THURSDAY, APRIL 19, 1877

AGRICULTURE IN THE UNITED STATES

Report of the Commissioners of Agriculture of the United States of America for the Year 1875. (Washington, Government Printing Office.)

THE first impression that strikes us upon taking up this substantial volume is closely allied to envy. Here is a fund of valuable and condensed information relating to every point connected with the development of the soil's resources, a record of original work and of experience at home, and abounding in suggestions from the practices of other countries. It is true we have to some extent, in the excellent transactions of our great agricultural societies, a means of presenting a digest of agricultural progress. But these are, and must to some extent be, written in popular style, whereas the Report before us, while deeply interesting, is essentially business-like and proportionally more useful to those whom it concerns.

It may be thought by many that a new country, of boundless extent like America, can scarcely have advanced to a stage in agricultural progress demanding the assistance of science; that the breaking up of virgin tracts by adventurous settlers is scarcely an occupation to elicit sympathy on the part of the workers in microscopic examinations and chemical analyses. Such is, however, not the case. "Farmers and planters," we are told, "now realise that there is something else in this important work beyond the mere drudgery of sowing, reaping, and curing;" and again, "the general awakening of interest in agricultural subjects has induced a considerable correspondence with the botanical division," as well as with the chemical and other departments.

The Report of the Commissioners includes those of the statistician, the entomologist, and the chemist; and besides these departments, details are given of the labours of the Horticultural, Botanical, Seed, and Microscopic Sections. The report of the statistician reveals the immense extent of cultivated land in the United States. Close upon 45,000,000 acres of maize, producing 1,321,000,000 bushels of corn account for the cheap rate at which this commodity has recently been offered in this country. The vast area of 26,381,512 acres of wheat producing, in 1875, 292,000,000 bushels, also throws light upon some of the difficulties of competition which now perplex the English wheat-grower. Here is a supply of wheat capable of feeding 53,000,000 human beings for one year, and, to put it in another light, grown upon eight times the area devoted to this purpose in Great Britain. The total population of the States is 38,115,641, so that they not only are able to feed themselves, but to export a sufficient amount to maintain the population of Great Britain nearly half a year.

The report of the Entomologist upon *Heteroptera* or "plant-bugs," contains a large number of illustrations and short descriptions of many species, some of which are injurious, while others, owing to their carnivorous tendencies, are beneficial. This information is followed with practical directions for coping with insect pests, which, if not novel, are at least useful. In the chemical section the effect produced by various mineral substances upon growing vegetables when added to the soil have been demonstrated by Mr. Abram McMurtrie. The deleterious effect of arsenical compounds has been tested upon plants grown in pots, and the results are vividly brought before the reader by illustrations showing the comparative sizes attained by the plants experimented on. The agriculturist is not as interested in substances detrimental to plant life as in those which produce an opposite effect. The lesson taught by such experiments is, however, exceedingly useful, for there is, no doubt, great room for experiments upon growing plants so placed that the surrounding conditions of soil, air, and water may be regulated with a special purpose in view.

A considerable section in the middle of the volume is occupied with an account of the sheep exhibited in the Vienna Exhibition of 1873. The information is no doubt highly useful, as it gives the American reader a graphic idea of the various breeds of English and Continental races of sheep. The ample details regarding the Merino sheep are chiefly taken without acknowledgment from a report contributed by Prof. Wrightson to the Journal of the English Agricultural Society, and are therefore familiar to English readers.

After 150 pages upon "Statistics of Forestry" and varieties of fruit, there is an interesting account of the method of curing forage by *ensilage*. This process consists in burying green fodder in pits (*silos*) or trenches, and covering it with earth. The process is applied to green maize, rye, rye-grass, rape, red clover, and autumnal vetches. It is impossible in a short notice like the present, to give a description of the method pursued, but there is no doubt that it is practicable. M. Crevat, after several years' trial, has settled upon pits of the following dimensions. Depth 7·55 feet, length 28·25 feet at the surface of the ground, sloping down to 24·28 feet on the bottom; breadth 8·53 feet at the top, and 6·56 feet at the bottom. Each pit has a capacity of about 1,412⅗ cubic feet, and appears capable of holding about 10½ tons of green fodder. There appear to be many modifications of the process, some farmers partially drying the fodder before pitting it, while others prefer pitting it fresh. Contrary as this may appear to our usual system of carefully drying hay before carting it, the general adoption of this method of storing fodder in many continental countries proves that green fodder may be preserved if firmly trodden down so as to exclude the air. The same plan succeeds admirably with sugar-beet pulp which may be kept in pits for any length of time. English farmers preserve brewers' grains by trampling them firmly into large vats, and, at the same time, sprinkling salt among them. Salt is also frequently employed in the process of *ensilage*, or making sour hay, but as often the process is completed without its assistance. The report of the Commissioner certainly throws light upon the subject, which we think deserves the attention of English agriculturists, and especially of colonists.

The general interest in scientific agriculture is remarkably evinced in America by the large number of agricultural colleges. There are no fewer than thirty-nine agricultural and mechanical colleges attended by 3,703 students and taught by 463 professors. When it is remembered that the total population of the States is only fractionally larger than our own, the fact of the existence of nearly 4,000 agricultural students is somewhat startling. In this country we have one agricultural college supported by less than 100 students. Yet we are the possessors of the most extensive colonies in the world, far exceeding, in extent, even the vast area of the United States. It may well be difficult for English agriculturists to compete with foreign rivals if the meagre number of agricultural students in England compared with America may be taken as in any degree a gauge by which interest in scientific progress may be measured.

CUMMING'S THEORY OF ELECTRICITY

An Introduction to the Theory of Electricity. By Linnæus Cumming, M.A. (London: Macmillan and Co., 1876.)

MR. CUMMING deserves our thanks for having made an effort to introduce into elementary teaching the advances in the treatment of electricity made chiefly by the labours of Green, Thomson, and Clerk-Maxwell. Mr. Cumming possesses all the qualifications necessary for such a task. He evidently has a full knowledge of the subject, and seems to possess, in addition, experience as a teacher. He has had, no doubt, great difficulties to encounter. These difficulties are not alone due to the limitations as to the mathematicial knowledge of his readers, which Mr. Cumming has justly imposed on himself. The books and papers out of which Mr. Cumming had to take his material, were written from various points of view, and they were chiefly addressed by scientific men to scientific men. It was natural that the same words should not be always used exactly in the same sense, the great object being that men already possessing a knowledge of the subject should understand each other. It is only when the knowledge of a certain subject is comparatively advanced that the terms settle down into a definite meaning. A text book, on the other hand, is addressed to students who at the most have only a slight acquaintance with the subject, and it should not only teach that particular subject, but also scientific method, and scientific reasoning. It is, therefore, of primary importance that the precise meaning of the term should be scrupulously adhered to. Even a good definition does not always ensure this, for there is often a metaphysical colouring which does not come out in the definition, but which we soon discover in the way a term is used. We take one example. The word potential is defined by Sir Wm. Thomson thus:—

"The potential at a point is the work which would be done on a unit of positive electricity by the electric forces if it were placed at that point without disturbing the electric distribution, and carried from that point to an infinite distance."

Nothing could be more precise than this, yet the word potential will call forth different associations in different minds, and this will greatly influence the way in which the word is used. Some writers will attach no meaning to the potential at a point, except in so far as they can imagine an electrified particle to be placed at that point, to others the expression will convey a perfectly definite meaning, defining the state of the medium at that point, irrespective of any electrified particle which might be placed there. It will generally be soon found out in what sense the writer uses the word.

The passage in Mr. Cumming's book which has suggested these remarks, is contained in Prop. 8, p. 203. The proposition runs thus:—

"In computing the potential of any closed circuit, we may substitute for it any closed circuit which is obtained by projecting the given circuit by means of lines of force."

The expression potential of a circuit may perhaps have sometimes been used for the induction or number of lines of force through a circuit; yet we imagine the term suggests rather the idea of action at a distance, and would be analogous to substituting in electro statics the expression "potential *of* a point" for that generally used—"potential *at* a point." Mr. Cumming has so consistently adopted the views and language of Faraday and Clerk-Maxwell, that we have been struck rather unpleasantly by the passage. This is, perhaps, only a matter of detail, and we may here remark that Mr. Cumming might with advantage have bestowed more care on the wording of his propositions. On p. 40, for instance, an experimental law is given, and two exceptions are added. With very little trouble the law might have been worded so as to admit of no exceptions. Other examples might be given.

There is one feature in the book about which we should like to make a few remarks. An occasional allusion to hypothetical matters cannot of course be altogether avoided, yet we think that in books like Mr. Cumming's, which are intended to give an outline of what is known, and not of what is unknown, of the subject, such allusions should be reduced to a minimum.

On p. 119 five propositions are given on molecules and atoms, which are not alluded to throughout the book except in the following passage:—

"From the last statement it can be easily seen that when the molecules of two different solids impinge on each other, as at the surface of contact, they cannot accommodate themselves to each other's motion, but constrain each other, this constraint producing a loss of energy. If, however, the two solids are of the same kind and at the same temperature, the molecules on each side of the surface of contact are swinging in exactly the same manner, and can easily accommodate themselves to each other's motion without more constraint than exists in the solid part of either body. It is this loss of energy owing to the unsymmetrical swinging of the molecules at the surface of contact which reappears as difference of potential between the two solids, or as the energy of electrical separation.

"The opposed electricities so separated will, for the most part, be heaped up on either side of the plane of separation by a Leyden jar action."

In the same chapter Mr. Cumming gives his opinion on the theory of the voltaic cell and electrolysis in general. We are told how we might imagine the atoms and molecules to be placed; we are told about polarisation; but Faraday's laws are not even alluded to.

It would, of course, be an advantage to science if Mr. Cumming were to take an active part in the theoretical and experimental investigation of the subject; yet we doubt whether a text-book on the theory of electricity is the best place to bring his views forward, especially if they are in contradiction to the best experiments we have on the subject (Sir William Thomson's). A teacher ought to be spared as much as possible from having to tell his students that he does not agree with the writer of a text-book.

The parts of Mr. Cumming's book which we have ventured to criticise refer chiefly to matters of taste. There is no doubt that in the hands of a good teacher the book will prove very useful. We hope that it will have a wide circulation, and that a second edition will soon enable Mr. Cumming to introduce such improvements as on a reperusal of his own book may occur to him.

ARTHUR SCHUSTER

OUR BOOK SHELF

Proceedings of the London Mathematical Society, vol. vii. November, 1875, to November, 1876. (London: Messrs. Hodgson and Son, Gough Square.)

IN the present volume we have about thirty communications made by eighteen writers. Prof. Cayley writes on Three-bar Motion (treating the matter in a different way from that in which it is handled in this same volume by Mr. S. Roberts, the priority of whose results is conceded by Mr. Cayley) on the Bicursal Sextic; Prof. H. J. S. Smith contributes short papers on the value of a certain Arithmetical Determinant and a Note on the Theory of the Pellian Equation; Lord Rayleigh has a note on the Approximate Solution of certain Potential Problems; Mr. Spottiswoode writes on Determinants of Alternate Numbers, working out some suggestions of Prof. Clifford. This last-named gentleman contributes the transformation of Elliptic Functions with a Note, and Free Motion under no Forces of a Rigid System in an *n*-fold Homaloid.

In Analysis, there are further papers by Mr. J. W. L. Glaisher on an Elliptic Function Identity, and the Summation of the Geometrical Series of the *n*th Order as a Definite Integral; Prof. Lloyd Tanner on the Solution of Certain Partial Differential Equations of the Second Order (two papers); Mr. J. Hammond on the Relation between Bernouilli's Numbers and the Binomial Coefficients, and on the Mean of the Products of the Different Terms of a Series; Mr. T. Muir on the Transformation of Gauss's Hypergeometric Series into a Continued Fraction; Mr. S. Roberts a Further Note on the Motion of a Plane under Certain Conditions; Mr. Hewitt on a Theorem of Eisenstein's.

