was never given a trial—in fact, not even made, or these faults would have been easily seen and rectified.

Pierre Daniel Huet, the inventor of this anemometer, was born at Caen on February 8, 1630. He was the author of many works, tutor to the Dauphin (1670), and Bishop of Avranches (1692). He died at Paris on January 26, 1721. The work from which the above description and accompanying sketch are taken is entitled "Huetiana; ou Pensées diverses de M. Huet, Évêque d'Avranches" (Amsterdam, 1723).

W. J. LEWIS.

VIRCHOW TESTIMONIAL FUND.

ON October 13, 1891, Prof. Rudolph Virchow celebrates his seventieth birthday. His pupils and admirers intend to commemorate the occasion by presenting him with a testimonial in recognition of his splendid services to medical science. A large and representative Committee has been formed in Germany with the view of collecting the necessary contributions, but it has been felt that this ought essentially to be an international movement, inasmuch as Prof. Virchow's followers are not of one nation, but of all.

In accordance with this view the undersigned have formed themselves into a Committee, in order to give Prof. Virchow's British admirers the opportunity of testifying to the gratitude which every member of the profession feels towards the man whose work in cellular pathology has so vastly contributed towards the advance of modern medical science, and may fairly be said to have made every member of the profession his pupil.

The form in which the universal feeling of gratitude is to find expression has been decided upon by the original German Committee. A large gold portrait medal is to be presented to Prof. Virchow himself, and bronze replicas of the same to members of his family and to some scientific institutions. The surplus—which, no doubt, will be large—is to be handed over to Prof. Virchow for the furtherance, subject to his decision, of scientific work.

To carry out this project the undersigned cordially invite the co-operation of the profession in the United Kingdom. Subscriptions, which are not to exceed two guineas, may be sent to the Hon. Treasurer, Dr. Lauder Brunton, 10 Stratford Place, London, W., and will be duly acknowledged in the medical journals. Cheques to be made payable to "Virchow Testimonial Fund," and to be crossed.

(Signed) JAMES PAGET, Chairman.
LAUDER BRUNTON, Hon. Treasurer.
FELIX SEMON, } Hon. Secs.
VICTOR HORSLEY, }

List of Committee of Virchow Testimonial Fund.

Henry W. Acland (Oxford), Th. Clifford Allbutt, John Banks (Dublin), W. Mitchell Banks (Liverpool), H. G. Barling (Birmingham), A. Barron, M.B. (Liverpool), J. S. Bristowe, M.D., W. H. Broadbent, Th. Lauder Brunton (Treasurer), Th. Bryant, H. T. Butlin, J. Chiene (Edinburgh), Andrew Clark, J. Coats (Glasgow), S. Coupland, J. Dreschfeld (Manchester), Dyce Duckworth, John Evans, Joseph Fayrer, D. Ferrier, W. H. Flower, M. Foster (Cambridge), W. T. Gairdner (Glasgow), Alfred Garrod, W. S. Greenfield (Edinburgh), F. de Havilland Hall, D. S. Hamilton (Aberdeen), T. Holmes, G. M. Humphry (Cambridge), J. Hutchinson, J. Hughlings Jackson, William Jenner, George Johnson, Joseph Lister, William MacCormac, Th. Oliver (Newcastle-on-Tyne), W. M. Ord, Richard Quain, George Paget (Cambridge), James Paget (Chairman), F. W. Pavy, George Porter (Dublin), R. Douglas Powell, J. Russell Reynolds, William Roberts, Ch. S. Roy (Cambridge), T. Burdon Sanderson (Oxford), E. A. Schäfer, S. G. Shattock, John Simon, A. R. Simpson (Edinburgh), E. M. Skerritt (Clifton, Bristol), Th. Grainger Stewart (Edinburgh), William Stokes (Dublin), Octavius Sturges, Th. Pridgin Teale (Leeds), William Turner (Edinburgh), Hermann Weber, Spencer Wells, C. S. Wheelhouse (Leeds), Samuel Wilks, A. H. Young (Manchester).

NOTES.

THE annual general meeting of the Geological Society will be held on Friday, February 20, at 3 p.m., and the Fellows and their friends will dine together at the Hôtel Métropole, Whitehall Place, at 7.30 p.m.

ON Tuesday Mr. C. Parker called attention in the House of Commons to the question of secondary education in Scotland, and moved, "That, for the better organization in Scotland of higher education, it is desirable that there should be grants in aid of it, not only, as at present, to the Universities and to primary schools, but also (as recommended by a Departmental Committee in 1888) to the public secondary schools, on condition of their general efficiency, and of free places being reserved in them for competition among children from the grant-aided primary schools." The motion was seconded by Mr. Parker Smith, and supported by Mr. D. Crawford, Colonel Campbell, Mr. S. Buxton, Mr. Bryce, and others. The Lord Advocate said that there was no conflict of opinion on the subject amongst the various sections of the House. On the question of financial aid, he might say that there was an immediate prospect of further money being available for education in Scotland. When the proper time came the Government would be prepared with a well-considered scheme of secondary education. The House would see that under these circumstances it was undesirable to pledge the Government to the terms of the resolution. This satisfactory assurance led of course to the withdrawal of the motion.

ON Sunday, February 8, the R. Università degli Studi at Naples is to hold a *festa* in honour of Prof. Arcangelo Scacchi, the eminent mineralogist, on the occasion of the fiftieth anniversary of his professoriate.

THE Essex Field Club, the foundation of which was noted in our columns eleven years ago (vol. xxi. pp. 215, 286, and 474), is about to enter on a new phase of its career. Since 1880, the Club has been carrying on most useful work in the county of Essex, and has deservedly taken rank as one of the most successful field clubs in the country. The publications now comprise some eight volumes of Transactions and Proceedings, together with the *Essex Naturalist*, the present form of the Club's journal. In addition to these publications, which are full of papers of local interest, the Club has also issued two volumes of "Special Memoirs"—the "Report on the East Anglian Earthquake," by Messrs. Meldola and White, and the "Birds of Essex," by Mr. R. M. Christy. Both of these volumes were reviewed in NATURE at the time of their publication. Although the Club has thus been carrying out its original programme for a period of eleven years, supported by a most energetic staff of officers, with Messrs. Meldola, Boulger, Holmes, and Fitch as successive Presidents, and Mr. William Cole as Honorary Secretary throughout the whole period of its existence, there is one branch of the Club's work which has been languishing, and which it is now proposed to take up and push forward with renewed vigour. It has always been present in the minds of the executive that one of the Club's functions was the establishment of a museum illustrating more especially the *local* natural history, geology, and prehistoric archæology of the county, but having also an educational side. Although there are already museums at Colchester, Chelmsford, and Saffron Walden, there is no establishment in the county which can be considered a local museum in the sense which the Club insists upon. To remedy this defect, and to set an example which it is hoped may be followed by other counties, an arrangement has been made between the Essex Field Club and the subscribers to the Essex and Chelmsford Museum, which was submitted to the Club at the eleventh annual general meeting held on Saturday, January 31, in the Museum at Chelmsford, under the presidency of Mr. E. A. Fitch. The formal resolution proposing the amalgamation of the two Societies was put to the meeting by Prof. Meldola, and seconded by Dr. Thresh, the Medical Officer of Health for the county, and carried unanimously. The two Societies will retain the name of the Essex Field Club, and the collections belonging to both will, it is hoped, be sooner or later combined, so as to form the nucleus of a museum in every sense worthy of the reputation of the Club and of the county. The draft scheme, which was submitted for final acceptation on Saturday, was drawn up by Mr. Cole, and had previously been adopted by the Committee of the Chelmsford Museum. An appeal will shortly be made on behalf of the amalgamated Societies for subscriptions from the public, and especially from those interested in the welfare of the county either as residents, as agriculturists, or as being concerned in its maritime industries. The funds thus raised are to be devoted to the erection and equipment of a museum building in Chelmsford, which is regarded as the most suitable locality for a county institution. Another scheme for extending the work of the Essex Field Club, in the direction of technical education, in accordance with the Local Taxation Act of 1890, was submitted formally to the Essex County Council on Monday last.

WE regret to announce the death of Dr. Karl Weihrauch, Director of the Meteorological Observatory of Dorpat, which occurred on January 19, in the fiftieth year of his age. As long ago as 1871 he was associated with Dr. Arthur von Oettingen in the management of that establishment, of which since 1876 he has had sole charge. The papers he has published have mainly had reference to the mathematical treatment of meteorological data.

M. ÉMILE REYNIER, well-known as an authority on electrical science, died of pneumonia on January 20, at the age of thirty-nine.

PARTICULARS have reached us of the death on October 31, 1890, of Mr. Cosmo Innes Burton, F.R.S.E., the first Professor of Chemistry in the Technical Institute recently founded by the English merchants in Shanghai. Mr. Burton, who was only in his twenty-eighth year, was well known in this country as an enthusiastic student of chemistry, well skilled in organic research, and exceptionally successful in University Extension lecturing. He was the youngest son of the late Dr. Hill Burton, Historiographer-Royal for Scotland, and inherited much of the versatility, originality, and conscientious laboriousness which distinguished his father. After studying at the Universities of Edinburgh, Munich, and Paris, he acted for a time as Research Assistant to Prof. Japp, at South Kensington, the record of his work being published in several papers. Returning to Edinburgh, he pursued private research and Extension lecturing until the appointment in China was offered to him last summer. He proceeded to Shanghai with his newly-married wife, and had just completed arrangements for commencing a course of lectures when his promising career of usefulness to science and to the world was ended by an attack of malignant small-pox.

THE London Chamber of Commerce, Botolph House, Eastcheap, are now displaying a most interesting collection of fibres of various kinds which have been supplied from the Kew Gardens Museum. The collection has been put together chiefly for the inspection and consideration of merchants and manufacturers.

THE expedition which is to be sent in the spring to the west coast of Greenland, by the committee of the Karl Ritter Endowment, is likely to be one of considerable importance. The chief of the expedition will be Dr. E. von Drygalski. Dr. O. Baschin will accompany it, defraying his own charges; and there will be a third scientific expert, who has not yet been selected. Dr. von Drygalski proposes to establish a station near the Umanackfjord, in about 70° 30′ north latitude, where Dr. Baschin will carry out a continuous series of meteorological observations, and from which he can make long or short excursions inland to study the interior ice. It is expected that the party will remain in Greenland about a year.