Under the heading of Geometry we may class Prof. Rudolf Sturm's paper on Correlative Pencils; Mr. A. B. Kempe's General Method of describing Plane Curves of the *n*th Degree by Linkwork; Prof. Wolstenholme's Loci Connected with the Rectangular Hyperbola.

There are a few shorter communications. We have said enough to give our mathematical readers an idea of the range of subjects treated in this volume. The names of the authors are a sufficient guarantee that the subjects are ably treated and brought down to the latest accepted results.

A Primer of Chemistry, including Analysis. By Arthur Vacher. (London: J. and A. Churchill, 1877.)

THIS little book attempts to present within the limits of a hundred pages "a general view of the elements of inorganic chemistry." It embodies the experience gained by the author during ten years in which he has been engaged in teaching the subject, and the result is that many points are treated in somewhat novel fashion. The subject is considered as fully as could be expected within the narrow limits mentioned, and the amount of information conveyed is really considerable and generally accurate.

The first sixty-seven pages contain chapters on "Experiments with some of the Elements," "The Use of Symbols" in formulæ, equations, and calculations, "Experiments with some Compounds," "Weights and Measures," "Classification of Compounds," and "List of Substances." The remaining thirty pages or so are devoted to Qualitative Analysis.

Perhaps the greatest novelty introduced is the use of the term *unit* instead of atomic or combining weight, so as to avoid using the terms *atom* and *molecule*, which the author thinks are "unsuitable for ordinary use among beginners;" and of *antimetal* instead of *radicle* (which latter by the way he incorrectly writes "radical"). It may be questioned whether the use of the term "unit" may not interfere with the conception of the meanings to be attached to "atom" and "molecule," which the pupil must gain afterwards. "Antimetal" is objectionable since all radicles are not antimetals; ammonium, for example, is a radicle which plays the part of a metal. Clearly the term is intended as equivalent to "acid radicle," or acid minus its basic hydrogen; it is never used in any other sense in the book, and its use with this restricted meaning may be advantageous, or at least free from objection.

Several items may be pointed out as requiring alteration or improvement; notably the following: that "a *compound*[1] is any substance which is not an element" (p. 11); that chlorine has a "*pale green* colour" (pp. 6 and 61); that oxygen is *insoluble* in water (pp. 39 and 56); and that $KMnO_4$ gives a *red* solution (p. 64). In working with test-tubes the student is several times directed to add "half an inch" of acid or water as the case may be. Of course it is evident what is meant, but test-tubes are of various sizes, and a large excess of acid or other liquid would be used if the directions were followed exactly with large tubes. On p. 77, "take the charcoal quickly to your nose" is another rather curious direction.

The analytical part of the book is the best; the tables throughout being reliable. The detection and separation of cobalt and nickel (Table III., p. 95) might be effected more quickly and easily by other methods than that given; and on p. 87, NO_3 as well as CrO_4 and Fe''' should be mentioned as decomposing H_2S. If these and several other minor improvements be made the "primer" will not be without value in imparting the rudiments of education in chemistry; and in these days when elementary text-books are becoming so numerous, may fairly count on being appreciated as it deserves by the class of students for whom it is intended.

W. H. W.

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. No notice is taken of anonymous communications.*]

Hibernation of Birds

IN NATURE (vol. xv., p. 465) there is a review of "Palmén on the Migration of Birds," and in the course of it the reviewer takes occasion to refer to what he calls the "hibernation mania" as one that is now and again revived, in spite of the fact that the migration of birds is fully proved, and that no evidence at first hand has ever been produced in favour of the supposition that birds ever lie dormant.

Having frequently heard my brother-in-law, Sir John McNeill, relate a circumstance which occurred to himself proving that swallows do occasionally lie dormant, I wrote to him asking him for the particulars. I now inclose his reply, which perhaps you will publish, as it may possibly elicit other evidence on the same matter.

Gilbert White's conviction that swallows do occasionally lie dormant in this country, was mainly founded on the fact that instances are not uncommon of swallows appearing suddenly

[1] A *chemical* compound being meant as is evident from the context.

during warm sunny days in winter, and again disappearing on the return of cold. This fact it is certainly very difficult to account for on any other supposition. ARGYLL

Argyll Lodge, Kensington, April 11

"In your letter received last night you tell me of an article in NATURE the author of which seems to deny that swallows ever hibernate, and asserts that no one has yet testified to the fact from his own personal observation. That, however, is a mistake, for I have stated and I now repeat that I have seen swallows in large numbers hibernating. The circumstances were these:—

"About twenty-five miles south of Teheran, the capital of Persia, there is a village called Kenara-gird near which is a stream of brackish water running in a deep bed with nearly perpendicular banks some forty or fifty feet high. Being largely impregnated with salt this stream is rarely if ever frozen, and in frosty weather is resorted to by flights of wild ducks. During a frost of unusual severity I went from Teheran to Kenara-gird, accompanied by Sir Henry Rawlinson, for the purpose of duck-shooting, the severity of the frost promising good sport. Having slept at the village we next morning followed the downward course of the stream along the north bank, and had proceeded about a mile, I should think, when we came to a place where there had quite recently been a small land-slip. The brink of the bank to the extent of perhaps twenty feet in length, and ten or twelve broad in the middle, tapering off to each end, had slipped, but had not fallen down the bank. Between this detached portion and the perpendicular face about ten feet high, from which it had broken off, we saw, to our great surprise, a number of swallows, not less, I am sure, than twenty or thirty, lying, as I at first supposed, dead, but on taking up one of them I found that it was alive but dormant; it was warm and its breathing was quite perceptible. I examined a considerable number, and found that they were all alive and breathing, but none of them gave any sign of consciousness. My attention was then attracted to the perpendicular face on our left, from which the slip had broken off, and which was perforated by a vast number of holes each about the size of a rat-hole. On looking into such of these as I was tall enough to see into, I found in all of them swallows in the same dormant state. I was able with finger and thumb to pull out swallows from several of these holes, and in each case found that the hole which penetrated horizontally a considerable way into the bank, contained more swallows in the same condition. In no case did I see one lying on another—they were all lying singly with their heads inwards, each head touching the tail of the bird before it. How far these holes penetrated into the bank, or what number of swallows each contained I did not ascertain, but it is plain that the original entrance to these dormitories, must have been in the external face of the portion that had slipped, which as I have stated, was, in the middle, from ten to twelve feet thick. The holes in the undisturbed portion may probably have been of equal or greater length, and if so the number of swallows hibernating there must have amounted to many hundreds."

Villa Poralto, Cannes, April 6

The Swallows and Cuckoo at Menton

THE swallow that arrived here on March 19 remained solitary until April 5. Early that morning a second arrived and entered the same room as the first. I saw them flying about together in the forenoon, and these two remain the only feathered occupants of that chamber. In the afternoon of the same day, however, a party of ten arrived and distributed themselves among the houses.

Madame Valetta, of whom I spoke in my previous letter (NATURE, vol. xv., p. 488), assures me that not during the last fifty years has one swallow preceded its fellows by so long an interval as this year; but perhaps it is only that her attention has not been drawn so much to the subject. It is certain, however, that unless more are yet to come, the swallows are this year fewer than ordinary by more than one-half. The opinion of the natives is that they have perished at sea.

I heard the cuckoo for the first time this year on April 1. But a lady had to'd me that she had heard it nearly a week before. DOUGLAS A. SPALDING

Cabrolles, près de Menton, France, April 13

Greenwich as a Meteorological Observatory

THE facts of observation appealed to by Mr. Eaton with the view of proving that Greenwich is, from artificial causes, more than half a degree warmer than the south-east of England generally, and is therefore not a suitable place for a meteorological observatory of the first order, evidently call for a closer critical examination than they have yet received. If from the sixteen stations within a radius of sixty miles from the metropolis given in the paper on "The Temperature of the British Islands," we omit those which are clearly inadmissible for the comparison with Greenwich owing to their position or to the short time during which observations were made, there remain the following eight stations as suitable for comparison:—Cardington, 52° 7′ lat. N.; Royston, 52° 2′; Colchester, 51° 53′; Hartwell, 51° 49; Oxford, 51° 46′; Great Berkhamstead, 51° 45′; Chatham, 51° 23′; and Aldershot, 51° 15′. The mean temperature of these eight stations, allowing for elevation, is 50°·6, and the mean temperature of Greenwich, 51°·1, results substantially agreeing with those given by Mr. Eaton.

It is necessary, however, to observe that the mean position of these places does not agree with that of Greenwich. Thus while the latitude of Greenwich is 51° 28′ north, the mean latitude of the eight stations is 51° 45′, or 0° 17′ farther north, their true mean position being about two miles due north of St. Albans. For this difference in latitude a correction of fully 0°·2 is required, judging from the position of the isothermal lines. The figures then stand thus: mean temperature of Greenwich, 51°·1; of the eight stations, 50°·8. On comparing the monthly means of the eight stations with those of Greenwich, it is seen that the residual excess of Greenwich is all but wholly occasioned by the high mean temperatures of June, July, August, and September, which are in each case 0°·9 higher than the means of the eight stations, these eight stations being nearly all outside or on the outskirts of the patch of high temperature around London during the summer months. It follows that the 0°·3 of excess of annual temperature at Greenwich over the eight stations is accounted for by the higher temperature of four out of the twelve months, and consequently cannot be due to artificial sources of heat in London, such as the consumption of fuel.

When drawing the isothermals of the British Islands seven years ago, no district of Great Britain occasioned so much trouble and uncertainty as the south-east of England, owing to the meagreness of the materials available for the purpose. Since, however, immediately to westward, the mean temperature of Oxford was seen to be 50°·4, Aldershot 51°·2, and Osborne 51°·8, it was inferred as the most probable state of the case that the mean temperature increased southwards over the south-east of England in the manner indicated by the annual isothermals accompanying the paper. This supposition was confirmed by the temperatures at Colchester and Chatham, the only two stations furnishing satisfactory data on the point, for while at Colchester, for instance, the mean temperature was 0°·5 lower than that of Greenwich, no less than 0°·4 of this difference was due to the lower temperature of the east coast at Colchester as compared with Greenwich during the five months beginning with December, when the temperature in the south of England increases from east to west.

The coast stations of the Channel could not be considered as furnishing authoritative evidence on the question, owing to the irregular distribution of their temperature, which seemed to indicate certain obscure and ill-understood causes in operation modifying the climates of that coast. The force of this remark will be apparent from the following mean temperatures:—Helston, 53°·9; Truro, 52°·2; Torquay, 51°·6; Sidmouth, 51°·1; Bournemouth, 51°·5; Ventnor, 52°·4; and Worthing and Eastbourne, both 50°·7. It is perhaps scarcely necessary to remark that it would be a mistake to attempt to draw any conclusion from differences of mean temperatures of different stations amounting to 0°·3 and under, seeing that the English observations generally were made with thermometers in protecting-boxes quite open on one side, and therefore exposed in varying degrees to indirect radiation from walls and other objects.

While Mr. Eaton has thus failed to prove from past observations that the consumption of fuel and the massing together of living beings in London has raised the mean temperature at Greenwich Observatory to the extent of half a degree, or indeed to any appreciable extent, above that of the south-east of England generally, it might nevertheless be well, seeing the question has been raised, to do something towards definitely answering it, by instituting at Greenwich and at about a dozen stations distributed over the south-east of England, observations of the temperature of the air, strict uniformity being secured by employing the same pattern of thermometer-box and by placing it under the same conditions at each place as regards height above the ground, the vegetable covering of the soil, and openness of situation. ALEXANDER BUCHAN

Edinburgh, April 9

THERE is one consideration which your correspondents, the secretary of the Scottish, and the president of the British Meteorological Societies have equally overlooked, and which may seriously affect the conclusions at which they arrive as to the suitability of Greenwich for a first-class meteorological station. Since the year 1846 the temperature observations at Greenwich have been made under conditions of exposure of thermometers which, whatever their merits or demerits, are not those usually adopted. In a paper published in the *Quarterly Journal of the Meteorological Society* (October, 1873) I have shown from the average of five years' daily comparisons that the effect of the method adopted at Greenwich upon the mean annual temperature is to obtain a result 0°·475 warmer than is obtained by the usual method. This quantity is almost identical with the excess which Mr. Eaton attributes to the local consumption of fuel, an explanation surely most inadequate. Thus the discrepancy pointed out by Mr. Eaton only serves to establish his opponent's case. Mr. Buchan on the other hand must be unaware that it is the eye observations alone, made from the revolving stand, that are relied upon for temperature results at Greenwich, and though his conclusion would seem to be correct it does not seem possible to sustain the argument by which he has arrived at it.

Orwell Dene, Nacton JOHN I. PLUMMER

Cast-Iron

I HAVE been struck by the statement I found in several books on physics that cast-iron expands when it gets cool. As some of these books are used as text-books in schools in this country, and as this statement is contrary to the experience of all practical men with whom I have conversed upon the subject, I think the following translation of an article which appeared in *Der Civil Ingenieur*, edited by K. R. Bornemann, in Freiberg, 1863, ix. Band, iv. Heft, p. 219, may not be uninteresting, explaining, as it seems to me fully, at least one of the facts on which the statement mentioned above appears to be based, viz., the fact that cold iron swims in liquid iron:— H. M.

"At a meeting of the Association of Saxon Engineers which took place in Freiberg in August last year (1862) Mr. H. Grüson, of Buckau, near Magdeburg, called the attention of the members to a phenomenon which had frequently been observed by him, but of which no proper explanation could be given at the time, viz., that pieces of cold cast-iron swim perfectly in molten iron. The question was raised, to what causes this may be due, and as from the physical point of view it was thought an interesting one, it was suggested that experiments should be made in order to obtain a proper explanation thereof.

"In consequence of this, M. Centner, Inspector of the Jacobi Iron-works, near Meisen, made such experiments, the result of which he communicated to the Association at a meeting on May 17, 1863. The following is an extract of Mr. Centner's report:— (Signed) W. TAUBERTH"

"Before anwering this question I made some experiments in order to ascertain whether this swimming is not caused by the specific weight of the body; by these I found confirmed that cold cast-iron weighs $\frac{1}{28}$ more than an equal volume of molten iron, for if a piece of cold cast-iron of 28 lbs. be used to form a mould, and if this mould be filled with molten iron, the new piece of metal thus obtained will only weigh 27 lbs. This weight, of course, is also that of the liquid metal which was required to fill the mould, formed from a piece weighing 28 lbs.

"For this reason, in making moulds for cast-iron, a measure is used which is $\frac{1}{96}$ longer than the ordinary measure, if the piece of iron to be formed is to have the full size of the ordinary measure.

"Repeated experiments with a mass of molten iron of 2,000 lbs. gave me further proofs that the causes of this swimming must be other than the specific weight.

"For my experiments I used four bodies of cast-iron of different shapes, but of the same volume, viz. a plate of 6″ inches in the square and 1″ thick, a cube of $3\frac{1}{3}$″, a cylinder of 4″ diameter, and 3″ height, and a ball of 4″ diameter. Each of these four bodies measured 36″ cube and weighed 7 lbs.

"If the cause of the swimming were the specific weight, an equal part of the volume of all these bodies ought to remain above the surface of the liquid iron, but such is not the case at all. The volume above the surface of the liquid iron is different in each of the four bodies; it is greatest with the plate and smallest with the ball. Thus it is dependent on the shape and position of the surface which rests on the liquid iron.

"In order to come to the real causes of this swimming, I must first remind the reader that in every hot liquid in an open vessel, in consequence of the more rapid cooling at the surface, a continuous current is originated, the interior hottest parts ascending and the exterior colder ones descending; and thus a more or less visible movement or agitation is produced in the mass. Such currents occur in every mass of molten iron, and are there especially remarkable in consequence of a contemporaneous ascension and separation of slags, which, when they have arrived at the surface, are generally pushed towards the edges.

"If a solid piece of iron be put on the liquid mass the former gets at once heated at the expense of the latter; the portions of water and of air which are contained in the solid piece get expanded and expelled with considerable force, thus forming a current in opposition to the ascending one above mentioned.

"This expulsion of air and water may even cause dangerous explosions, if the usual precaution is neglected to warm the solid piece somewhat, before it is brought into contact with the liquid mass.

"Now there is no doubt that these opposite forces alone are able to raise the heavier solid piece more or less according to the more or less favourable surface it presents.

"But besides this there is to be taken into consideration that the overweight of the solid piece of iron is diminished by the previous heating which when the solid piece comes into contact with the liquid, is at once augmented and that the proportion of heat of the molten iron to that of the solid piece must to some extent have an influence on the more or less deep immersion of the latter.

"A further cause, although a slight one, of this swimming of the solid piece is the cohesion of the liquid iron; but at any rate this becomes of some importance in conjunction with the above-mentioned continuous ascending of slags which collect under the swimming body and retain partly the air expelled by the latter, helping in this way to keep it afloat.

"Solid cast-iron being $\frac{1}{28}$ heavier than an equal volume of molten iron, the overweight of each of the four bodies used for my experiments is consequently only $\frac{1}{4}$ lb., and in the present case it is therefore only this one *quarter of a pound* which the above-mentioned opposite forces have to lift within areas of 12″ to 36″ square in order to keep the body swimming.

"On increasing the size of the solid bodies, however, it will be easily understood that a limit to this swimming will soon be reached, and indeed I accidentally found this limit on my first trial in quadrupling the sizes of the four bodies so that each of them weighed 28 lbs.; for all the bodies with the exception of the plate which was 12″ in the square and 1″ thick went to the bottom. The plate on being put gently on the liquid mass was just kept afloat, but its surface was a little below the surface of the molten iron. 1 lb. overweight therefore with a surface of 12″ in the square could scarcely be kept swimming.

"The behaviour of the other three bodies at the bottom was remarkable in consequence of a continuous vehement ebullition accompanied by the shooting out of long white brilliant flames, and these phenomena can only be attributed to the water and air expelled by the heat.

"These experiments with bodies of 28 lbs. weight show therefore that above this weight, without giving to the body a more favourable surface than 12″ in the square, these bodies do not what is properly called swim in the sense that part of the solid body is kept above the level of the liquid. For if the bodies, for instance the ball, the cube, and the cylinder on being moved, rise and fall a little alternately, this can no longer be called swimming, for it is just the transition from overweight to equilibrium.

"That the greater or lesser degree of density of the different sorts of iron will also exercise an influence cannot be doubted.

"Less fortunate but still interesting was an experiment which I made with four pieces of zinc of the same shapes as the pieces of iron on 200 lbs. of liquid zinc, when with the pieces of 7 lbs. each the same thing took place as with the cast-iron pieces of 28 lbs. each on liquid iron, viz., the plate was just kept afloat and the three other bodies went to the bottom.

"With zinc, therefore, this phenomenon of swimming does not occur with such heavy bodies as with iron, and this may be explained by the fact that with zinc, in consequence of the much smaller difference of temperature between the liquid and the solid body, the currents mentioned above with reference to the iron must necessarily be far less strong.

"With similar modifications according to the temperature required for their liquefaction the swimming takes place with all other metals."

Tycho Brahe's Portrait

IN NATURE (vol. xv., p. 406) is published a copy of a portrait of Tycho Brahe in the possession of Dr. Crompton of Manchester. Although it seems, from the inscription in the corner, that the portrait is a contemporary one, there does not appear to me to be sufficient reason for preferring this portrait, of the origin of which nothing whatsoever is known, to others of the same date. Both Tycho's "Epistolæ" and "Mechanica" contain an engraving by J. D. Geyn from the year 1586, and if the newly-discovered portrait really (as conjectured by Dr. Crompton) should have been painted to be engraved for the "Mechanica," it can hardly have been considered a good likeness, as the engraving by Geyn was preferred. The latter is very like the portrait on Tycho's large wall-quadrant, of which an engraving in the "Mechanica" gives us an idea, and which Tycho himself mentions with the following words:—"Hanc effigiem magna solertia expressit Thobias Gemperlinus eximius artifex (quem mecum Augusta Vindelicorum in Daniam olim receperam) idque tam competenter, ut vix similior dari possit." This portrait is from 1587.

The Royal Gallery at Frederiksborg (about twenty English miles from Copenhagen) contained a fine portrait of Tycho Brahe, which unfortunately was burned in the great fire in 1859, when so much of that beautiful castle was destroyed. It agreed on the whole with the two above-mentioned portraits, while the long narrow face on the Manchester portrait shows hardly any resemblance to the features on the others. I may also add, that the fine monument erected by Tycho Brahe's heirs in the church in Prague (Teinkirche), where he was buried (of which I have seen a copy in Copenhagen), is very like Geyn's and Gemperlin's engravings.

The article which accompanies the portrait in NATURE contains several small mistakes, which perhaps also occur in Brewster's "Martyrs of Science." Tycho was not born in Sweden but in Denmark, as the province of Schonen (with the island of Hven) belonged to the latter country from ancient times and up to 1660, and he was of an ancient Danish noble family. His castle was called "Uraniborg" (Latin Uraniburgum, the Celestial Castle), the Observatory "Stjerneborg" (Stellæburgum). J. L. E. DREYER

Observatory, Birr Castle, Ireland

Yellow Crocuses

CAN any of your readers elucidate this problem? When, a fortnight ago, the yellow crocuses flowered, the sparrows all at once made a terrible onslaught upon them. I found the gardener in Lincoln's Inn Gardens one day mourning over a fine line of crocus plants, every flower of which was in absolute ruins. All the work of the sparrows, he said. I have seen them, too, on the flower-boxes in my windows here frequently, tearing at the crocus blooms. Yet now, later, the blue and striped crocuses are blowing, and the sparrows leave them altogether untouched. What is there in the London bloom specially that attracts the London sparrow? The taste is, I think, peculiar to the town bird. In gardens at a distance from, and immediately around, London, I have watched plenty of yellow crocus blossoms, not one flower of which has been attacked.

Gray's Inn, April 6 ALFRED GEORGE RENSHAW

Tropical Forests of Hampshire

IN Mr. J. Starkie Gardner's lecture on The Tropical Forests of Hampshire (NATURE, vol. xv. p. 232), the following statement occurs which is open, I think, to considerable question:—"All the shipworms generally known to us live only in salt-water, and are so delicately organised that the slightest mixture of fresh-water instantly kills them." This sweeping assertion is partly qualified by allusion to the occurrence of a species described by Mr. George Jeffries as inhabiting fresh-water, and the fact of bored wood being found 300 miles up the Gambia River; still as Mr. Gardner speaks of these facts as a "theory" still in need of verification, I would point out that no waters are more infested with the shipworm than the deltas of tropical rivers wherein the water is often largely brackish if not potable.

My own experience is confined to the delta of the Irawadi, a tangled maze of creeks, the waters of which are brackish or salt for about a third of the year, and slightly so, and even potable, during the other months. The large canoes, however, which traverse these creeks are much injured by some species of shipworm, and so little does the easy remedy of exposing them to fresh-water answer, that the Birmese are in the habit of firing their bottoms from time to time; opportunity is taken of a high spring tide to get the boat well on shore. The ends are supported on blocks of wood, and a shallow saucer-shaped cavity is made underneath which is filled with straw or other combustible matter, which gives a fierce but short-lived flame. Fire is now applied and the bottom of the boat is for some minutes kept wrapt in flame, which steams the worms to death in their holes. I cannot recall any instances of bored wood well above the tide-way, but wherever the water is occasionally brackish, thus far the worms seem capable of settling. What species occur in Pegu I cannot say. Percival Wright has described *Nausitora dunlopei* from the rivers of Eastern Bengal, and it may not improbably extend to the Irawadi delta, as *Novaculina gangetica* and a species of Scaphula closely allied to the Gangetic species do. The two Birmese species of Scaphula are both estuary forms, whereas the type of the genus in the Ganges is found a thousand miles from the sea, which suggests the plasticity of some species, which if met with fossil would be unhesitatingly regarded as marine. W. THEOBALD,

Camp, Jhilum District Geological Survey of India

Hog Wallows or Prairie Mounds

IN NATURE (vol. xv., p. 274), Mr. Wallace quotes a letter from his brother in regard to the so-called Hog-wallows of California, in which their origin is ascribed to *débris* left at the broad foot of a retiring glacier modified by the erosion of innumerable issuing rills, and asks if this structure is known to occur elsewhere. As I have observed the same formation in many parts of the Pacific slope and have tried to explain it, I hope I may be allowed to say a few words on the subject.