WE have received from Mr. Clement L. Wragge the following statement, written at Nouméa, New Caledonia, December 22, 1890:—"I have much pleasure in stating that I have just established a first-order meteorological station at Nouméa, under the auspices of the Queensland Government. The instruments are placed on the premises of the Australasian United Steam Navigation Company's agency, and consist of a fine Kew barometer by Adie; dry, wet, maximum, and minimum thermometers exposed in the 'Stevenson' screen (enlarged pattern); a Richard barograph and thermograph; capacious rain-gauge; earth-thermometers; and electric or 'turnover' thermometers of Negretti and Zambra's manufacture. The Governor of New Caledonia, M. Pardon, received me most kindly, and promised any assistance in his power. Early next month I hope to have placed a set of instruments at Aneiteum or Havannah, in the New Hebrides, and we also contemplate establishing a station at Tahiti, and other places in the South Pacific. Our observer at Nouméa is Mr. Samuel Johnston, a permanent resident, who takes a warm interest in the matter. Mr. Johnston's brother also assists, and every precaution has been taken to insure permanency and continuous records."

IN the first quarter of the year 1890, many places in Queensland suffered so severely from floods caused by excessive rainfall, that the Governor of that colony called for a special report upon the subject. This has been drawn up by Mr. Wragge, and contains numerous tables of rainfall for the months of January to March, 1888, 1889, and 1890, arranged for comparison. The report also contains data respecting the flood levels of certain rivers and creeks, and interesting reports of the condition of stock and state of country from the owners of cattle stations, referring both to the drought of 1888–89 and the floods of 1890. Mr. Wragge attributes the abnormal state of the weather which produced the floods to the unusual extension of the north-west monsoonal system, the isobars of which at times enveloped nearly the whole of Australia, thus changing the character of the usually arid conditions of the interior.

THE committee of the Lancashire County Council have recommended that the whole of the grant in aid made to the county of Lancaster under the Local Taxation (Customs and Excise) Act, 1890, should be appropriated for purposes of technical education, including agricultural and commercial instruction. The amount of the grant at the disposal of the county is estimated at £39,000. The committee have received 101 applications for assistance towards the expenses of carrying on existing schools and institutions for the purposes of technical instruction. They recommend that the special grant be placed to a separate account, to be applied in such manner as the Council may from time to time determine. It is recommended that grants be made to local authorities, or to institutions, schools, or classes under public management, the grants to be conditional upon suitable premises, appliances, and apparatus being provided. It is proposed to grant £500 for migratory lectures upon agricultural instruction, and to grant £500 for the purpose of assisting the formation of migratory dairy schools in such agricultural centres as would aid in their establishment by providing premises, appliances, and other facilities for the work.

THE *Oxford University Extension Gazette* reports that the County Council of Devonshire has voted £3000 for scientific lectures during the present year, and it is proposed to engage four lecturers to deliver twelve full courses on elementary mechanics and chemistry. Two of these lecturers are probably to be from Oxford, and two from Cambridge.

A MEMORIAL from the Dundee Chamber of Commerce, and numerous merchants, manufacturers, and others of that town, in favour of a decimal system of coinage, weights, and measures, was sent the other day to the Chancellor of the Exchequer. Mr. Goschen, in acknowledging the memorial, says:—"I must own frankly for myself that, though I am sensible that powerful arguments can be put forward in support of the decimal system, I cannot undertake to recommend its adoption to the country."

DR. GOEBEL has for some time been carrying on botanical researches in British Guiana. The Demerara *Argosy*, which speaks of his visit with much satisfaction, says that one of his chief objects is to study the morphology and life-history of a peculiar order of plants, of obscure affinities, known in systematic botany as the *Podostemaceæ*. "These plants" says the *Argosy*, "which grow on the submerged rocks in the falls and rocky river-beds of most or all of our main rivers, are known now to many of our gold diggers and others travelling up and down the rivers by the beautiful clusters or sheets of pink bloom which they present when the rivers subside and they become exposed in the dry seasons. They comprise many species and several genera. They adhere to the rocks, as seaweeds do, by the disk-like base of the stem, holding with such extreme tenacity in the stress and strain of the rushing waters that in removing them by manual force a portion of the rock is often broken away attached to the plant. The greater part of the year they are deeply submerged, floating as seaweed floats at the bottom of the sea, but as the waters subside in the dry seasons they take the opportunity while exposed to flower and fruit." There are numerous unsettled points as to their life-history, morphology, histology, &c., and, according to the *Argosy*, Dr. Goebel, on his return to Europe, will publish many results which are new to science and very interesting.

FROM Dorsetshire a singular instance of starlings being eaten by rooks is reported. It seems that, during the very severe weather we had lately, a flock of starlings was observed on a farm at West Stafford, near Dorchester, followed by a number of rooks in hot pursuit. The larger birds soon came up with their prey, and quickly despatched them, and, after stripping them of their feathers, devoured them then and there. When the scene of the occurrence was inspected, just afterwards, the ground was found to be strewn with their feathers, but beyond these not a vestige of the starlings could be discovered. It seems that the rooks, from sheer hunger, must have been driven to this extremity, owing to the scarcity of other kinds of food.

THE "Photographer's Diary and Desk-book" for the present year, which is issued by the proprietors of the *Camera*, should be in the possession of every photographer. It contains a good condensed account of dark-room procedure, including the latest discoveries that have been made in photographic printing. All the various formulæ, both for development and printing, which are recommended by each individual maker, have been revised, and are printed in a type that can be easily read in a dark-room. A few notes have been collected relating to some of the important and useful novelties in photographic apparatus, and in many cases illustrated. The diary part of the book consists of good smooth paper interleaved with blotting-paper, and ample room is allowed for the insertion of diary notes, with a few pages for memoranda. A useful addition might be made by carrying the diary a few days into the January of the following year; this might prove a source of convenience to many photographers.

THE report on the collection of birds made by the late Dr. Ferdinand Stoliczka, the naturalist of the Yarkand Mission of 1874, will shortly appear, when the record of Forsyth's expedition will be complete. The work was originally written by Mr. A. O. Hume, C.B., but the manuscript, on the eve of publication, was destroyed by a native servant, along with the other valuable manuscripts of this well-known naturalist. The collection of Yarkand birds was brought to England with the rest of the Hume collection by Mr. Bowdler Sharpe, who was entrusted by Mr. Hume with the task of completing the memoir. We understand that Mr. Sharpe has incorporated in his paper the chief results obtained by Dr. Henderson, Dr. Scully, and the other observers who accompanied the various expeditions to Eastern Turkestan, and will be a monographic report on the work done by all the English naturalists who have visited Central Asia.

WE learn from the *Times* that the Windsor and Eton Angling Preservation Association is about to place 1000 of the famous Loch Leven trout from Sir Gibson Maitland's Howietown fishery in the Thames waters in the Windsor district. The fish will be conveyed from Stirling in ten tanks. The artificial stocking of the river with trout has been carried out by the society with marked success, the captures during the last two years in the Windsor waters having been nearly double those of 1888.

IN 1868, Mr. A. S. Merry delivered a lecture before the Royal Institution of Swansea, under the title of "Heat." He has just published, in pamphlet form, the propositions then propounded. In this it is asserted that "interstellar space is occupied by two elements, which may be named electrine and thermine, which unite together and neutralize each other, forming the interstellar ether." All physical phenomena are explained on the supposition that this ether permeates all matter, and, under various conditions, is decomposed into its constituents. Absolute zero is produced by the perfect neutralization of thermine by electrine. Hence, on separating electrine from the ether, thermine is liberated, and the development of heat is the result.

THE Government of British North Borneo has accepted the sum of £100 from the Royal Geographical Society of Australasia, for Baron de Lissa to carry out a survey of Mount Kinabalu, which will be undertaken jointly with an agricultural survey by the Government of British North Borneo.

MESSRS. F. WARNE AND CO. will shortly issue the English edition of Major Casati's work, "Ten Years in Equatoria, and the Return with Emin Pasha." It will contain nearly two hundred original illustrations, and several maps.

IN NATURE of January 8 (p. 231) reference is made to Dr. J. D. E. Schmeltz as director of the Leyden Ethnographical Museum. The director is Dr. L. Serrurier. Dr. Schmeltz is "conservator" or assistant-keeper.

IN Mr. Howes's letter on "the morphology of the sternum," printed in NATURE of January 15 (p. 269), there is a mistake due to a slip of the pen. The word "presence" (line 7) ought to be "absence."

THE following are the arrangements for science lectures at the Royal Victoria Hall during February:—3rd, "From Dry Bones to Useful Material," by Mr. Ward Coldridge; 10th, "Plants and Animals of the Coal," by Prof. H. G. Seeley; 17th, "Our Chalk Hills," by Mr. F. W. Rudler; 24th, "A Trip to New Zealand," by Prof. Hall Griffin.

A THEORY attempting to explain the nature of the relationship between the optical activity of many substances in solution, and the hemihedrism of their crystalline forms, is advanced by Dr. Fock, the author of the new work on chemical crystallography, in the current number of the *Berichte*. It is certainly a most significant fact that all those substances whose solutions are capable of rotating the plane of polarization of light, and whose crystalline forms have been thoroughly investigated, are found to form hemihedral crystals—that is to say, crystals some of whose faces have been suppressed, and whose two ends are therefore differently developed. Moreover, in those cases where both the right rotatory and left rotatory varieties of the same chemical compound have been isolated and examined, as in the case of dextro- and lævo-tartaric acid, the hemihedral crystals are found to be complementary to each other, the faces undeveloped upon the one being present upon the other, so that the one is generally as the mirror-image of the other. Several ingenious attempts to account for the wonderful geometrical arrangement of the molecules in a crystal have been made of recent years by Bravais, Mallard, and others, who developed the "Raumgitter" theory, and by Sohncke, who showed that all possible crystallographical forms could be referred to systems of points; yet it has been found necessary by these crystallographers to assume a polarity of the molecule itself in order to fully explain the phenomenon of hemihedrism. This conclusion is, moreover, borne out by the more recent work of Lehmann upon his so-called "liquid crystals." It is, indeed, evident that hemihedral crystals owe their hemihedrism to a differentiation of the various parts of the molecules themselves in space. Dr. Fock assumes, for the purpose of connecting this fact with the optical rotation of the dissolved crystals, the tetrahedral form for the element carbon, in the most recent conventional sense employed by Wislicenus, Van't Hoff, Victor Meyer, and other exponents of the new "stereo-chemistry." The axis of polarity of a molecule containing an asymmetric carbon atom, will, of course, be determined by its centre of gravity and the heaviest "corner" of the tetrahedron, and Dr. Fock shows that rotation of the molecule will be most easy round this axis, and in the direction, right or left, determined by the relative weights of the atoms or groups disposed at the other three "corners." He further shows that, if we consider any direction of vision through the solution, we must practically consider two positions of the molecules, in both of which the axis of rotation is parallel with our line of sight, and in one of which the apex of the tetrahedron is turned towards us, and in the other is directed away from us and the other three corners presented to us. As the molecules are, of course, in rapid motion, we must consider all other positions as balancing each other, and being resolved eventually into these two directions. It is then easy to see, as it is now accepted from Fizeau's work that the movement of molecules is capable of influencing the direction of light-waves, that there must be two oppositely moving circularly polarized rays produced. Now, it is generally supposed that the rotation of liquids is really due to the division of the light into two circularly and oppositely polarized rays, one of which, however, is stronger than the other, and determines the apparent optical activity. Dr. Fock completes his theory by showing the probability that there would be just this difference in the amount of rotation of the light in the two cases of the differently disposed molecules, those with their "apices" turned towards the direction of incidence of the light affecting it to a different extent from those whose "bases" were the first to receive it. The theory is well worth following out in the original memoir, many confirmations of it being adduced from other properties of hemihedral crystals.