The peculiar configuration of surface so well described by Mr. Wallace, is very widely diffused in America, and has been described under different names. In California the mounds are called *Hog-wallows*, but elsewhere they are known as *Prairie mounds*. This latter is the better name since they are found only in grassy, treeless, or nearly treeless regions. They occur over much of the Prairie region or "*plains*" east of the Rocky Mountains; also over portions of the *basin* region, *e.g.*, in Arizona; also over much of the bare grassy portions of California, *e.g.*, along the lower foothills of the Sierra and adjacent portions or the San Joaquin plains; also over enormous areas in Middle Oregon, on the eastern slope of the Cascade mountains, an undulating grassy region; also on the level grassy Prairies about the southern end of Pugit Sound, Washington territory.

They have been ascribed to the most diverse causes. In Texas, where they are very small, Prof. Hilgard thinks they are *ant-hills*. In Arizona, where they are also imperfectly developed, Mr. Gilbert thinks they are the ruined habitations of departed *Prairie dogs*. In some portions of California, also, where they are small, they have been popularly ascribed to *burrowing squirrels*. In the Prairies, about Pugit Sound, where they are splendidly developed, their great size and extreme regularity has suggested that they are *burial mounds*, and that the Prairies are veritable cities of the dead. It is possible that the cause may be different in different places, but I am sure that no one who has examined them in California, and especially in Oregon and Washington, can for a moment entertain any of these theories for the Pacific slope.

In a paper "On the Structure and Age of the Cascade Mountains," published in the *American Journal* for March and April, 1874, p. 167 and p. 259, among some miscellaneous points suggested by the main subject in hand, I discuss this one of Prairie mound. I there attribute them to *surface erosion under peculiar conditions*, these conditions being a *bare country* and a *drift-soil finer and more movable above* and coarser and *less movable below*. Erosion removes the finer top-soil, *leaving it only in spots*. The process once commenced, weeds and shrubs take possession of the mounds as the best soil, or sometimes as the driest spots, and hold them, preventing or retarding erosion by their roots. In some cases, perhaps in most cases, a *departing vegetation*, *i.e.*, a vegetation gradually destroyed by increasing dryness, seems to be an important condition. For my full reasons for holding this view I must refer the reader to my paper, but I may say in passing that in the bare hilly regions of Middle Oregon, on the east side of the Cascade Mountains, every stage of gradation may be traced from circular mounds, through elliptic, long elliptic, to ordinary erosion furrows and ridges.

Mr. Wallace asks in conclusion whether so extensive and uniform a deposit could be due to *glaciers* alone, or is it necessary to suppose *submergence?*

In answer I would say that nothing is to me more puzzling than the drift deposits on the Pacific slope, and I suppose the same is true everywhere. The prairies about Pugit Sound have evidently been submerged during the Champlain epoch, and I suppose the mound structure to have been formed after emergence, and the exceptional perfection of the mounds in that region may be due to this fact. But there is not the slightest evidence of submergence in the mound region of Oregon. All the high, bare, grassy, hilly, eastern slopes of the Cascade Mountains are covered evenly with a pebble and boulder drift, graduating upwards into a finer top soil. From this surface-soil are carved the mounds, which cover hill and dale so thickly that, viewed from an eminence the whole face of the country seems broken out with measles. This universal drift-covering, twenty to thirty feet thick over thousands of square miles, I know not what to call it, unless it be the *moraine profonde* of an ice-sheet.

JOSEPH LE CONTE

University of Cal., Oakland, Cal., March 6

OUR ASTRONOMICAL COLUMN

WINNECKE'S COMET, 1877, II.—In a note by Prof. Winnecke in M. Leverrier's *Bulletin* of April 13, it is remarked with respect to the elements of the comet discovered by him on April 5, "a great analogy exists between these elements and those of the comets 1827, II., and 1852, II., and it acquires a certain importance from the fact that the intervals are nearly equal."

The second comet of 1827 was discovered by Pons at Florence and Gambart at Marseilles, on June 20, and was observed at Florence until July 21; the original observations will be found in *Astron. Nach.*, No. 128. The best orbit is by Heiligenstein.

The second comet of 1852 was detected by M. Chacornac at Marseilles on May 15, and was observed at Vienna till June 8. On the suggestion of d'Arrest, the elements were calculated by Hartwig, without any assumption as to the eccentricity, and the resulting orbit proved to be a hyperbola, which, as d'Arrest remarked, rendered the identity of this comet with the second of 1827, which had been suspected by several astronomers very unlikely. Now, however, that a comet has made its appearance after a like interval with elements bearing a certain resemblance to those of the comets of 1827 and 1852, it may not be without interest to examine into the possibility of identity a little further. The elements of the three comets may be taken to be as follow:—

		1827, II.		1852, II.		1877, II.
T	...	June 7·84	...	April 19·58	...	April 18·14
π	...	297° 31′·7	...	280° 0′·6	...	252° 0′·0
☊	...	318° 10′·5	...	317° 8′·4	...	317° 51′·3
i	...	43° 38′·8	...	48° 52′·9	...	56° 42′·7
q	...	0·8081	...	0·9050	...	0·9283

The motion is retrograde.

It is evident from a comparison of the three orbits that if they applied to the same comet, great perturbation must have taken place between the successive returns, the line of apsides in particular having considerably retrograded, and the inclination of the orbit increased by several degrees. This suggests an examination of the path of the comet near the nodes with respect to proximity to the orbits of the planets.

Assuming the mean of the two intervals for the period of revolution, we have 24·93 years, and for the semi-axis major 8·5338, and taking as sufficient for our present purpose the perihelion distance of 1852, the angle of eccentricity is 63° 22′·4. Hence it will be found that the radius-vector at the ascending node is 1·0008, which is less than 0·013 from the orbit of the earth; but to bring the two bodies together at this point the passage through perihelion must take place about September 3, which is not the case in any of the above years. At the opposite node the radius-vector is 5·966, not so very much greater than the radius-vector of Jupiter in the same longitude as to forbid the hope of finding a much closer approach. Accordingly on calculating the distances at different points of the orbit about the descending node, it appears on the assumption we have made with regard to the period of revolution, that in heliocentric longitude 139° the comet would be distant from the orbit of this powerful planet only 0·15 of the earth's mean distance from the sun, and it would arrive in this longitude about 480 days after perihelion passage, and therefore at the end of September, 1828, and the middle of August, 1853, but at these times the heliocentric longitude of Jupiter was about 232° and 265° respectively, and the planet was far removed from the comet in both years.

The case is a very curious one and possibly unique of its kind: similarity of elements at three epochs separated by very nearly equal intervals, and on the assumption of a corresponding period of revolution, a very near apparent approach to the planet which so greatly disturbs the cometary orbits, yet action to account for outstanding differences of elements, could not have taken place on either occasion of the comet's passage through the part of its orbit where great perturbation would be looked for.

A NEW COMET.—On Monday morning telegraphic intimation of the discovery of a new comet by M. Borrelly on the evening of the 14th reached England from Marseilles, and its position was determined the same night at Mr. Barclay's Observatory, Leyton. The place is thus given in M. Borrelly's telegram:—April 14, at 9h. 30m., R.A. 16° 31′, N.P.D. 34° 56′; daily motion in R.A. + 120′, in N.P.D. − 50′. On the 16th the comet was visible enough in a large-sized Berlin "Cometensucher," but was not a bright object in such an instrument.

OBSERVATIONS AT CORDOBA.—Dr. B. A. Gould, director of the National Observatory of the Argentine Republic at Cordoba, writes with respect to several objects to which allusion has been made in this column. Referring to μ Doradus—after remarking that it was noted as 5 m. by Lacaille, 6 m. by Rümker or Dunlop about 1825, and 8½ m. or 9 m. by Moesta, between February 1860 and January 1865, Dr. Gould says: "Our observations of it here have been on the following dates:—1870, Dec. 27; 1871, Jan. 19, 30, March 16, April 13; 1873, March 7, on which days it was looked for in the work upon the Uranometry. Also it has been observed with the meridian circle 1874, Jan. 12, 26; 1875, Jan. 5, 9, 11, 20; 1876, Jan. 5, Feb. 12, 14. Some difficulty was experienced in recognising it on account of several other stars of the same order of brightness being situated in its immediate vicinity. The identification was confirmed, however, as soon as the equatorial telescope was mounted. The estimates of magnitude were from 8 to 8½, but I see no reason to believe that it has changed since December 1870. * * Mr. Thome estimated it as 8·3 m. last night" (March 3). Dr. Gould proceeds, "While writing, let me add a word regarding the red star in Sculptor, mentioned in the same number of NATURE. This is one of the most intensely red stars which I know in the sky. But I should neither call it 'orange-red' nor 'red purple,' nor 'couleur rose,' but a brilliant scarlet. In such cases, however, different eyes bear different witness, and different individuals express themselves very differently to communicate the same idea." Dr. Gould intends at the earliest opportunity, to obtain numerical values for this and some other stars, by means of a Zöhlner's colorimeter. The star to which we are alluding is in R.A. 1h. 21m. 10s. N.P.D. 123° 11′ 48″ for 1874·0, according to observations at Cordoba.

The cluster γ Argus, respecting which Gillis reported changes since Sir John Herschel's observations, has been photographed several times, and Dr. Gould adds that he has similarly eight plates of η Argus and its surrounding stars—of which a very large number are secured upon the photograph by an exposure of eight or ten minutes.

TYPICAL LAWS OF HEREDITY[1]

III.

If a graphic representation is desired, which will give the absolute number of survivors at each degree, we must shape the rampart which forms nature's target so as to be highest in the middle and to slope away at each side according to the law of deviation. Thus Fig. 6 represents the curved rampart before it has been aimed at; Fig. 7, afterwards.

I have taken a block of wood similar to Fig. 4, to represent the rampart; it is of equal height throughout. A cut has been made at right angles to its base with a fret-saw, to divide it in two portions—that which would remain after it had been breached, Fig. 5, and the cast of the breach. Then a second cut with the fret-saw has been made at right angles to its face, to cut out of the rampart an equivalent to the heap of pellets that represents the original population. The gap that would be made in the heap and the cast that would fill the gap are curved on two faces, as in the model. This is sufficiently represented in Fig. 7.

The operation of natural selection on a population already arranged according to the law of deviation is represented more completely in an apparatus, Fig. 8, which I will set to work immediately.

It is faced with a sheet of glass. The heap, as shown in the upper compartment of the apparatus, is three inches in thickness, and the pellets rest on slides. Directly below the slides, and running from side to side of the apparatus, is a curved partition, which will separate the pellets as they fall upon it, into two portions, one that runs to waste at the back, and another that falls to the front, and forms a new heap. The curve of the partition is a curve of deviation. The shape of this heap is identical with the cast of the gap in Fig. 7. It is highest and thickest in the middle, and it fines away towards either extremity. When the slide upon which it rests is removed, the pellets run down an inclined plane that directs them into a frame of uniform and shallow depth. The pellets from the deep central compartments (it has been impossible to represent in the diagram as many of these as there were in the apparatus) will stand very high from the bottom of the shallow frame, while those that came from the distant compartments will stand even lower than they did before. It follows that the selected pellets form, in the lower compartment, a heap of which the scale of deviation is much more contracted than that of the heap from which it was derived. It is perfectly normal in shape, owing to an interesting theoretical property of deviation (see formulæ at end of this memoir).

Productiveness follows the same general law as survival, being a percentage of possible production, though it is usual to look on it as a simple multiple, without dividing by the 100. In this case the front face of each compartment in the upper heap represents the number of the parents of the same class, and the depth of the partition below that compartment represents the average number that each individual of that class produces.

To sum up. We now see clearly the way in which the resemblance of a population is maintained. In the purely typical case, each of the processes of heredity and selection is subject to a well-defined and simple law, which I have formulated in the appendix. It follows that when we know the values of 1° in the several curves of family variability, productiveness, and survival, and when we know the co-efficient of reversion, we know absolutely all about the ways in which that characteristic will be distributed among the population at large.

I have confined myself in this explanation to purely typical cases, but it is easy to understand how the actions of the processes would be modified in those that were not typical. Reversion might not be directed towards the mean of the race, neither productiveness nor survival might be greatest in the medium classes, and none of their laws may be strictly of the typical character. However, in all cases the general principles would be the same. Again, the same actions that restrain variability would restrain the departure of average values beyond certain limits. The typical laws are those which most nearly express what takes place in nature generally; they may never be exactly correct in any one case, but at the same time they will always be approximately true and always serviceable for explanation. We estimate through their means the effects of the laws of sexual selection, of productiveness, and of survival, in aiding that of reversion in bridling the dispersive effect of family variability. They show us that natural selection does not act by carving out each new generation according to a definite pattern on a Procrustean bed, irrespective of waste. They also explain how small a contribution is made to future generations by those who deviate widely from the mean, either in excess or deficiency, and enable us to calculate whence the deficiency of exceptional types is supplied. We see by them that the ordinary genealogical course of a race consists in a constant outgrowth from its centre, a constant dying away at its margins, and a tendency of the scanty remnants of all exceptional stock to revert to that mediocrity, whence the majority of their ancestors originally sprang.

Appendix.

I will now proceed to formulate the typical laws. In what has been written, 1° of deviation has been taken equal to the "probable error" = C × 0·4769 in the well-known formula $y = \frac{1}{c\sqrt{\pi}} . e^{-\frac{x^2}{c^2}}$. According to this, if x = amount of deviation in feet, inches, or any other external unit of measurement, then the number of individuals in any sample who deviate between x and $x + \delta x$ will vary as $e^{-\frac{x^2}{c^2}} \delta x$ (it will be borne in mind that we are for the most part not concerned with the coefficient in the above formula).

Let the modulus of deviation (c) in the original population, after the process has been gone through, of converting the measurements of all its members (in respect to the characteristic in question), to the adult male standard, be written c_0.

1. Sexual selection has been taken as *nil*, therefore the population of "parentages" is a population of which each unit consists of the mean of a couple taken indiscriminately. This, as well known, will conform to the law of deviation, and its modulus which we will write c_1 has already been shown to be equal to $\frac{1}{\sqrt{2}} . c_0$.

2. Reversion is expressed by a fractional coefficient of the deviation, which we will write r. In the "reverted" parentages (a phrase whose meaning and object have already been explained)

$$y = \frac{1}{rc\sqrt{\pi}} . e^{-\frac{x^2}{r^2 c^2}}.$$

In short, the population, of which each unit is a reverted parentage, follows the law of deviation, and has its modulus, which we will write c_2, equal to rc_1.

3. Productiveness:—We saw that it followed the law of deviation; let its modulus be written f. Then the number of children to each parentage that differs by the amount of x from the mean of the parentages generally (*i.e.*, from the mean of the race), will vary as $e^{-\frac{x^2}{f^2}}$; but the number of such parentages varies as $e^{-\frac{x^2}{c_2^2}}$, therefore if each child

[1] Lecture delivered at the Royal Institution, Friday evening, February 9, by Francis Galton, F.R.S. Continued from p. 514.

absolutely resembled his parent, the number of children who deviated x would vary as $e^{-\frac{x^2}{f^2}} \times e^{-\frac{x^2}{c_2^2}}$, or as $e^{-x^2\left\{\frac{1}{f^2} + \frac{1}{c_2^2}\right\}}$. Hence the deviations of the children in their amount and frequency would conform to the law, and the modulus of the population of children in the supposed case of absolute resemblance to their parents, which we will write c_3, is such that—

$$\frac{1}{c_3} = \sqrt{\left(\frac{1}{f^2} + \frac{1}{c_2^2}\right)}.$$

We may, however, consider the parents to be multiplied

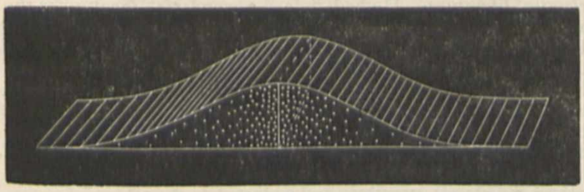

FIG. 6.

and the productivity of each of them to be uniform. It is more convenient than the converse supposition and it comes to the same thing. So we will suppose the reverted parentages to be more numerous but equally prolific, in which case their modulus will be c_3, as above.

4. Family variability was shown by experiment to follow the law of deviation, its modulus, which we will write v, being the same for all classes. Therefore the amount of deviation of any one of the offspring from the mean of his race is due to the combination of two influences, the deviation of his "reverted" parentage and his own family variability; both of which follow the law of deviation. This is obviously an instance of the well-known law of the "sum of two fallible measures" (Airy, "Theory of Errors," § 43). Therefore the modulus of the population in the present stage, which we will write c_4, is equal to $\sqrt{(v^2 + c_3^2)}$.

5. Natural selection follows, as has been explained, the same general law as productiveness. Let its modulus be written s; then the percentage of survivals among children, who deviate x from the mean, varies as $e^{-\frac{x^2}{s^2}}$, and for the same reasons as those already given, its effect will be to leave the population still in conformity

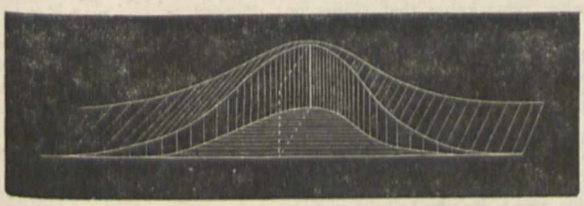

FIG. 7.

with the law of deviation, but with an altered modulus, which we will write c_5, and

$$\frac{1}{c_5} = \sqrt{\left(\frac{1}{s^2} + \frac{1}{c_4^2}\right)}.$$

Putting these together we have, starting with the original population having a modulus $= c_0$:—

1. $c_1 = \frac{1}{\sqrt{2}} c_0.$
2. $c_2 = r c_1.$
3. $c_3 = \sqrt{\left\{\frac{f^2 c_2^2}{f^2 + c_2^2}\right\}}.$
4. $c_4 = \sqrt{\left\{v^2 + c_3^2\right\}}.$
5. $c_5 = \sqrt{\left\{\frac{s^2 c_4^2}{s^2 + c_4^2}\right\}}.$

And lastly, as the condition of maintenance of statistical resemblance in consecutive generations:—

6. $c_5 = c_0.$

Hence, given the coefficient r and the moduli v, f, s, the value of c_0 (or c_5) can be easily calculated.

In the case of simple descent, which was the one first

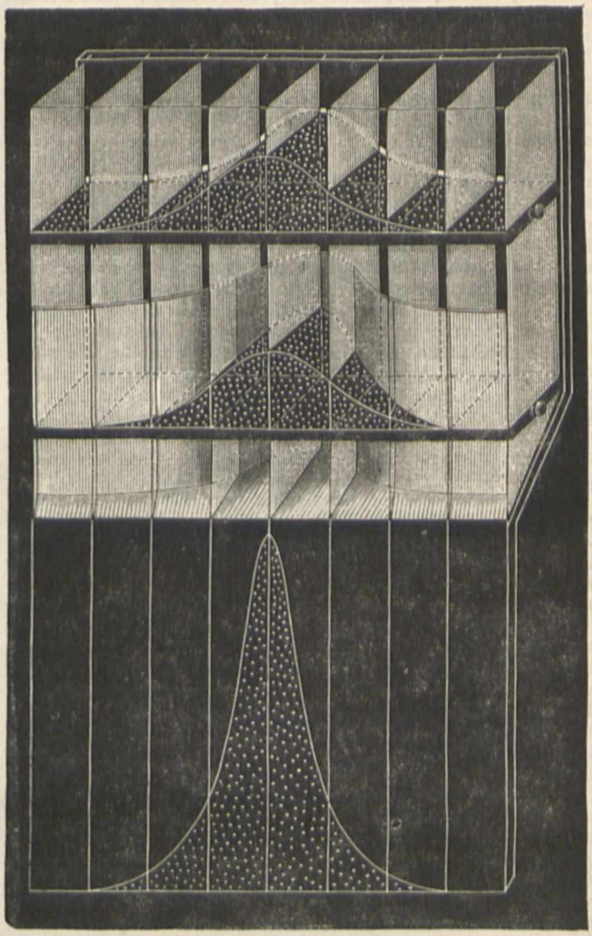

FIG. 8.

considered, we have nothing to do with c_0, but begin from c_1. Again, as both fertility and natural selection are in this case uniform, the values of f and s are infinite. Consequently our equations are reduced to—

$$c_2 = r c_1\,;\ c_4 = \sqrt{\left\{v^2 + c_2^2\right\}}\,;\ c_4 = c_1,$$

whence

$$c_1^2 = \frac{v^2}{1 - r^2}.$$

CARL FRIEDRICH GAUSS

BORN APRIL 30, 1777, DIED FEBRUARY 23, 1855.[1]

DE MORGAN in his "Budget of Paradoxes" (p. 187), tells the following story:—The late Francis Baily wrote a singular book, "Account of the Rev. John Flamsteed, the first Astronomer-Royal:" it was published by the Admiralty for distribution, and the author drew up the distribution list.

[1] We adopt the date given by the Baron Sartorius von Waltershausen in his "Gauss. Zum Gedächtniss," Leipzig, 1856. Encyclopedists and other authorities are pretty equally divided between this date and April 23. All the English Cyclopædias we have consulted, with the exception of Chambers's (1874), give April 23. We may also mention that on the list of students at the Collegium Carolinum the name is Johann Friedrich Karl Gauss. We have followed Gauss himself in our heading.

Certain rumours led to a run upon the Admiralty for copies. "The Lords were in a difficulty; but on looking at the list they saw names, as they thought, which were so obscure, that they had a right to assume Mr. Baily had included persons who had no claim to such a compliment as presentation from the Admiralty. The secretary requested Mr. Baily to call upon him. 'Mr. Baily, my Lords are inclined to think that some of the persons in this list are perhaps not of that note which would justify their lordships in presenting this work.' 'To whom does your observation apply, Mr. Secretary.' 'Well, now let us examine the list; let me see; now—now—now—come!—here's Gauss—*who's Gauss?*' 'Gauss, Mr. Secretary, is the oldest mathematician now living, and is generally thought to be the greatest.'" Their Lordships ultimately expressed themselves perfectly satisfied with the list. Who then was Gauss? He was the son of a bricklayer at Brunswick, and it was the wish of his father that the boy should be a bricklayer too. The lad, however, was another Pascal,[1] and early showed a marvellous aptitude for calculation; indeed he might be said to have "lisped in numbers," for he used jokingly to say that he could reckon before he could talk. When scarcely three years old he pointed out the inaccuracy of an account, "Vater, die Rechnung ist falsch, es macht so viel," and the boy was right. At the public school of Büttner he soon attracted the attention of Bartels, subsequently Professor of Mathematics at Dorpat, and father-in-law of Struve, by whom he was brought under the notice of Charles William, the reigning Duke of Brunswick. The Duke became Gauss's good friend, and sent him in 1792[2] to the Collegium Carolinum, much against the father's wish. Having nothing more to learn from the professors here, he went in 1795[3] to Göttingen, as yet undecided whether to pursue philology or mathematics. Kaestner was at this time mathematical professor, of whom Gauss said: "He was the first of geometers among poets and first of poets among geometers."

Here, too, he was independent of his teachers, and having made several of his greatest discoveries in analysis (the Higher Arithmetic especially became his favourite study, and he called it a divine science, "Mathematics, the Queen of the Sciences, and Arithmetic, the Queen of Mathematics"[4]), henceforth he made mathematics the main study of his life.