THE additions to the Zoological Society's Gardens during the past week include a Red-necked Grebe (*Podiceps griseigena*), presented by Mr. Thos. Hardcastle; two Japanese Pheasants (*Phasianus versicolor* ♂ ♀) from Japan, presented by Mr. E. Wormald, F.Z.S.; two Passerine Owls (*Glaucidium passerinum*), European, presented by Mr. St. John Northcote; forty River Lampreys (*Petromyzon fluviatilis*) from British fresh waters, presented by Mr. Thos. F. Burrows; a Black-headed Lemur (*Lemur brunneus* ♂) from Madagascar, a Triton Cockatoo (*Cacatua triton*) from New Guinea, deposited; a Milne-Edwards Porphyrio (*Porphyrio edwardsi*), a Grey-headed Porphyrio (*Porphyrio poliocephala*) from Siam, purchased; a Variegated Sheldrake (*Tadorna variegata*) from New Zealand, an Indian Python (*Python molurus*) from India, received in exchange; an American Bison (*Bison americanus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE TRANSITS OF VENUS IN 1761 AND 1769.—The Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac, vol. ii. Part 5, contain a discussion of observations of the transits of Venus in 1761 and 1769, by Prof. Simon Newcomb. The discussion was undertaken because of the mutations of opinion as to the value of the observations. For more than a century these observations were looked upon as affording the best data for the determination of the solar parallax. Now, however, opinion leans considerably to the opposite direction.

The general theory on which all the previous discussions were founded is said by Prof. Newcomb to be (1) that the formation of the thread of light at ingress and its breaking at egress mark the true time of tangency of the dark limb of Venus with the bright limb of the sun; (2) that a definite interval intervenes between this formation or breaking of the thread of light and the moment known as apparent or geometric contact of the limbs, which interval arises from and depends upon irradiation. A little consideration, however, will show that the time of formation of the thread of light, and therefore the interval between the two phases of contact, must vary with the observer, the quality of the telescope employed, and the conditions of vision. The clearer and steadier the air, and the sharper the vision, the more nearly must the two phases approach each other, until, under the best conditions, they come together. The indefinite and varying character of the phenomena, therefore, favours the division of the observations into the following classes: (1) those in which the formation or extinction of the thread of light is stated to have been observed; (2) cases in which some phenomenon of contact was noted earlier than the formation of the thread of light at ingress or later than its disappearance at egress; (3) observations in which no statement is made from which it can be inferred that one phase rather than the other was observed. These different kinds of observation have been satisfactorily treated by introducing corrections into the equations of condition.

The collected observations take up a large amount of space, and are of prime importance. Their classification and discussion, and the treatment of residuals in the formation of the equations of condition, is also in keeping with Prof. Newcomb's previous work. With respect to the values of the coefficients expressing the effect of imperfections of vision upon the visibility of the contacts, it is concluded that—(1) under the worst ordinary conditions of vision, Venus, at visible external contact, impinged heliocentrically $0''.7$ further upon the sun than it did under the best conditions, telescopic and atmospheric; (2) in the case of second contact the thread of light, when first seen, was heliocentrically $0''.16$ thicker under the worst than under the best conditions; (3) in the case of third contact no difference is shown in the thickness of the thread of light under different conditions when it vanished from sight.

When the weights of the observations of contacts III. and IV. in 1761, and contacts I., II., III., IV. in 1769, are considered, the value found for the equatorial horizontal parallax of the sun is

$$\pi = 8''.79 \pm 0''.051 \text{ or } \pm 0''.034,$$

where $0''.051$ represents the mean error, and $0''.034$ the probable one.

The mean probable result found by Encke from a discussion of the same observations was $8''.571$, with an estimated probable error of $0''.037$, which error was afterwards found to be too small. A variety of causes are put forward to account for the wide difference in the results, and it is hoped that some other astronomer will be able to make a thorough comparison of the two determinations.

Prof. Newcomb also provisionally concludes that the correction to Leverrier's latitude of Venus at the descending node for the mean of 1761 and 1769 is $+1''.915$, while the correction to Leverrier's longitude of the node (1765·5) appears to be $+32''.4$.

LEYDEN OBSERVATORY.—The fifth and sixth volumes of the *Annalen der Sternwarte in Leiden* have recently been issued by the Director, Dr. H. G. Van de Sande Bakhuyzen. The observations of stars contained in the former volume have been made with the usual care. The latter deals with the reduction of the zenith distances of several stars.

THE PRINCIPLE OF LAMARCK AND THE INHERITANCE OF SOMATIC MODIFICATIONS.[1]

"To reject the influence which use or disuse of a part may have on the individual or on its descendants is to look at an object with one eye."—SIR WILLIAM TURNER.

IN last year's lectures we divided the factors of organic evolution into two great classes—firstly, primary factors; and secondly, secondary factors.

The primary factors are those which act directly on the individuals of a given generation; or indirectly on the individuals of the succeeding generation in consequence of a modification of the reproductive elements. Such are light, heat, climate in a general way, nutriment, the nature of the water for aquatic organisms, &c. Further primary factors are the ethological reactions of animals or plants against the inorganic and the living surroundings—what Lamarck called their needs and habits, what Darwin named the struggle for existence, sexual competition, migrations, &c.

We have seen that the action of these primary factors alone and of heredity could give rise to new races and consequently to new species, according to the law of Delbœuf. For this it is enough that the factors act continuously or even periodically, and that the changes produced are not disadvantageous to the modified organism; because, in this last case, natural selection comes into play and rapidly produces an elimination of the less favourable. But the most constant of primary factors of evolution are strongly aided by the secondary ones. These preserve and rapidly augment the results brought about by the primary factors, and determine the adaptation to any given environment of the forms whose variability has been acting. In the case of fully differentiated organisms, *i.e.* all whose parts are specially and rigorously adapted to definite conditions of existence, when a primary factor begins to modify one of these conditions, a return to biological equilibrium is henceforth impossible, and the organism vanishes. This explains the disappearance in olden times of highly differentiated forms (Trilobites, Ammonites, &c.) as a result of apparently unimportant changes in the state of the surroundings. Thus we also can understand how very slight ethological modifications would promptly bring about the annihilation of so highly specialized types as Peripatus, Ornithorhynchus, &c.

But on organisms still possessing a certain plasticity, still having a certain number of elements of unfixed value to dispose of, the action of primary factors causes only a momentary rup-

[1] Prof. Giard's opening lecture, in the Sorbonne, of his course on "Organic Evolution" (chair founded by the City of Paris).

ture of ethological equilibrium, and consequently more or less extensive variations. Then the secondary factors come in, and eliminate some and fix others of these variations, forming, from a dynamic aspect, new states of equilibrium; and from a morphological aspect, new species. This is the *rôle* of natural selection, of sexual selection, of segregation, and the other secondary factors we shall study this session.

The study of the primary factors of evolution is sometimes called Lamarckism. For Lamarck believed that it was possible to explain the evolution of all organisms by the action of these factors, to which he added heredity alone.

On the other hand, Darwin, while not denying the *rôle* of the primary factors in the production of new species, strove to show that the most important part should be given to natural selection and a small number of other secondary factors. Hence the name of Darwinism given to the study of these factors by many biologists.

Of late, attempts have been made to oppose Darwinism to Lamarckism, or at least to give almost exclusive weight to the one or to the other. Although we have protested several times already against these exaggerations, too often inspired by a deplorable chauvinism, the discussion has become so important of late that it is well to give it a few passing words. Among the disciples of Darwin, some, such as Romanes, have tried to show that natural selection alone cannot explain all the details of organic evolution; and that, along with it, other agents must be considered. Romanes has especially studied a new secondary factor, which he calls *physiological selection*, whose value we shall discuss later in the course. Moreover, Romanes does not reject the influence of primary factors any more than Darwin.

But other naturalists, more Darwinian than Darwin, refuse to admit any other cause of evolution than natural selection. They excommunicate at the same time Romanes, Delbœuf, and the new adherents to the views of Lamarck, revived and placed in touch with modern knowledge. At the head of the ultra-Darwinists is Weismann, who, in his numerous essays, strives to show that the explanations of Lamarck may be replaced by others drawn solely from the mechanism of selection. These essays, partly translated into English, have been received with great favour by the majority of British biologists, and have brought powerful help to the eminent Alfred Russel Wallace, who shares with Darwin in the honour of the discovery of natural selection, and has never ceased to give to this factor an altogether preponderating influence in the formation of species.

In an address delivered at Cologne on September 20, 1888, before the Association of German Naturalists, Weismann went the length of saying:—"I believe I am able to affirm to-day that the material existence of a transmission of acquired characters cannot be proved, and that there exist no direct proofs of the principle of Lamarck."

But what is the principle of Lamarck? That illustrious biologist formulated two fundamental laws. In his own words:—

(1) In every animal which has not got beyond the period of developing, the frequent and sustained use of any organ gradually strengthens it, develops it, enlarges it, and gives it a power proportionate to the duration of the using of it; while the continued disuse of this or that organ imperceptibly weakens it, and it deteriorates, loses its power by degrees, and finally disappears.

This is the law of *ethological reaction* or the law of *adaptation*.

(2) All that Nature has allowed individuals to gain or lose by the influence of the circumstances to which their race has been exposed for a long time, and, consequently, by the effect of predominant use of this organ or continued disuse of that, is conserved in the new individuals who spring from them, and who therefore find themselves better adapted than their ancestors, if the conditions of existence have not changed.

This is the *principle of heredity*, and it is to this law that Weismann alluded when he spoke of the principle of Lamarck.

If this principle of Lamarck is inaccurate and not demonstrable, one sees that the *rôle* of the primary factors is markedly lessened. The transmission of characters specially determined by these factors is no longer a scientific fact; their action is bound to set in motion in a vague way the variability of the germs, without which it is impossible to show a precise nexus of causes, a rigorous connection between the primary factor which acts and the variation it produces.

Before we begin our study of secondary factors we must examine one question—How far must we admit the restrictions to the primary factors brought forward by Weismann, and, before all, what have we to think of the absolute denial of Lamarck's principle?