Having finished his college course, he returned to Brunswick, and in 1798 repaired for a short time to Helmstadt to consult the library there. Again the next year we find him at Helmstadt, and he is now able to improve his acquaintance with Pfaff, having had only an hour or two of intercourse with him in the previous year, and the two mathematicians were much together, the probability being that Gauss communicated more than he received.[5]

In 1807, whilst a private teacher at Brunswick, the Emperor of Russia offered him a chair at the Academy of St. Petersburg, but by the advice of Olbers he declined the appointment.[6] On July 9 in this year he was appointed the first director of the new Göttingen Observatory and Professor of Astronomy in the University. His life henceforth was spent at Göttingen, in the midst of continuous work; in other respects it was quite uneventful. From the year 1828, when he was invited to Berlin by Humboldt to attend a meeting of natural philosophers in that city, he never left his university until 1854, in which year railway communication was opened up between Hanover and Göttingen.[1] His life was passed in a simple and regular manner, he enjoyed good sound health in spite of the fatigues of night observations, he seldom required a physician until a few months before his death, when he suffered much from asthma, which was subsequently complicated by the accession of dropsy. So passed away in his seventy-eighth year, Gauss, one of the greatest lights of the present age, a mathematician worthy to be placed on the same high platform as Archimedes and Newton.[2]

[1] *cf.* Prof. H. J. S. Smith's Presidential Address, *Proceedings* of London Mathematical Society, vol. viii p. 18, and Larrouse. At the age of ten he was acquainted with the Binomial Theorem and the theory of infinite series, "Gauss. Z Ged.," p. 13.

[2] "Gauss. Zum Gedächtniss," p. 15. Roy. Ast. Soc *Monthly Notices*, vol. xvi. pp. 80–83. Larrouse, "Grande Dictionnaire," Paris, 1872, gives erroneously 1789.

[3] Larrouse and Michaud's "Biographie Universelle," Paris, 1856, both give this date 1794; see also Roy. Ast Soc. *Monthly Notices*.

[4] "Gauss. Z. Ged.," pp. 79, 86.

[5] Roy. Ast. Soc. *Notices* point out that the idea that Gauss studied under Pfaff is an erroneous one This error occurs in the "Encyclopædia Brit," 1856 (8th edition). Laplace, when asked who was the greatest mathematician in Germany, replied, Pfaff; his interrogator said he should have thought Gauss was. "Oh," replied Laplace, "Pfaff est bien le plus grand mathématicien de l'Allemagne, mais Gauss est le plus grand mathématicien de l'Europe." The statement that Gauss graduated at Helmstadt in 1799 (*Proceedings* of Roy. Soc., vol. vii p. 598) is erroneous; see "Gauss. Z. Ged.," p. 22. The degree was conferred upon him *in absentiâ*. No information upon this point is given either in Poggendorff, "Biog. Lit Handwörterbuch," Leipzig, 1863, or in the *Göttingische gelehrte Anzeigen* (3rd vol. for 1855).

[6] Olbers, in a letter to Heeren, states that Gauss had a marked objection to a mathematical chair; his desire was to obtain the post of astronomer at an observatory, in order that he might spend all his time upon his observations and his profound studies for the advancement of science.

We are told that his tastes were simple (he never wore any of the numerous decorations which were showered down upon him), and that he had the full knowledge, which men of genius often have, of his superiority to the mass of mankind.[3] Though he looked upon mathematics as the principal means for developing human knowledge,[4] he yet fully recognised the beneficial influence of an acquaintance with classical literature. He had indeed a wonderful faculty for the acquisition of languages; he was acquainted with most of the European languages, and could speak many of them well.[5] At the age of sixty-two he commenced the study of the Russian language, and mastered it in two years. He took a great interest too in politics to within a few weeks of his death. His lectures, in which he adopted the analytic method, were exceedingly clear expositions; in them he liked to discuss the methods and the roads by which he had arrived at his great results. He required the closest attention, and objected to the taking of notes, lest his hearers should lose the thread of his argument. The students seated round the lecture-table listened with delight to the lucid and animated addresses of their master; addresses more resembling conversations than set lectures. The chief figure in this group stands before us with clear, bright eyes, the right eyebrow raised higher than the left (*more Astronomorum*), a forehead high and wide, overhung with grey locks, and a countenance whose variations were all expressive of the great mind within.[6] We can well understand how his pupils reverenced him and never forgot these meetings. Gauss was always ready to converse even with persons unacquainted with the subjects he had made his own, and his animation in doing so bore evidence to the delight he took in the contemplation of nature. It was this feeling that led him a short time before his death to have engraved at the foot of his portrait the following lines as expressing best the philosophy of his ideas and of his writings:—

> "Thou, Nature, art my Goddess, to thy laws
> My services are bound!"

"Gauss. Z. Ged.," p. 79. Shakspeare, King Lear, Act I. Scene ii.

The full list of Gauss's writings would fill many of our columns; there is a list on columns 854–857 of Poggendorff; Larrouse gives a very full list also, but the most complete list we know, not including the larger works, is given in the Royal Society's Catalogue of Scientific Papers. The titles are given of 124 papers.

One of Gauss's earliest discoveries is the "method of least squares." This method, though first published by Legendre, was applied by Gauss as early as the year 1795.[7] It is somewhat remarkable that Gauss has devoted so few memoirs to

[1] He is said never to have slept from under the roof of his own observatory but on the one above-named occasion, and in the last-named year, *i.e.*, the year before he died, to have seen for the first time a locomotive. During this visit to Berlin, Gauss made the acquaintance of Weber. "Z. Ged." p. 61.

[2] To use the words of Gauss's successor at Göttingen. A great living English mathematician says: "The mathematician lives long and lives young; the wings of his soul do not early drop off, nor do its pores become clogged with the earthy particles blown from the dusty highways of vulgar life." (Dr. Sylvester's address at the Exeter Meeting of the British Association, 1869.) He cites Leibnitz 70, Euler 76, Lagrange 77, Laplace 78, Gauss 78, Plato 82, Newton 85, Archimedes 75 (then killed by a Roman soldier), Pythagoras 99.

[3] "Gauss. Z. Ged.," p. 95. He was a man of determined character, of strong will, and one who disdained all half-heartedness; (and p. 102) His character showed a curious mixture of self-conscious dignity and childlike simplicity. Larrouse says he was but little communicative and morose, not to say peevish.

[4] A short time before his death he spoke to a celebrated psychologist on the possibility of putting psychology on a mathematical basis.

[5] "Gauss. Z. Ged.," p. 94, says he read Gibbon and Macaulay's histories with great interest. He was immensely amused (p. 93) with "The Moon rises broad in the north-west," which occurs in one of Sir W. Scott's novels. He would not tell his friends what had set him laughing until after collecting a variety of editions of the novel in question he found that the passage was not a misprint.

[6] We are here indebted to M. Wagener the writer of the notice in the "Biographie Universelle (Michaud)," Paris, 1856.

[7] Theoria Motus, lib. ii. § iii. See Glaisher "On the Law of Facility of Errors of Observations, and On the Method of Least Squares." Roy. Ast Soc. *Memoirs*, vol. xxxix (1872), in which is collected much information on the subject. Also Todhunter's "History of Theory of Probability," § 1,017 and elsewhere. Roy. Soc. *Proceedings*, p. 592.

subjects of an algebraic character. If we except a comparatively unimportant paper on Descartes' Rule of Signs, which appeared in *Crelle's Journal* (1828), his only algebraical memoirs relate to the theorem that every equation has a root. Of this he gave no less than three distinct demonstrations, one in 1799, one in 1815, and one in 1816. That in 1799 formed the subject of his first published paper: "Demonstratio nova theorematis omnem functionem algebraicam, rationalem integram unius variabilis in factores reales primi vel secundi gradus resolvi posse"—his inaugural dissertation as a candidate for the degree of Doctor of Philosophy in the University of Göttingen. This demonstration was repeated over again in 1849 with certain changes and simplifications. These demonstrations are prior to any other;[1] for various reasons those subsequently given by Cauchy have been justly preferred for insertion in modern text-books.

A new epoch in certain branches of analysis dates from the publication of the "Disquisitiones Arithmeticæ" (Leipzig, 1801),[2] and from the researches with which some years later Gauss supplemented or further developed the theories contained in that work. We must bear in mind that he found the theory of numbers as Euler and Lagrange had left it. The former enriched it with a multitude of results, relating to Diophantine problems, to the theory of the residues of powers, and to binary quadratic forms; the latter had given the character of a general theory to some at least of these results by his discovery of the reduction of quadratic forms and of the true principles of the solution of indeterminate equations of the second degree. Legendre (with many additions of his own) had endeavoured to arrange as much as possible of these scattered fragments of the science into a systematic whole in his "Essai sur la Théorie des Nombres." But the "D. Ar." was in the press when this important treatise appeared, and what in it was new to others was already known to Gauss. This grand work merits an analysis at our hands, but lack of space compels us to pass on at once to the fourth section. The greater portion of it is occupied with a research, which of itself alone would have placed Gauss in the first rank of mathematicians. "If p and q are positive uneven prime numbers, p has the same quadratic character with regard to q that q has with regard to p; except when p and q are both of the form $4n + 3$, in which case the two characters are always opposite, instead of identical." This is the celebrated Fundamental Theorem of Gauss, known also as the Law of Quadratic Reciprocity of Legendre. Gauss discovered it (by induction) in March, 1795, before he was eighteen; the proof given of it in this section he discovered in April of the year following.[3] He cannot at the earlier date have been aware that the theorem had been already enunciated (though in a somewhat complex form) by Euler, and that Legendre had attempted, though unsuccessfully, to prove it in the *Memoirs* of the Academy of Paris for 1784. The question of priority of enunciation or of demonstrating by induction in this case is a trifling one; any rigorous demonstration of it involved apparently insuperable difficulties. Gauss was not content with once vanquishing the difficulty, he returns to it again in the fifth section, and there obtains another demonstration reposing on entirely different, but perhaps still less elementary principles. In January, 1808, he submitted a third demonstration to the Royal Society of Göttingen; a fourth in August of the same year; a fifth and sixth in February, 1817. It is no wonder he should have felt a sort of personal attachment to a theorem which he had made so completely his own, and which he used to call the "gem" of the higher arithmetic. His six demonstrations remained for some time the only efforts in this direction, but the subject subsequently attracted the attention of other eminent mathematicians, and several proofs differing substantially from one another, and from those of Gauss, have been given.[4] It would be impossible to exaggerate the important influence which this theorem has had on the subsequent development of arithmetic, and the discovery of its demonstration by Gauss must be certainly regarded (it was so regarded by himself), as one of his greatest scientific achievements. The fifth section ("these marvellous pages") abounds with subjects, each of which has been the starting-point of long series of important researches by subsequent mathematicians. In the *Additamenta* to this section Gauss characteristically adds: "ex voto nobis sic successit ut nihil amplius desiderandum supersit Nov. 30—Dec. 3, 1800." It is remarkable that he should never have published the wonderful researches to which he here alludes. They first saw the light sixty-three years later in the second volume of the collected edition of his works.[1] Till the time of Jacobi, it is not too much to say, that the profound researches of the fourth and fifth sections were passed over with almost universal neglect, but the seventh section at once made the reputation of the "D. Ar." The well-known theory of the division of the circle, comprised in this section, was received with great and deserved enthusiasm as a memorable addition to the theory of equations and to the geometry of the circle. Gauss's note on § 365 ("circulum in 17 partes divisibilem esse geometrice, deteximus 1796, Mart 30")[2] is interesting because it shows that he was not yet nineteen when he made this great discovery. Even more remarkable, however, is a passage (§ 335), in which he observes that the principles of his method are applicable to

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Carl Friedrich Gauss.

many other functions beside the circular functions, and in particular to the transcendents dependent on the integral $\int \frac{dx}{\sqrt{1-x^4}}$. This almost casual remark shows (as Jacobi long since observed) that Gauss at the date of the publication of the "D. Ar." had already examined the nature and properties of the elliptic functions and had discovered their fundamental property, that of double periodicity. This observation of Jacobi's is amply confirmed by the papers on elliptic transcendents, now published in the third volume of Gauss's collected works.[3]

The "D. Ar." were to have included an eighth section; at first it was intended to contain a complete theory of congruences, but subsequently Gauss appears to have proposed to continue the work by a more complete discussion of the theory of the division of the circle. Manuscript drafts on each of these subjects were found among his papers; the first of them is especially interesting, as it treats of the general theory of congruences from a point of view closely allied to that subsequently taken by

[1] This dissertation (Helmstadt, 1799), so little known that Lagrange appears not to have been acquainted with it, and "Cauchy has received in France all the praise due to a first discoverer."—Larrouse.

[2] For an amusing notice of this work see "Biographie nouvelle des Contemporains" (Paris, 1822): "Cet ouvrage a obtenu un succès d'après lequel on serait tenté de croire que le charlatanisme envahit quelquefois jusqu'au domaine des mathématiques" (see Roy. Soc. *Proceedings*, pp 590, 591, *ubi supra*) Twelve years later ("Biographie universelle et portative des Contemporains," Paris, 1834) we read, "Il suffit de dire qu'en général ses travaux sont estimés des mathématiciens les plus distingués et qu'ils se recommandent autant par leur exactitude que par la clarté, la précision et l'élégance du style." Laplace's saying, quoted above, also shows in what estimation Gauss was held at that date. Lalande speaks of his talent and zeal, "Histoire," p. 813 (1803).

[3] See Gauss's note (pp. 475, 476 of vol. i. of his "Werke," edited by Schering).

[4] By Jacobi and Eisenstein in Germany, M. Liouville in France; perhaps the simplest of all (one allied in its character to the third proof of Gauss) is one by M. Zeller (see *Messenger of Mathematics*, No. lvii., January, 1876 for an account by Prof. Paul Mansion)

[1] The theorem to which they refer had, in the interval, been rediscovered and demonstrated by Lejeune Dirichlet. This demonstration has been to a certain extent simplified by M. Hermite, and the form of proof found in Gauss's papers after his death approaches very nearly to that adopted by M. Hermite.

[2] Schering's edition, *ubi supra*. M. Chasles passes by this discovery without any notice of it; in this case the language could not be the barrier: "Par suite de notre ignorance de la langue dans laquelle ils sont écrits." "Aperçu Historique," p. 215. Delambre gives an account in his "Rapport Historique sur les progrès des Sciences," Paris, 1810. In the Roy. Ast. Soc. *Notice* are some pertinent remarks.

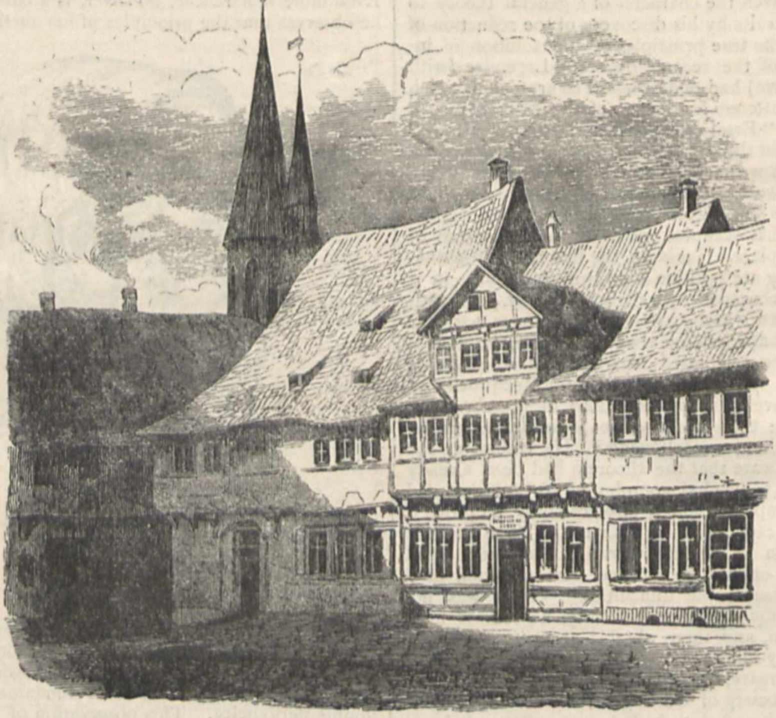
[3] On p. 593 Roy. Soc. Obituary Notice will be found the story of Gauss and Jacobi. For every theorem in the subject of elliptic integrals produced by the latter, Gauss could show its fellow among his manuscripts.

Evariste Galois and by MM. Serret and Dedekind. This draft appears to belong to the years 1797 and 1798.

To complete our hasty sketch of the arithmetical works we need only mention (1) the remarkable interpretation of the arithmetical theory of positive binary and ternary quadratic forms, which will be found in his review of the works of L. Seeber [1831] ("Werke," vol. ii. p. 188); and (2) the two important memoirs on the theory of biquadratic residues (1825 and 1831). In the second of these memoirs he gives a theorem of biquadratic reciprocity between any two prime numbers no less important than the quadratic law, viz., "If p_1 and p_2 are two primary prime numbers, the biquadratic character of p_1 with regard to p_2 is the same as that of p_2 with regard to p_1." This theorem itself and the introduction of imaginary integers upon which it depends, are memorable in the history of arithmetic for the number and variety of the researches to which they have given rise.[1]

A writer remarks each work of Gauss is an event in the history of science, a revolution, which, overturning the old theories and methods, replaces them by new ones and advances science to a height which no one had before dreamed of.[2] We have given proof of this in one branch of mathematics; we shall see that the witness is true as to other branches also.

The discovery of the planet Ceres at Palermo on the first day of the present century led to Gauss's taking up the subject of astronomy. He did not come into possession of the requisite data until the October following. In a few weeks he determined the elements of its orbit with sufficient accuracy so that the Baron de Zach was enabled to rediscover the planet at the first attempt he made for that purpose on December 7. This discovery was soon followed by that of three other small planets. These discoveries supplied Gauss with the means of further improving his solution of the problem, and in 1809 he brought out at Hamburg his "Theoria motus corporum cælestium in sectionibus conicis solem ambientium." This contains an "elaborate discussion of the various problems which present themselves in the determination of the movements of planets and comets from observations made on them under any circumstances."[1] Gauss's other astronomical researches are chiefly contained in De Zach's *Monatliche Correspondenz*, the *Transactions* of the Royal Society of Göttingen, and the *Astronomische Nachrichten*; all are contributions of the highest order of excellence.



Gauss' Birthplace in Brunswick.

To astronomy Gauss joined geodesy, and the Hanoverian Government charged him with the triangulation and measurement of an arc of the meridian between Göttingen and Altona. This he accomplished between the years 1821 and 1824. For carrying out his purpose he invented many methods quite original.[3] It was his intention to publish an extensive work upon geodesy, but he did not accomplish his purpose. He contributed two memoirs on the subject to the Royal Society of Berlin (1844, 1847).

Mr. Todhunter in his "History of the Theories of Attraction," devotes §§ 1162-1175 to an analysis of a memoir by Gauss, "Theoria attractionis corporum sphæroidicorum ellipticorum homogeneorum methodo novâ tractata" (Royal Society of Göttingen, March 18, 1813). Mr. Todhunter says, "he completely succeeds in his design; his solution is both simple and elegant."[2] He further remarks, "Gauss's writings are distinguished for the combination of mathematical ability with power of expression; in his hands Latin and German rival French itself for clearness and precision."

In another of Mr. Todhunter's works ("Calculus of Variations," 1861) he discusses in his third chapter (pp. 37-52) a memoir

[1] In our account of Gauss's arithmetical work we have throughout reely referred to Prof H J. S. Smith's presidential address (see above) and his two reports on the theory of numbers (Brit. Assoc. Reports, 1859, pp. 228-267; 1860, pp. 120-172). But we are still more deeply indebted to him for references and criticisms most kindly given in the midst of the pressing claims of his other numerous engagements

[2] Wagener, in Michaud's "Biographie Universelle." Prof. Cayley writes, "All that Gauss has written is first rate; the interesting thing would be to show the influence of his different memoirs in bringing to their present condition the subjects to which they relate, but this is to write a History of Mathematics from the year 1800."

[3] He invented the heliotrope to render angles visible at as great a distance as possible; this he did by reflecting the rays of the sun. He also devised a method for the correction of the errors which occur in an extensive system of triangulation.—"Gauss. Z. Ged.," pp. 51-53.

[1] Roy. Soc. *Proceedings*, p. 592; Roy. Ast. Soc. *Monthly Notices* (as above). A curious fact is recorded. The preface to this work is dated March 28, 1809, just two centuries after Kepler's "Præfatio de Stella Martis," March 28, 1609; "Gauss. Z. Ged.," p. 40. After the publication of this work Gauss became "a member of all the learned societies from the Polar Circle to the Tropics"

[2] Chasles (quoted by Todhunter) calls it "le beau mémoire de M. Gauss." Another celebrated memoir, "Allgemeine Lehrsätze . . . Anziehungs- und Abstossungs-kräfte" (Leipsic, 1840), is treated by Todhunter, § 1,253. In this last Gauss uses the name *Potential* (apparently independent of Green) § 790. See also Maxwell's "Electricity," § 70.

by Gauss entitled "Principia generalia Theoriæ figuræ Fluidorum in statu æquilibrii" (Royal Society of Göttingen, 1833).[1] It relates to the theory of capillary attraction, and demonstrates in a new way some results which had already been obtained by Laplace. The part analysed by Mr. Todhunter is that devoted to the solution of a problem in the calculus of variations, "involving the variation of a certain double integral, *the limits of the integration being also variable*; it is the earliest example of the solution of such a problem." In 1831 we find Gauss commencing the study of crystallography; in a few weeks he had mastered the subject. We find that the question of the rationality or irrationality of the ratios of the crystallographic coefficients had attracted his attention.[2]

We can only touch upon Gauss's further contributions to geometry.[3] To him are due many fundamental theorems in the theory of curve-surfaces; also on the development of surfaces; thus it was he who found the equation to developable surfaces. He was used to say "that he had laid aside several questions which he had treated analytically, and hoped to apply to them geometrical methods in a future state of existence, when his conceptions of space should have become amplified and extended."[4]

Those not acquainted with Gauss's writings would think we must have exhausted our account of them. In 1831, however, on Weber's arrival at Göttingen, physical questions took the first place in Gauss's thoughts, and separately and in conjunction many works were brought out by these two philosophers. There is so full an account of Gauss's achievements in this direction in the Royal Society's Obituary Notice, that we need only refer to it.[5] His contributions, we may briefly say, to the knowledge of electro-magnetism and terrestrial magnetism were perhaps the most considerable and important of his achievements. He invented the magnetometer, and was one of the first to point out the possibility of sending signals by galvanic currents, and so contributed to the invention of the electric telegraph.