If we follow Weismann in the very special criticism he has made of this principle, we find, at the outset, that he restricts considerably the limits in which Lamarck applied the law of inheritance of acquired characters:—

"We must not cite," says Weismann, "as facts capable of direct observation, transmissions of acquired characters in cases of injury or of mutilation: the observation of the transmission of functional hypertrophy or of atrophy has never been made, and one scarcely can hope to find it in the future, because it is a territory hardly accessible to observation."

Moreover, Weismann affirms that organs rudimentary through want of usage may be explained perfectly without the intervention of the principle of Lamarck.[1]

He reduces what one commonly calls acquired characters to a very narrow category of modifications, which in no way correspond to what Lamarck intended by the same expression.

In reality, among the many modifications of organisms, often in a vague manner called acquired characters, Weismann distinguishes those which affect the elements of the body—*somatogenic* modifications; and those which influence the reproductive elements—*blastogenic* modifications.

If, for example, a man has a finger amputated, his tetradactylity is a *somatogenic*[2] property; if, on the contrary, a child be born with six fingers, his hexadactylity arises from a special state of the germ, and is a *blastogenic* peculiarity. With this definition and limiting of somatogenic modifications to mutilation and to wounds, with which Weismann is content, then it is certain that the *majority* of somatogenic modifications are not transmitted by heredity.

"It is evident *a priori*," as Duval justly remarks ("Le Darwinisme," p. 309), "that only those variations can be inherited which have their source in an influence affecting the whole organism in such a fashion as to bring about profound transformations, of which the variation in question is a local manifestation. And indeed, if that modification be simply a local manifestation of a general tendency of the organism, it is, however, true that descent may transmit merely the tendency, which only shows itself later in the subsequent products of the variation in question. It is this that is presented to us in the case of atavism, in which the variation jumps over one generation.

"But a sudden accident, such as a blow which destroys part of the organism, does not result in a modification of the whole organism, and hence does not represent any general tendency nor any chance of forming an inheritable mutilation. The gardener, in slowly modifying plant or shrub by special conditions of culture, brings out variations which he may hope to see reproduced in the descendants; but when he capriciously prunes the branches of a shrub, he knows well that neither by slippings nor by seedlings can he get produced from that shrub, deformed by the sharp instrument, new plants which will bud forth similar deformations."

Thus Weismann seems to have given himself much trouble with meagre result in his discourse "On the Hypothesis of a Hereditary Transmission of Mutilations." In such a subject each case must be studied separately, and if, after cutting the caudal appendices from five successive generations of white mice, Weismann observed no modification with the descendants of these animals, that only proves that the sectioning of a mouse's tail carries with it no profound modification of the organism of these animals.

Similarly, all the discussion about the tailless cats of the Isle of Man and of Japan seems to us very ably and logically conducted, but the conclusions drawn therefrom do not go beyond the compass of that particular case. Among the feline species, at least in a domestic state, the existence of a caudal appendage more or less developed is of very secondary significance, and the artificial selection by man, guided by caprice or prejudice, may lead to the disappearance of that appendage in certain localities, particularly in islands.

[1] The demonstration of this assertion which Weismann has tried to give does not seem to me sufficient. I do not believe it is any more justifiable to make the assertion that the principle of Lamarck will be inapplicable to many instincts, in particular to those which appear only once in the life of an animal. But this discussion will be more *à propos* when we are studying the laws of heredity.

[2] We keep Weismann's terminology, though "somatic" seems a better word.

There is a whole series of facts which Weismann might have cited in support of his manner of view, but which do not furnish any argument more demonstrative against the inheritance of somatogenic modifications, if one gives to the word a meaning wider than that of simple mutilation. I speak of phenomena so curious as voluntary mutilation or autotomy, of which I recently pointed out the frequency and variety.[1] Innumerable generations of lizards have voluntarily broken off their tails to escape from various enemies, without that appendage ceasing to reappear among their descendants. At the most, one may say that selection has rendered this mutilation more easy and more frequent with certain species of saurians, as with certain echinoderms, certain molluscs, &c. The organism has acquired the power of parting easily with this or that part, while the part, sometimes seemingly without any use, does not fail to reappear in each new generation, because its suppression produces no reaction in the other organs.

But this is not always the case. Mutilations and wounds, which at first seem of little importance, nevertheless call forth somatogenic modifications as often inherited, because they give to the organism affected a disturbing action, which probably extends to the reproductive elements.

Weismann has not even made allusion to cases of this sort, of which a certain number were noted by Prof. Brown-Séquard long ago.[2]

Here are the leading varieties of the inheritance of the effects of accidental injuries, as given by that investigator:—

(1) Epilepsy in the descendants of guinea-pigs, male or female, in whom it was originally produced by cutting the sciatic nerve or the spinal cord.

(2) A singular change in the shape of the ear, and a partial shutting of the eyelids in the descendants of individuals (guinea-pigs) which had these as the result of cutting the cervical sympathetic nerve.

(3) Exophthalmia in the descendants of guinea-pigs which had this protrusion of the eye after an injury to the fourth ventricle.

(4) In the descendants of certain individuals in which a lesion of the restiform body had been produced, there occurred ecchymosis, followed by dry gangrene, besides other changes of the blood-supply to the ears.

(5) Absence of phalanges or whole toes of the hind paws in descendants of guinea-pigs which had accidentally lost their toes after cutting the sciatic nerve.

(6) Morbid state of the sciatic nerve in the descendants of individuals which had had that nerve divided, and the successive appearance of the phenomena, described by Brown-Séquard as characteristic of the periods of development and of abatement of epilepsy, and especially the appearance of an epileptic area in a part of the skin of the head and neck, and of the disappearance of hair around that area the moment the disease showed itself.

(7) Muscular atrophy of the thigh and leg of guinea-pigs, offspring of individuals with muscular atrophy following resection of the sciatic nerve.

(8) Defect in one or even both eyes of guinea-pigs whose parents had an eye deteriorate after the cutting of the restiform body.

Prof. Brown-Séquard has shown that the inheritance of the morbid conditions mentioned above may manifest itself in one side only, while both sides were affected in the parent. The inverse may also exist. Further, if the parent and descendant both have the morbid state in only one side, it sometimes happens that the side is not the same in both cases. The inheritance of these conditions may be wanting in one generation, and appear in the succeeding one. The female is better able to transmit morbid states than the male. As to the frequency of these transmissions, Prof. Brown-Séquard affirms that with more than two-thirds of the animals born of parents which have had several of these morbid conditions resulting from accidents, such modifications have shown themselves. The transmission by heredity of several of these pathological states may happen for generations, and has been proved to the fifth and even to the sixth generation.

These interesting facts have been confirmed since by Mr. E. Dupuy, who, further, has tried to explain them by an alteration of nutrition. One is astonished that none of the naturalists who have taken part in the discussion about the transmission of acquired characters so long carried on in NATURE, has thought to verify or even to discuss these facts.

After the preceding it seems to me that the partisans of Weismann's ideas have not paid sufficient attention to the marked reactions which certain somatogenic lesions may have on the modified organism, and in turn on the descendants.

Recently the botanists have given still more curious examples of the transmission of acquired characters. Certain somatogenic modifications produced by the slow action of parasites or symbions on various plants are capable of being transmitted by heredity. Scarcely four years ago Duval could write: "The oak and other trees have certainly borne galls since most primæval times, and yet nobody expects to see them produce inherited excrescences without the intervention of insects whose puncture is the origin of the galls." To-day that cannot be said of all galls and gall-like productions. Since then I have shown that, in a large number of cases, these productions profoundly modify the organism affected, and give rise to phenomena so singular that I have described them under the name of *parasitic castration* (*castration parasitaire*).

According to the excellent researches of A. N. Lundstroem, the deformations (*trichomes*), produced on the leaves of the lime and several other trees and shrubs by the prick of the arachnidans, are perfectly inheritable, even when those plants are grown protected from the parasites which have caused the modifications in the ancestors.

According to the researches of Treub and other botanists, the same is true for the singular transformations (*myrmecoccidies*), resulting from the action of the ants on several tropical plants.

Even whilst holding to the action of the most common primary factors, we believe we can establish in a stable fashion the transmission by heredity of somatic modifications. A certain number of acquired characters, which are specially revealed by somatogenic peculiarities, are moreover accompanied by correlative blastogenic modifications (and not merely consecutive as in the preceding cases) of such a nature that it becomes impossible to make the distinction proposed by Weismann, and these characters are justly considered inheritable by a majority of naturalists.

As in these examples the primary factors have modified at the same time the individual and the future product, the application of the principle of Lamarck cannot be disputed in the least degree. We invoke here the testimony of a naturalist, little suspected of partiality for the idea of evolution in general, and for Lamarck in particular. Godron, in his book "Sur l'Espèce et les Races chez les êtres organisés" (vol. ii. pp. 7, 8), tells how, according to Bishop Heber, dogs and horses taken from India into the Cashmere mountains become covered with wool; and how domestic animals in the tropics have their hair shortened and stiffened (sheep in Peru, Guinea, &c., merinos in South Sea Islands), or disappearing altogether (dog of Guinea, cattle of South America). The inverse action is not shown in our domestic animals brought from the tropics, which, says Godron, "proves that the action of climate is not always immediate or absolute."

Do not these last cases show that the modification produced is not due simply to the action of primary factors on the individuals, but that the blastogenic properties have been equally affected, and it follows that the principle of Lamarck finds its application?

Finally, if for certain plants modified, be it by their habitat among the mountains, or by their habitat on the sea-shore, the return to the normal type may take place the first generation; one knows that there are others with whom this return cannot be effected until after a long series of cultures. What cultivator does not know that there is a chance to keep up any race by taking for progenitors only the individuals showing most markedly the characters of that race? While in most cases the domestic races have been produced simply in view of the modifying of certain somatogenic characters, the breeder at the same time has produced unconsciously the correlative blastogenic modifications which insure the transmission of these somatogenic peculiarities.

But while there is acting the primary factor of the ethological reaction, that which Lamarck specially had in view, we may prove also the transmission of acquired character, or, if one prefers to employ Weismann's terminology, the concomitance in the parent of somatogenic modifications and of blastogenic modifications, destined to cause the reappearance in the off-

[1] Giard, "L'Autotomie dans la série animale" (*Revue Scientifique*, 1887, vol. xxxix. p. 629).

[2] See especially Brown-Séquard, "Faits nouveaux établissant l'extrême fréquence de la transmission par hérédité d'états organiques morbides, produits accidentellement chez des ascendants" (*Comptes rendus de l'Académie des Sciences*, March 13, 1882).

spring of somatogenic modifications of the same nature, even when the causative factor has ceased to act on the offspring.

Godron (*loc. cit.*, ii. 24), shows how the close relationship existing between muscles and skeleton makes any great change in the former affect the latter, and therefore the external appearance of the animal. The confinement of Brahmaputra and Cochin-China fowls prevents the use of the pectoral muscles, which become smaller, the wings also shorten, and the birds lose the power of flight, while the law of balancing of organs demands a development of the lower members. He also notes the change of shape of the horse according as it is used for riding or haulage; and the effect of continuous milking on secretions and development of mammifery organs of cows, and the diminishing of the udder and stoppage of milk-giving as the calf takes to cropping the grass, when continuous milking has ceased for several generations (*e.g.* on a return to wild conditions).

Among contemporary physiologists, Prof. Marey has insisted on the casual connection which exists between the animal mechanics and comparative morphology. While recognizing the importance of the facts already known, he has not ceased to demand new experiments for the purpose of knowing if the modifications one can produce on an animal by an exaggerated exercise of certain muscles cannot possibly be transmitted to its descendants. "One cannot yet affirm," he says, "but it is very probable, that the evolution theory will receive this last confirmation."

In this matter, as in many others, if evolutionists must content themselves in most cases with experiments unconsciously carried on in Nature, or those of breeders, instead of applying themselves to verifications made with all the rigour of modern scientific precision, is it not because of the deplorable insufficiency of our laboratories? One is astonished that in no country, not even where science is held in greatest honour, does there yet exist an *institut transformiste* consecrated to the long and costly experiments now indispensable for the progress of evolutionary biology.

The partisans of Weismann's ideas raise the objection that, in all the cases mentioned above, it is not the somatogenic character, but a blastogenic property, in virtue of which the descendant is susceptible of being impressed by the primary characters which determine that somatogenic character to the same and even to a superior degree to its parents.

This likeness, or rather harmony, between blastogenic modification and correlative somatogenic modification, is quite inexplicable if one will see nothing but a simple coincidence, accidental in origin, and fixed only later by selection. In reality, all takes place as if the somatogenic character were itself inherited, and putting aside all theoretical bias, it appears much simpler and more exact to explain the matter in this fashion. What else is it but heredity, this reappearance in the offspring at a given moment of physico-chemical or mechanical conditions, identical with those which have determined in the parent a morphological and physiological condition, resembling that which showed itself at a like moment in the progeny. Unless you attribute to the phrase *blastogenic modification* a mysterious and extra-scientific meaning, to speak of inherited blastogenic properties is simply to say that the order of the mechanical states which will be realized later in the development of a living being is already contained in the germ in a potential condition. Consequently, to say that at a given moment an animal inherits the possibility of losing its hair under the influence of heat, is equivalent to saying that it inherited the loss of hair which happened to its ancestors under the same conditions. When one goes to the root of the matter, the discussion becomes a simple dispute about words.

Besides, as Sir William Turner noted in a remarkable lecture on heredity, there are other facts which show that the separation of the reproductive and the somatic cells is not so absolute as Weismann and his followers seem to admit. If, in some animals, *Moina* for instance, the separation of the genital cells happens so precociously that they can already be distinguished in the first stages of the segmentation, one can affirm that in the majority of cases these cells come from somatic cells, and their plasma has passed through innumerable cellular generations before becoming the specialized sexual individuals of the colony.

In certain organisms, and particularly in plants, it even seems as if any somatic cell whatever is capable, in certain definite cases, of behaving like a parthenogenetic genital cell, and of completely reproducing the organism. Sachs has shown this for certain cells of the roots, of the leaves, and of the buds of several mosses.

One also knows when leaves of *Begonia* are cut, and the pieces grown in a hot-bed, one can get new stems which will bear flowers and fruits.

Undoubtedly it would be the same with some animals whose regenerating powers are highly developed (*e.g.* Turbellarians and certain Oligochætes) if one could nourish sufficiently the artificially separated bits. Theoretically one may say that each cell of a Planarian possesses in itself all that is needed for the reproduction of a new individual.

How is one to admit that a modification of somatic cells will not be followed by a correlative transformation of the product and of its blastogenic cells?

Variations produced by budding give us similar arguments, and show clearly the influence which the modification of certain somatic cells may have on other somatic cells and on the reproductive cells.

More interesting still, from the same point of view, are certain observations on the influence which the grafted subject may have, not only on the somatic elements, but even on the fruits of the graft. Darwin says:—

"Several North American varieties of the plum and peach are well known to reproduce themselves truly by seed; but Downing asserts, 'that when a graft is taken from one of these trees and placed upon another stock, this grafted tree is found to lose its singular property of producing the same variety by seed, and becomes like all other worked trees;'—that is, its seedlings become highly variable. Another case is worth giving: the Lalande variety of the walnut-tree leafs between April 20 and May 15, and its seedlings invariably inherit the same habit; while several other varieties of the walnut leaf in June. Now, if seedlings are raised from the May-leafing Lalande variety, grafted on another May-leaving variety, though both stock and graft have the same early habit of leafing, yet the seedlings leaf at various times, even as late as June 5" ("Animals and Plants under Domestication," 2nd ed., 1875, vol. ii. p. 247).

Inversely, the graft may communicate to the subject grafted certain somatic modifications with which it itself is affected. For instance, one knows that when one grafts the variegated variety of jasmine on the ordinary form, the latter sometimes bears buds with variegated leaves. The same is true of the laurel and of the ash. One has been able to produce even a half-breed of the graft, and perhaps the most curious are those obtained by Prof. Hildebrand at the request of Mr. Darwin. After having raised all the eyes of a smooth-skinned potato, and also those of a rough-skinned red potato, Hildebrand inserted them the one in the other reciprocally, and succeeded in raising two plants. Among the tubers produced by those two plants he found two red and scaly at one of their extremities, one white and smooth at the other, the intermediate portion being white and marked with red stripes.

These last examples bring us to cite facts of another nature, still insufficiently known to-day, but which seem to prove in an unexceptionable manner the influence of the somatic on the blastogenic cells. I am speaking of what Darwin called the direct action of the male element on the maternal form and even on the ulterior products.

"Even as long ago as 1729 it was observed that the white and blue varieties of the pea, when planted near each other, mutually crossed, and in the autumn blue and white peas were formed within the same pods." But this modification of the colour of the fruit may extend even to the husk, *i.e.* to the somatic cells of the maternal organism. "Mr. Laxton has cultivated the tall sugar-pea, which bears very thin green pods, becoming brownish-white when dry, with pollen of the purple-podded pea, which, as its name expresses, has dark-purple pods with very thick skin, becoming pale reddish-purple when dry. Mr. Laxton has cultivated the tall sugar-pea during twenty years, and has never seen or heard of its producing a purple pod; nevertheless, a flower fertilized by pollen from the purple pod yielded a pod clouded with purplish-red" (Darwin, *loc. cit.*, i. p. 428).

Numerous analogous examples of the action of the pollen of certain plants on the ovary of neighbouring varieties, have been collected by Gallesio, Naudin, Anderson, &c. Only recall the famous apple-tree of Saint-Valery, so carefully studied by Tillett of Clermont-Tonnerre. This tree did not produce pollen in consequence of the abortion of its stamens, and had to be artificially fertilized each year. The operation was done by the young girls of the district, by means of pollen taken from different varieties. Fruits of various varieties and sizes, colour and flavour, resulted, resembling the sorts which had furnished the pollen.

As the ovary of plants perishes after the production of the fruit, and presents transitory connections with the plant itself, it is not probable that the somatic modifications produced by the pollen extend to the cells of the branch or of the stem. For the same reason these modifications cannot have a reaction on the subsequent products.

But with animals, and especially with the Mammalia, where the fœtus is for a long time in intimate connection with the mother, one may suppose that the action of the male element will have an influence on the maternal organism first, and later on the subsequent descendant.

"In the case often quoted from Lord Morton, a nearly purely-bred Arabian chestnut mare bore a hybrid to a quagga; she was subsequently sent to Sir Gore Ouseley, and produced two colts by a black Arabian horse. These colts were partially dun-coloured, and were striped on the legs more plainly than the real hybrid, or even than the quagga. One of the two colts had its neck and some other parts of its body plainly marked with stripes. Stripes on the body, not to mention those on the legs, are extremely rare . . . with horses of all kinds in Europe, and are almost unknown in the case of Arabians. But what makes the case still more striking is that in these colts the hair of the mane resembled that of the quagga, being short, stiff, and upright. Hence there can be no doubt that the quagga affected the character of the offspring subsequently begot by the black Arabian horse" (Darwin, *loc. cit.*, i. p. 435).

Turner, who recalls Darwin's example, found the assumption that attributes the presence of the stripes to a reversion towards an ancestor common to horse and quagga too complex and hypothetical. He believes that the mother, while she had the hybrid in her womb, acquired from it the faculty to transmit the characters of the quagga, owing to the necessary nutritive changes during the development of the fœtus. The germinative plasma of the mother, belonging to the ovules not yet ripe, will have been modified in the ovary itself; and this acquired variation will have its reaction on the later-born individuals of the same mother.

The same explanation has been admitted by other physiologists for similar facts often proved by breeders and by hunters, for different domestic animals, and especially for dogs. Indeed, one knows that when a bitch has been covered for the first time by a dog of another breed, its subsequent offspring will show one or more little peculiarities belonging to that other breed, although she has been covered afterwards by dogs of her own race.

The accuracy of this hypothesis will be strongly restricted if, as certain observers, such as Mr. Chapuis, affirm, the influence of the first male also shows itself in the case of birds (pigeons) where the relations between the mother and the little ones are much less intimate than among the Mammalia. But, however it be with this explanation, the fact itself, outside of all theory, sufficiently shows the close connection which exists among the reproductive and the somatic elements.

In order not to leave the domain of facts scientifically established, or hypotheses susceptible of a more or less easy proof, I shall set aside the influences which impressions produced on the senses and nervous system of the mother may have on the offspring. The popular belief in these influences is very ancient, for we read in Genesis that Jacob placed rods whose bark was marked in various ways before his father-in-law's sheep, in order to get certain markings on the lambs which the ewes bore. But the antiquity of a belief is not always a proof of its accuracy, and I admit, with Weismann, that the cases quoted to prove the transmission of physical characters are not convincing, even in a case as curious as that of the mare of Baer.

Nevertheless, it seems to me very difficult to admit that the emotions and psychical impressions, which act so energetically and so evidently on all our secretions, have no influence on the products of the genital glands. Perhaps, outside the conditions of the surroundings and of education, which should be put in the first rank, one may attribute to an action of this sort the fact that all of one generation accept with the greatest ease the ideas which had been warmly combated and repelled by the preceding generation. It seems to me impossible that the intellectual movement caused by men of genius in one or more branches of human knowledge—a movement propagated and disseminated by men of letters and artists—has no reaction on the blastogenic elements of the contemporary generation, and consequently on the generation following, which thus will be prepared by hereditary transmission for an altogether new order of psychic modalities.

Finally, a last consideration leads us again to combat the opinion of those who maintain that acquired somatogenic characters cannot be transmitted from parents to infants. If, as already quoted from Turner, we push this theory to its final consequences, we are led to suppose that the ancestors of actual living beings, and the primordial protoplasm itself, possessed in themselves all the variations which have appeared since; and as, according to this hypothesis, the primary factors have acted only on the individual and not on the blastogenic elements (which alone can be transmitted), we must conclude that these possessed from the beginning, *i.e.* from the appearance of living matter, an evolutionary potency in a certain measure indefinite. We shall thus be led to the idea of creative forces, regulated, it is true, by selection. Thus again the door will be open to directing agents, immanent or outside of matter, and we shall require to renounce the grand mechanical conception of the universe, seen by Descartes, and followed up by the inquirers of the eighteenth century.

If, on the other hand, we admit the transmission of somatogenic characters in the measure proved by the facts cited above, the transformation of living beings will become much quicker, because it will not depend entirely on the chances of internal variation, but will be determined by the action of primary factors.

The *rôle* of selection and of secondary factors will remain most important, accelerating and regulating the transformation.

But before passing to the examination of secondary factors, we shall first study a biological phenomenon which we find whenever new organisms are produced—hereditary transmission. In explaining the production of these forms, whether we make use of the principle of Lamarck, the law of Delbœuf, or the selection of secondary factors, we have seen we always must admit the action of heredity.

Properly speaking, heredity is neither a primary nor a secondary factor. It is the integral, the sum of indefinitely small variations, produced on each anterior generation by the primary factors. The laws of heredity, hardly studied yet experimentally, offer a vast field for the sagacity of biologists. Several of these laws, and especially the law of homochronic heredity (*l'hérédité homochrone*), give good arguments for the principle of Lamarck. The most recent embryological researches begin to afford us a little insight into the mechanical process of hereditary transmission, and the deeper phenomena of reproduction.

It is only after carefully examining all the information acquired on these delicate matters that we can begin to study the secondary factors of evolution with profit.

THE INSTITUTION OF MECHANICAL ENGINEERS.

ON Thursday and Friday of last week, the 29th and 30th ult., the forty-fourth annual general meeting of the Institution of Mechanical Engineers was held in the theatre of the Institution of Civil Engineers, the latter society extending their usual hospitality to the sister Institution.

There were but two papers on the agenda, viz.:—On some different forms of gas furnaces, by Mr. Bernard Dawson; and on the mechanical treatment of moulding sand, by Mr. Walter Bagshaw, of Batley.

The fourth report of the Research Committee on Friction, which deals with experiments on the friction of a pivot bearing, was also down for reading, but time did not permit of it being taken. This was chiefly due to the fact that Mr. Macfarlane Gray proposed an alteration in the bye-laws, in virtue of which any full member who had paid thirty annual subscriptions—£3 each—should become a life member without further payment. This proposal received influential support in the course of a long discussion, but was nevertheless negatived on a division by a considerable majority.

The President, Mr. Joseph Tomlinson, occupied the chair on both evenings.

Mr. Dawson's contribution was one of considerable interest, and gave rise to a long discussion. The paper was illustrated by a large number of wall diagrams which covered the whole side of the theatre. The author treated his subject in a comprehensive manner, going into the question historically, and dealing with gas furnaces of almost all kinds; many of the types described being indeed only interesting from a historical standpoint, as they had not proved valuable from an economic point of view. As Mr. Dawson said, however, one often learns as much from failures as from successes; and it is necessary at times to know what to avoid in order to know what to imitate.

From what we have said it will be evident that we cannot hope to follow the author into his description of the many types of gas furnaces he deals with, both from limitations of space, and also from lack of the pictorial aids he had called in, by means of the diagrams, in describing the arrangements of the furnaces. We must therefore confine ourselves to the broad features of the paper, and refer those of our readers who wish to follow up this most interesting subject to the Transactions of the Institution.

The author commenced by stating that the greater number of gas furnaces in which crude heating gas has been successfully applied, have been of the reversing regenerative type. There are many processes, however, requiring temperatures below that maintained by the use of regenerators, and in these gas furnaces have also been used with success. It is also often an advantage to be able to concentrate in one spot the manipulation of all the fuel required in scattered furnaces. For these reasons, amongst others, it is often desirable to employ gas fuel when the cost of saving in fuel may be a secondary consideration. The annealing of steel castings, heating plates and angle bars, &c., are cases in point. On the other hand, there are cases in which a higher temperature is required, such as cannot be attained by combustion of gas with cold air, and in these continuous regeneration—as opposed to reversing regeneration—may be applied; the regeneration having the effect of recovering the heat from the waste gases. In either case the escaping gases must retain sufficient heat to secure the necessary draught; in fact regeneration may be carried too far. The author gives a useful word of warning on this point, some designers being of opinion that they cannot have too much of the good thing, regeneration. There have been many failures due to a want of appreciation of this point.

The author divides gas furnaces into four classes: (*a*) with reversing regeneration; (*b*) with continuous regeneration; (*c*) non-regenerative; and (*d*) with blowpipe or forced blast.

Furnaces with reversing regeneration (Class *a*) are of several different kinds. (1) The ordinary Siemens furnace, the arrangement of which is well known. (2) The Batho or Hilton furnace, in which the regenerators are above ground. (3) Furnaces in which the air only is regenerated, the gas being admitted direct. (4) Furnaces in which a portion of the waste heat is taken back to the producer.[1] (5) The regenerative blast-furnace stoves of the Cooper and Whitwell types.

In furnaces with continuous regeneration (Class *b*), the air is heated in flues by radiation or conduction from the bottom of the furnace, and through thin walls which separate the air-flues from the flues that carry the spent gases to the chimney.

In non-regenerative furnaces (Class *c*), the air is admitted to the furnace at atmospheric temperature.

The blowpipe or forced blast furnaces (Class *d*) are of two kinds: firstly, those in which air is supplied at atmospheric temperature by a fan; and secondly, those in which the air is heated by the spent gases by being passed either through coils or stacks of pipes, or else through brick tubes or flues.

For reasons already stated, we cannot follow the author into the details of the various types here broadly sketched. The classification is, however, valuable, and supplies a standard which doubtless will be followed by others when dealing with this subject of daily growing importance.

Before closing our brief abstract of this paper, we will repeat a quotation the author makes from an address of the late Mr. Holley, delivered sixteen years ago, as it does justice to the foresight of that great American engineer and metallurgist, to whom not only his own countrymen, but European engineers also, owe so much. In his Presidential address to the American Institute of Mining Engineers, Mr. Holley said: "Regenerative furnaces will gradually but inevitably take the place of the ordinary heating, puddling, and melting furnaces, thus preventing the application of unspent furnace heat to steam generation." It should be remembered that in those days the generation of steam was looked on, in the general metallurgical trades, as the proper and legitimate means of recovering heat from waste furnace gases. How ill the device served this end those who know the difficulties and dangers of furnace gas fired boilers will recognize.

[1] This is the new Siemens furnace which was fully described in a paper read before the Iron and Steel Institute, by Mr. John Head, in 1889.

The discussion on this paper was opened by Mr. Aspinall, the Superintendent of Mechanical Engineering to the Lancashire and Yorkshire Railway, who bore testimony to the successful working of gas furnaces in engineering practice at the company's works at Horwich.

Mr. John Head, who is connected with Mr. Frederick Siemens, also spoke at some length, in the course of his speech dealing with the new Siemens furnace, and giving instances of its successful working.

Mr. Smith-Casson, of Lord Dudley's Round Oak Iron Works, also gave interesting particulars of a furnace he had designed and erected. This furnace has overhead regenerators, a type which is now attracting a good deal of attention. It is interesting to note that Mr. Smith-Casson does not advocate overhead regeneration in all circumstances. It is a subject, he said, upon which he has still an open mind. As another speaker pointed out, there is this objection to an elevated regenerator, that the heated air naturally rises to the highest point, and therefore the circulation may not be as efficient as in cases where the regenerators are placed below the hearth.

Mr. A. Slater described a device in an ordinary boiler furnace in which iron retorts are placed at the back of the furnace bridge, and in these steam is dissociated and returns to the furnace for combustion of the gases. As Mr. Macfarlane Gray pointed out, this appears nearly akin to the perpetual motion theories; but a useful effect may be obtained by transferring heat from a place where it is not wanted to a place where it is. Mr. Slater said the application of this device gave a saving of 38 per cent. of fuel burnt, which only proves that Mr. Slater's boilers must have been of extremely bad proportions originally.

A good deal of the discussion turned on the burning of gaseous fuel in steam-boilers. In connection with this subject we cannot do better than quote a remark made by Prof. Alexander Kennedy. As to the saving of burning gas with regenerative furnaces in metallurgical operations, there can be but little divergence of opinion; but in the case of generation of steam, quite a different set of conditions will arise. In steel-making, for instance, it is necessary that there should be intense local heat, and the gases must leave the furnace at an enormously high temperature. In boiler furnaces intense local heat is to be avoided, and the products of combustion pass to the chimney comparatively cool. Thus a steam-boiler may show an evaporative efficiency or fuel economy so high that little more heat is left in the spent gases than is necessary to supply chimney draught, and in such a case regenerators would be useless. In metallurgical operations the efficiency of the furnace would be something absurdly low without regenerators, perhaps not more than 5 per cent. We commend these remarks to those visionaries who think that so much better results can be obtained by complicated gas-generating devices in steam-boilers, than by burning coal simply logically on a grate.

The paper of Mr. Bagshaw was of a nature which confined its interest chiefly to practical founders, and does not require extended notice at our hands.

The summer meeting of the Institution will be held at Liverpool during the last four days of July.

SCIENTIFIC SERIALS.

THE *Quarterly Journal of Microscopical Science* for January contains:—Studies on the comparative anatomy of sponges, by Arthur Dendy, M.Sc.: (3) On the anatomy of *Grantia labyrinthica*, Carter, and the so-called family Teichonidæ (plates i. to iv.). In the introduction to this paper the author refers to the large collection of sponges made by Mr. Bracebridge Wilson in the neighbourhood of Melbourne, during the last few years, numbering about 2000 specimens. This series, as well as the collection in the National Museum at Melbourne which has been placed at his disposal by Sir F. McCoy, he hopes to name and describe in time; but as such a work must extend over some years, he purposes from time to time to note new or important forms. The present paper describes a large and beautiful calci-sponge, originally described by Mr. Carter as *Trichonella labyrinthica*, but better located in the genus Grantia as defined by Vosmaer. It is very large for a calcareous sponge, well-grown specimens being about three inches in height and a little more in breadth. In adult forms there is a stout cylindrical stem surmounted by a greatly convoluted cup-shaped mass. Into the detailed description it would be impossible to enter; but in regard to the recent controversy about the existence of "Sollas's membrane" it may be mentioned that in this species this membrane remains visible even when the collars of the cells are retracted, thus indicating that it is probably a more or less permanent structure, and no mere temporary fusion of the margins of adjacent collars. As to the family Teichonidæ, it must be abandoned, and this branch of Lendenfeld's genealogical tree has to be cut off. (4) On the flagellated chambers and ova of *Halichondria panicea* (plate v.). In this study the minute structure of the above portions of this common British sponge are described from specimens killed with osmic acid. In this sponge the collared cells, when the chamber is seen in section, stand some little distance apart from each other. They have short nucleated bodies, surmounted by delicate funnel-shaped collars; these are all connected at their margins by a very distinct membrane, and the flagella of the collared cells were seen plainly projecting through the collars and into the cavity of the chamber; thus the question of the co-existence of Sollas's membrane and the flagella is settled. The ovum possesses a nucleus with a nuclear membrane and nucleolus, and it is suspended by a pedunculated envelope in the lacuna.—On *Megascolex cæruleus*, Templeton, from Ceylon; together with a theory of the course of the blood in earthworms, by Dr. A. G. Bourne (plates vi. to ix.). During a short visit in 1889 to Ceylon the author obtained thirty-eight species of earthworms; only seven of these have been found in India, and about twenty-nine Indian species have not yet been found in Ceylon. The author summarizes his theory of the circulation as follows: the vascular system consists of a portion in the cephalized region, and of other portions metamerically repeated in all succeeding segments. The cephalized portion differs only from that occurring in any other segment in having undergone a synthesis, and also in the presence of contractile hearts. Throughout the body, blood is forced from the contractile vessels into the peripheral networks; thence it is conveyed by a system of intestino-tegumentary vessels to intestinal capillaries, and from these it returns to the contractile vessels.—On a little-known sense-organ in Salpa, by A. B. Lee (plate x.). This organ, mentioned and figured by Ussow in 1876, seems not to have been since alluded to; Ussow's figures are very imperfect. The organ appears to be either a taste bulb, or as the author inclines to think, "a sensory areometer or hydrometric apparatus."—Immunity against Microbes (Part 1*a*), by M. Armand Ruffer.

Bulletin de la Société des Naturalistes de Moscou, 1890, No. 1. —Ornithological fauna of the Amu-daria region, from Tchardjui to Kelif, by M. Zarudnoi. The monograph mentions 159 species of birds, of which 138 nest within the region itself (116 in its cultivated part, 37 in the neighbouring desert, and 25 in towns). Hardly ten more species can be found which nest in the region. Many of the enumerated species are very scarcely represented. The deserts in the north of the Amu have almost the same bird-fauna as the Transcaspian region, although they differ as to their amphibians and reptiles; while further north, in Khiva, M. Bogdanoff found, as known, a much richer bird-fauna, probably due to the proximity of Lake Aral. The enumeration of species is accompanied by short notes relative to their habitats and feathering; some measurements are also given.—The system of chemical elements, by B. Tchitchérine (in French). This most valuable work, the importance of which was pointed out by Prof. Mendeleeff in his Faraday Lecture, is summed up for the *Bulletin*. The researches of the author into the numerical laws of the system bring him to a most interesting hypothesis relative to the structure of simple bodies; it evidently cannot be dealt with in a short note.—Studies as to the development of Amphipods, Part 4, by Mme. Marie Rossiiskaya-Koschewnikowa, being the history of development of the *Sunamphitoë valida*, Czerniawski, and the *Amphitoë picta*, Rathke (in French, with plates).—The Cladoceræ of the neighbourhood of Moscow, by Paul Matile (in German, with plates). The species *Daphnia dentata*, *Ceriodaphnia setosa*, and *Macrothrix borysthenica* are new.—Note on the Spongillidæ of the neighbourhood of Moscow, by W. Zykoff.

No. 2.—The Neocomian deposits of the Vorobievo Hills (near Moscow) by A. Pavloff (in French). The ferruginous sandstones and sands lodged between the Volgian (intermediate between Cretaceous and Jurassic) deposits and the ground moraine of the great ice-sheet are supposed to belong to the Cretaceous age, Wealdian, and Neocomian. The following fossils testify the Cretaceous age of the brown sandstone: *Olcostephanus* (*Ammonites*) *discofalcatus*, Lah.; *O. progrediens*, Lah.; *O. Decheni*, Röm. (not Weerth); and *Crioceras Matheroni*, D'Orbigny.—On the Turgaisk meteorite, by E. D. Kislakovsky. It was discovered by Kirghizes in 1888, when tilling the soil at Bish-tube, in the Nikolaevsk district of the province of Turgai, and consisted of two pieces—one about 70 pounds and the other about 36 pounds. The bigger one was bought by M. Nazaroff, who discovered also a third fragment (205 grammes) which was found some 3 feet north of the preceding. It has been given to the Moscow Society, and M. Kislakovsky's paper (illustrated by one plate) contains the results of its chemical analysis.—A catalogue of Lepidoptera of the Kazan province; Part 1, Rhopalocera, by A. Krulikovski (in Russian). The Lepidoptera of Kazan are very interesting, no fewer than 144 species of diurnal butterflies being already described by the author.—The *Tomicus Judeichii*, Kirsch., by Th. Teplouchoff (in German, with a plate). Its supposed identity with *T. duplicatus*, Sahlb., is discussed. Though formerly considered as a Uralian species, it has now been found all over middle Russia, as far as Courland.—On the history of development of *Hydrodictyon utriculatum*, Roth., by A. Artari (in German, with a plate).—Zoological researches in the Transcaspian region (continued), by N. Zarudnoi. Thirty-six species of reptiles and three amphibians are mentioned, and the catalogue of Mammalia and birds is completed according to observations made in 1889.

SOCIETIES AND ACADEMIES.

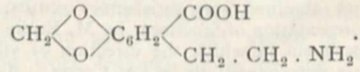
LONDON

Physical Society, January 16.—Prof. W. E. Ayrton, F.R.S., President, in the chair.—The thanks of the meeting were unanimously accorded to the Maxwell Memorial Committee for presenting to the Society a copy of Maxwell's scientific papers. —Prof. G. M. Minchin read a paper on Photo-electricity. His experiments on the subject were commenced in 1877, in attempting to produce a photographic image of a distant object. The result sought for has not hitherto been obtained, but the experiments have led to the discovery of many interesting phenomena. Some of these were shown to the meeting. Electric currents are produced by the action of light on silver plates coated with collodion or gelatine emulsions of bromide, chloride, iodide, or other silver salts, or with eosine, fluorescine, and other aniline dyes, when the plates are immersed in a suitable liquid and one plate illuminated whilst the other is screened. The directions of the currents depend on the materials employed, and the blue end of the spectrum is most effective. Currents have a photographic effect on the plates, and this action is strictly confined to the parts through which the current has passed. Comparatively strong currents were obtained from plates coated with eosine and gelatine. A curious reversal was observed with some cells, the exposed plate first being positive to the screened one, and almost immediately afterwards became negative. On shutting off the light, a transient increase of current resulted, and afterwards disappeared gradually. M. Becquerel, who has studied the action of silver plates coated with bromide, &c., concludes that the nature of the exposed plate (whether positive or negative) depends on the thickness of the surface layer. The electromotive force of such cells rarely exceeds $\frac{1}{20}$ of a volt. Uncleaned tinfoil plates in common tap water give a current when one is exposed to light and the other screened. Cleaning the plates destroys the effect. In nearly every case the exposed plate was first positive, and after a time became negative; and, by exposing various parts of a plate (some portions of which had been previously exposed), the currents could be varied in direction at will. These peculiarities may explain the known divergence of tin from Volta's law. The phenomena have also been studied by aid of the electrometer. Tinfoil obtained from tobacco packages was found to be very sensitive to light. One side of such foil is dull and the other bright, and, by pasting slips of it on opposite sides of a glass plate, so that dissimilar sides were outermost, and immersing them in alcohol, a cell giving an E.M.F. of $\frac{1}{10}$ volt when the dull side was exposed to light was obtained. The addition of any salt to the liquid, with a view to diminishing the resistance, invariably reduced the E.M.F. Experiment showed that the alcohols were by far the best liquids to use with tin plates. A process for producing very sensitive tin plates was described, which apparently results in the formation of white oxide of tin on the surface of the foil. With one such plate and another unsensitized plate the best results have been obtained by immersing them in methyl alcohol prepared from oil of wintergreen. From experiments on the variation of E.M.F. with the intensity of light, it was found that the square of the E.M.F. is proportional to the intensity. Some tin cells behave in a very peculiar manner, for it often happens that a good cell will exhibit no E.M.F. after being kept a few days. A slight impulse or tap given to the cell or its support restores the sensitiveness; another impulse makes the cell unsensitive, and these effects can be repeated indefinitely. Such cells the author calls "impulsion cells," and some were exhibited at the meeting. The sensitive plate of one of these cells had different properties at its two ends, for impulses had no effect on the nature of the lower end, but changed the upper end from positive to negative and *vice versâ*. Electro-magnetic impulses such as produced by sparks are capable of altering cells from the unsensitive to the sensitive state, but fail to produce the reverse effect; a Hertz oscillator restored the sensitive state in a cell placed at a distance of 81 feet away. The "impulsion effects" can be got rid of by renewing the alcohol on several successive days. During last year the author made some selenium cells by spreading the melted substance on metal plates and immersing them in liquids together with an uncoated plate. Of the various metals and liquids tried, aluminium and acetone gave the best effects. The process of forming these "seleno-aluminium cells" was described. One of their peculiarities is that they are nearly equally sensitive to rays of all colours; and when exposed to strong light may give an E.M.F. of $\frac{1}{2}$ to $\frac{3}{5}$ of a volt, the sensitized plate being negative. An arrangement of 50 cells in series with an electrometer was exhibited, whereby the E.M.F. generated by light falling on the cells could be caused to ring a bell, light or extinguish electric lamps, &c. In conclusion, the author pointed out the possible applications of photo-electricity to photometry, telephotography, and the utilization of solar energy. At the request of the President, Prof. Minchin promised to show the experiments on February 13, on which date the discussion on the paper is to take place.—Prof. F. R. Barrell exhibited and described a lecture-room apparatus for determining the acceleration due to gravity. A number of iron balls are allowed to fall through a certain height in such a way that one starts off when its predecessor arrives at its destination. From the time occupied by all the balls, the time for one can be found, and, knowing the distance traversed, *g* can be determined. The apparatus consists of two electro-magnets joined in series with a battery and key, together with a ball-feeding device. One of the magnets is vertically over the key and serves to catch the balls as they emerge from the feeding tube, whilst the other magnet actuates a kind of slide for supplying successive balls. When one ball falls on the key, it breaks circuit, and thus causes the first-mentioned magnet to let go its ball. The key then springs up again, thus making circuit; the feeding magnet then supplies another ball, which is caught by the holding magnet until the falling ball reaches the key, and the operations are repeated. Fairly accurate results can be obtained by the apparatus.—Sir John Conroy's paper on the change in the absorption spectrum of cobalt glass by heat was postponed.

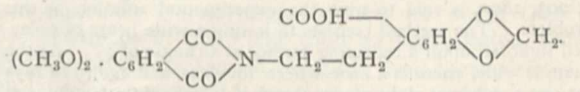
Anthropological Institute, January 27.—Anniversary Meeting.—Dr. John Beddoe, F.R.S., President, in the chair.—The following gentlemen were elected officers and Council for the ensuing year:—President: Dr. E. B. Tylor, F.R.S. Vice-Presidents: E. W. Brabrook, Hyde Clarke, and F. W. Rudler. Secretary: C. Peek. Treasurer: A. L. Lewis. Council: G. M. Atkinson, H. Balfour, C. H. E. Carmichael, Rev. Dr. R. H. Codrington, J. F. Collingwood, Dr. J. G. Garson, H. Gosselin, Sir Lepel Griffin, K.C.S.I., T. V. Holmes, H. H. Howorth, M.P., R. Biddulph Martin, Rt. Hon. the Earl of Northesk, F. G. H. Price, Charles H. Read, I. Spielman, Oldfield Thomas, Coutts Trotter, Sir W. Turner, F.R.S., M. J. Walhouse, General Sir C. P. Beauchamp Walker, K.C.B.

Edinburgh.

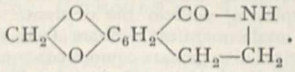
Royal Society, January 19.—The Hon. Lord Maclaren, Vice-President, in the chair.—Prof. W. H. Perkin, Jun., read a paper on berberine. The alkaloid berberine, $C_{20}H_{17}NO_4$, yields, on oxidation with potassium permanganate, a number of substances, of which the more important are: oxyberberine, $C_{20}H_{17}NO_5$; dioxyberberine, $C_{20}H_{17}NO_6$; berberal, $C_{20}H_{17}NO_7$; anhydroberberilic acid, $C_{20}H_{17}NO_8$; and berberilic acid, $C_{20}H_{19}NO_9$. The study of these substances has given many results which afford a very clear insight into the constitution of the alkaloid. Anhydroberberilic acid dissolves in alkalies, forming a salt of berberilic acid; and this latter substance, when boiled with dilute sulphuric acid, is decomposed into hemipinic acid $(CH_3O)_2C_6H_2(COOH)_2$, and a new base, $C_{10}H_{11}NO_4$, which was shown to have the constitution



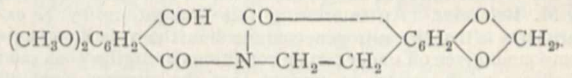
The constitution of anhydroberberilic acid is, therefore,



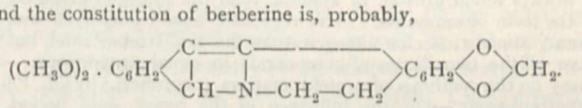
Berberal is decomposed by boiling with dilute sulphuric acid into pseudopianic acid, $(CH_3O)_2C_6H_2\left\langle\begin{matrix}COH\\COOH\end{matrix}\right.$, and a substance, $C_{10}H_9NO_3$, which is the internal anhydride of the base, $C_{10}H_{11}NO_4$, described above, and which, therefore, has the constitution



The constitution of berberal is represented by the formula—



and the constitution of berberine is, probably,



A detailed account of these experiments has appeared in the Journal of the Chemical Society (1889, p. 63, and 1890, p. 992).—Dr. Thomas Muir read a paper on some hitherto unproved theorems in determinants. Symbols such as

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & a_6 \\ b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \end{vmatrix} = 0$$

indicate the vanishing of *all* the expressions whose vanishing is indicated by the component determinants

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \\ d_1 & d_2 & d_3 & d_4 \end{vmatrix} = 0, \quad \begin{vmatrix} a_1 & a_2 & a_3 & a_5 \\ b_1 & b_2 & b_3 & b_5 \\ c_1 & c_2 & c_3 & c_5 \\ d_1 & d_2 & d_3 & d_5 \end{vmatrix} = 0, \text{ \&c.}$$

Dr. Muir has proved directly that the law of multiplication of such symbols is the same as that of the multiplication of determinants, and he has applied this result to obtain the proof of various theorems in determinants which have been hitherto unproved, though known to be true.—Dr. Muir also discussed a problem of elimination connected with glissettes of the ellipse and hyperbola. Prof. Tait has proved that the glissettes of an ellipse, which slides on rectangular axes, can be obtained as glissettes of an hyperbola sliding on axes inclined to the former. The equation of the glissette, referred to the guides as axes, is obtained by the elimination of a variable quantity between two equations. In carrying out the elimination, Prof. Tait obtained an equation of the tenth degree. But Prof. Cayley had shown that the equation should be of the eighth degree; and therefore Prof. Tait's equation contained an extraneous factor. Dr. Muir has succeeded in determining this factor.—The Hon. Lord Maclaren read a paper on the equation of the glissette of the curve $\frac{x^n}{a^n} + \frac{y^n}{b^n} = 1$. He obtains two equations by elimination between which the equation of the glissette can be found.

PARIS.

Academy of Sciences, January 26.—M. Duchartre in the chair.—An isochronous pendulum, by the late Prof. Phillips. This was one of the last memoirs prepared by Prof. Phillips before his death. It contains a description of a method of rendering the oscillations of a pendulum perfectly isochronous by means of a small steel spring. M. Wolf has conducted a series of experiments with a view of testing the efficiency of the method, and has obtained very satisfactory results.—On the approximate representation of functions, by M. Emile Picard.—On a recent experiment in which the direction of vibration in polarized light is determined, by M. A. Cornu. A paper by Herr Wiener, contained in *Wiedemann's Annalen*, vol. xl. p. 203, 1890, is said to give the experimental solution of this problem. The method consists in letting a wide beam of polarized light fall upon a reflecting surface at an angle of 45°. As the beam is wide, there is a zone where incident and reflected rays cut one another at right angles; and if interference phenomena are produced in this zone, the direction of vibration of the polarized light must be normal to the plane of polarization and perpendicular to the direction of propagation. In order to find the nodes and ventral segments, M. Wiener has used an extremely thin photographic pellicle, so transparent that it will allow a free passage to the two waves which cross at its surface, and yet sensitive enough to receive impressions. By means of this exploring pellicle the existence of interference fringes has been made manifest.—Some facts relating to the history of the principal nitrogenous compounds contained in vegetable mould, by MM. Berthelot and G. André.—New observations on the volatile nitrogen compounds given off by vegetable mould, by M. Berthelot. An interesting fact brought out by the experiments is that the nitrogen contained in the volatile organic compounds given off under certain conditions by argillaceous sand is always much greater in amount than the nitrogen given off in the form of ammonia. The vegetable mould employed was twenty times richer in nitrogen than the argillaceous sand, but gave off the two classes of compounds in equal proportions.—Essay on the synthesis of proteid matters (peptones), by M. P. Schutzenberger.—On the influence of the recent cold period on some of the animals in the menagerie of the Muséum d'Histoire Naturelle, by M. A. Milne-Edwards. The author remarks on the acclimatization of various animals which are generally supposed not to be able to live through the cold experienced this past winter, and on the death from cold of indigenous animals living under the same conditions.—Observations of comets Zona and Brooks (II. 1890) made with the great equatorial of Bordeaux Observatory, by MM. G. Rayet and Picard. Observations for position were made on December 8 and 28, and on January 6, in the case of Zona's comet. Brooks's comet was observed on January 7, 9, 11, 14, and 15.—On the personal equation in transit observations, by M. F. Gonnessiat. Two instruments have been utilized in the observations, having apertures of 57 mm. and 135 mm. respectively. The "eye and ear" and the "electrical" method have been studied concurrently; and various objects, from nebulæ to the sun, have been observed. In the former method the greatest plus value of the personal equation was 0·13s. for planets from 90″ to 20″ in diameter (second edge), and the greatest minus value was 0·02s. for stars of about the ninth magnitude. For faint nebulæ observed in a dark field having faintly luminous cross wires, the value reached +0·30s.—Arithmetical theorems, by M. H. Minkowski.—A purely algebraic demonstration of the fundamental theorem of the theory of equations, by M. E. Amigues. The theorem is that every complete algebraic equation with real or imaginary coefficients admits of at least a real or imaginary root.—On the movements of a double cone rolling on two guides, by M. A. de Saint-Germain.—On the resistance of the air to the movement of a pendulum, by M. G. Defforges. Commandant Defforges has determined the law of variation of the time and amplitude of oscillations executed by pendulums employed in geodetic operations, in terms of the pressure of the surrounding fluid.—On Huygens's principle, by M. A. Potier.—A theorem having reference to the calculation of certain electrical resistances, by M. C. E. Guillaume. The author considers the effect of the plugs of a resistance-box upon the values of resistances derived from it.—Researches on the application of the value of rotatory power to the determination of the combinations formed by aqueous solutions of malic acid with white alkaline phospho-molybdates, by M. D. Gernez.—On the conductivities of isomeric organic acids and their salts, by M. Ostwald.—Reply to M. Ostwald's note, by M. Daniel Berthelot.—Electro-metallurgy of aluminium, by M. A. Minet. An ingot of aluminium was exhibited which had been obtained by the electrolysis of aluminium fluoride, with an electromotive force of about four volts.—Employment of the calorimetric bomb for the determination of the heat of combustion of coal, by M. Scheurer-Kestner.—The mordants employed in dyeing, and their relation to Mendeleeff's periodic law, by M. Prud'homme. The author establishes a relation between the shades of colour obtained by fixing dyes with different metallic oxides, and the atomic weight of the substance employed. The shades, therefore, vary in a manner which follows the periodic series of the elements.—Experimental researches on tetanus, by MM. Vaillard and H. Vincent.—Chemical theory of the coagulation of blood, by MM. M. Arthus and C. Pagès.—Note *à propos* of diabetes, by M. H. Arnaud.—On the development of muscular fibres, by M. Louis Roule.—The vision of Gastropods, by M. Victor Willem.—Influence of some internal causes on the presence of starch in leaves, by M. Emile Mer.—Contribution to the study of green Bacteria, by M. P. A. Dangeard.—Conclusions relative to the inclosures in the trachyte from Mont Dore, by M. A. Lacroix.—Influence of the nature of soil on the conduction of heat, by MM. Ch. André and J. Raulin.—On the barometric pressure at Naples at different altitudes, by M. Eugène Semmola.—A magnetic perturbation exactly coincident with the earthquake observed at Algiers on January 15, by M. Moureaux.—On the method of correction of temperature for the emergent stem of a mercury thermometer proposed by M. Guillaume, by M. Renou.

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