[6] "If we except the great name of Newton (and the exception is one which Gauss himself would have been delighted to make) it is probable that no mathematician of any age or country has ever surpassed Gauss in the combination of an abundant fertility of invention with an absolute rigorousness in demonstration, which the ancient Greeks themselves might have envied. It may be admitted, without any disparagement to the eminence of such great mathematicians as Euler and Cauchy that they were so overwhelmed with the exuberant wealth of their own creations, and so fascinated by the interest attaching to the results at which they arrived, that they did not greatly care to expend their time in arranging their ideas in a strictly logical order, or even in establishing by irrefragable proof propositions which they instinctively felt, and could almost see to be true. With Gauss the case was otherwise. . . . . It may seem paradoxical, but it is probably nevertheless true that it is precisely the effort after a logical perfection of form which has rendered the writings of Gauss open to the charge of obscurity and unnecessary difficulty. The fact is that there is neither obscurity nor difficulty in his writings, as long as we read them in the submissive spirit in which an intelligent schoolboy is made to read his Euclid. Every assertion that is made is fully proved, and the assertions succeed one another in a perfectly just analogical order; there is nothing so far of which we can complain. But when we have finished the perusal, we soon begin to feel that our work is but begun, that we are still standing on the threshold of the temple, and that there is a secret which lies behind the veil and is as yet concealed from us . . . . no vestige appears of the process by which the result itself was obtained, perhaps not even a trace of the considerations which suggested the successive steps of the demonstration. Gauss says more than once that, for brevity, he only gives the synthesis, and suppresses the analysis of his propositions. '*Pauca sed matura*' were the words with which he delighted to describe the character which he endeavoured to impress upon his mathematical writings. . . . . If, on the other hand, we turn to a memoir of Euler's, there is a sort of free and luxuriant gracefulness about the whole performance, which tells of the quiet pleasure which Euler must have taken in each step of his work; but we are conscious nevertheless that we are at an immense distance from the severe grandeur of design which is characteristic of all Gauss's greater efforts. The preceding criticism, if just, ought not to appear wholly trivial; for though it is quite true that in any mathematical work the substance is immeasurably more important than the form, yet it cannot be doubted that many mathematical memoirs of our own time suffer greatly (if we may dare to say so) from a certain slovenliness in the mode of presentation; and that (whatever may be the value of their contents) they are stamped with a character of slightness and perishableness, which contrasts strongly with the adamantine solidity and clear hard modelling, which (we may be sure) will keep the writings of Gauss from being forgotten long after the chief results and methods contained in them have been incorporated in treatises more easily read, and have come to form a part of the common patrimony of all working mathematicians. And we must never forget (what in an age so fertile of new mathematical conceptions as our own, we are only too apt to forget), that it is the business of mathematical science not only to discover new truths and new methods, but also to establish them, at whatever cost of time and labour, upon a basis of irrefragable reasoning.

"The μαθηματικὸς πιθανολογῶν has no more right to be listened to now than he had in the days of Aristotle; but it must be owned that since the invention of the 'royal roads' of analysis, defective modes of reasoning and of proof have had a chance of obtaining currency which they never had before. It is not the greatest, but it is perhaps not the least, of Gauss's claims to the admiration of mathematicians, that, while fully penetrated with a sense of the vastness of the science, he exacted the utmost rigorousness in every part of it, never passed over a difficulty, as if it did not exist, and never accepted a theorem as true beyond the limits within which it could actually be demonstrated."

It will be evident to our readers that this notice has been drawn up with a purpose. The town of Brunswick proposes to celebrate the hundredth anniversary of Gauss's birthday, and the committee hope to have received before the 30th instant, sufficient subscriptions to enable them to lay the foundation stone of a memorial statue. We have endeavoured to present in a strong light[1] the claims which this great mathematician has upon mathematicians, not only in Germany, but on mathematicians in this country.[2]

Gauss might himself have considered his works his best monument ("exegi monumentum aere perennius,") and possibly if sufficient funds flow in, the committee might see their way to the bringing out a centenary edition of them. In this way they would confer a great boon upon mathematicians everywhere, for at present his writings are, as our great mathematical historian writes, "very costly."[3]

R. TUCKER

[1] Read Sept. 28, 1829.

[2] See Gauss's review of Seeber's Untersuchungen über die Eigenschaften der positiven ternären quadratischen formen" in the *Göttingen gelehrte Anzeigen* (1831) or *Crelle*, vol. xx. p. 312. Prof. H. J. S. Smith "On the Conditions of Perpendicularity in a Parallelopipedal System." (London Math. Society's *Proceedings*, December, 1876). His method of drawing the crystals was essentially the same as that devised subsequently by Prof. Miller, of Cambridge. "Gauss. Z. Ged.' p. 61.

[3] Disquisitiones generales circa superficies curvas (*Transactions*, Göttingen, 1827).

[4] "Gauss. Z. Ged.," p. 81, quoted by Prof Sylvester (*ubi supra*). Gauss's connection with the so-called Gaussian logarithms is pointed out on p. 75 of the Report of the Committee on Mathematical Tables (Brit. Assoc., 1873.) Reporter, Mr. J. W. L. Glaisher.

[5] "Gauss, as a member of the German Magnetic Union, brought his powerful intellect to bear on the theory of magnetism and on the methods of observing it, and he not only added greatly to our knowledge of the theory of attractions, but reconstructed the whole of magnetic science as regards the instruments used, the methods of observation, and the calculation of the results, so that his memoirs on Terrestrial Magnetism may be taken as models of physical research by all those who are engaged in the measurement of any of the forces in nature."—Prof. Clerk-Maxwell's "Electricity and Magnetism" (1873), p. viii. We may also refer for a statement of some of Gauss's discoveries to §§ 140, 144, 409, 421, 454, 706, and 744. *Cf* also Prof. Maxwell's Address (Brit. Assoc, Liverpool, 1870). Pp. 594–598 for accounts of the memoir "Intensitas vis magneticæ terrestris ad mensuram absolutam revocata" (1832) and of the Theory of the Earth's Magnetism (1839): "Allgemeine Theorie des Erdmagnetismus.

[6] We quote freely from notes placed at our service for this article by Prof. H. J. S. Smith. "Summus Newton," "Gauss. Z. Ged.," p. 84.

[1] Our task has given us much pleasure; it has been accomplished in the midst of many interruptions. All our authorities have been given. We close, as the author of the Book of Maccabees closes, with saying: "If I have done well and as is fitting the story, it is that which I desired; but if slenderly and meanly, it is that which I could attain unto." Subscriptions may be sent to the office of NATURE up to the 26th instant.

[2] 'Sein Tod wird nicht allein in allen deutschen Landen sondern auch unter allen gebildeten Nationen der Welt die tiefste Trauer erzeugen." *Gelehrte Anzeigen*, No. 16, December 3, 1855.

[3] Carl Friedrich Gauss' Werke, Herausgegeben von der königlichen Gesellschaft der Wissenschaften zu Göttingen: vol. i. ii. 1863, vol. iii. 1866, vol. iv. 1873, vol. v. 1867, vol. vi. 1874, vol. vii. 1871. These are all we have seen. The editor is Schering. The house in which Gauss was born bore the number 1550, and was situated on the west side of the Wendengraben. It now has a memorial tablet. The house was sold in 1804, and the family removed to another in the Mühlenstrasse, near St. Giles's Church. "Z. Ged.," p. 8.

METEOROLOGICAL NOTES

METEOROLOGICAL LUSTRUM OF 1871–75.—To the seventh Meteorological Report of the Grand Duchy of Baden, by H. Oscar Ruppel of Carlsruhe, just published, there is appended a paper giving the averages of the observations of pressure, temperature, humidity, rain, and snow, and thunderstorms made at the sixteen stations of the Grand Duchy during the Meteorological Lustrum ending with 1875. Considering the many physical and climatical inquiries of the highest importance which such averages, calculated for absolutely the same terms of years over considerable portions of the earth's surface, are certain greatly to elucidate, it is to be hoped that other meteorological institutes and societies will take the trouble to prepare and publish similar averages for their respective countries. In view of the more special inquiries which such averages are calculated to further, it will be necessary that anemometrical averages be included, and that all the averages be given for each of the different hours of observation.

DISTRIBUTION OF BAROMETERS IN FRANCE.—In virtue of the President's decree, signed by M. Thiers, for reorganising the French National Observatory, that establishment issues weather warnings for agricultural purposes. As it was impossible to send 40,000 telegrams daily (one to each parish) without gradually extending the institution, M. Leverrier decided that the daily telegrams should be sent only to those parishes which possessed an aneroid barometer and made arrangements for exposing it to public inspection at the same place where the official warnings were posted. Having obtained ready assistance from the Association Scientifique de France, of which he is the president, M. Leverrier was enabled to make the price of the aneroids as low as 20 francs (16*s.*). From the beginning of the year about 800 communes purchased the barometer, and now enjoy the free transmission of weather warnings. The number is increasing at the rate of about ten a day, and it is supposed that by the end of the present year 10,000 communes will be in constant communication with the national Observatory. The public barometer is to be used by local observers for interpreting, on their own responsibility, the weather-warnings issued by the Observatory. Special meteorological organisations have already issued general rules for this purpose partially based on Fitzroy's "Weather Manual," partly on special observations. The mean pressure for all these barometers, irrespective of the altitude of the stations is to be considered 760 mm., as it was supposed impossible to establish comparisons without thus displacing the variable. Isobaric curves are drawn daily on observatory maps after each observation has undergone correction by a constant number. M. Leverrier has established a rule for the determination of that constant. When he supposes the weather will be quite settled for a few days he sends to his correspondents a telegram stating *attention, réglage.* Each correspondent is ordered to observe the barometer at 6 P.M., and on the two following days at 9 A.M. and 6 P.M. The result of these three observations in millimetres is to be sent to the observatory for the determination of the value of the correction. When that number has been found it is sent to the station through the Minister of Public Instruction. The Mayor is informed officially how many divisions the indicating needle of his aneroid must be turned, left or right, in order that the correct reading may be read.

STORM IN THE SOUTHERN AND EASTERN COUNTIES.—A storm of unusual violence swept over this part of England on Wednesday last week, rising in Hertfordshire to a fearful hurricane. At Sacombe the whole of the farm buildings occupied by Mr. Mardell were destroyed, and one of his workmen killed. Large trees were broken across, hundreds of fruit-trees uprooted and carried away, and a large wall blown down. In a wood near Little Munden, one hundred fir trees were destroyed.

AURORAS IN CANADA DURING THE PAST WINTER.—We learn from a correspondent in Ontario that auroral phenomena have been unusually rare in that part of Canada during the four months preceding the middle of March. In that region, where auroras are usually very brilliant and frequent at that season of the year, only two have been noticed during these four months.

SOLAR RADIATION IN WINTER AND SUMMER.—M. A. Crova communicates to the *Bulletin International* of the Paris Observatory, March 20, a note on some observations he made near Montpellier on January 4 and July 11, 1876, with the view of ascertaining the calorific intensity of solar radiation received at the surface of the ground in winter and summer. These two days were selected as being characterised throughout by uninterrupted brilliant sunshine, and, there being no sea-breeze, uninterrupted calorific transparency of the air, and as being as near as possible to the winter and summer solstice respectively. The results arrived at are that the heat received normally on January 4 was 0·610 of that received on July 11, and the heat received over the surface of the ground on January 4 was 0·281 of that received on July 11. These results give a measure of the inequalities produced in winter and in summer by the obliquity of the sun's rays and by the duration of the sun above the horizon, between the absolute values of the intensity of solar radiation, and between the relations of the quantity of heat emitted directly to that which is received over the horizontal surface of the ground.

HAILSTONES IN INDIA.—Dr. Bonavia, of Lucknow, sends us the following:—On April 12, 1876, at 8.30 P.M., after a great deal of lightning and thunder in the north-west, a hailstorm occurred in Lucknow. We evidently only got the edge of the storm, as it was passing towards the north-east. The fall of hail was not plentiful, but the generality of the stones were enormous. The hailstones were of all sizes, from that of peas and marbles to that of oranges, two inches and more in diameter. The largest I measured, about half-an-hour after the fall, was a flat oval, resembling a paper-weight, with a depression in the centre above and below. Its circumference measured eight inches, its long diameter 2¾ inches, its short diameter 2¼ inches, its thickness 1¼ inches. Two others I measured had a circumference of 7¼ inches and 6¼ inches respectively. Some were of the above shape; others almost spherical; others might have readily served as models of the large flat China peach, with a depression above and below. Most of them had curious mammillary projections all over the surface, which strongly reminded one of some kind of Echinus. Their internal structure can best be described by stating that it resembled exactly that of agates. It consisted of concentric layers, with a more or less wavy outline, commencing from a small nucleus. The layers varied in thickness. Some were transparent; others opaque. One large oval stone, instead of having, like others, its nucleus in the centre of its oval, had it quite at one end. The nucleus was the size of a small marble; it was spherical, but the sphere was not complete. It appeared as if a small round hailstone had first been formed, then a bit of it chipped off, and afterwards a large oval hailstone agglomerated round it, leaving it at one end of the oval. I have been informed that one hailstone, weighed some time after it fell, was four ounces in weight; another weighed 2¼ ounces.

THE WEATHER OF EUROPE.—We have received the *Monthly Weather Reports* of the *Deutsche Seewarte* for March and April, 1876, in which the main features of the weather of Europe during these months are briefly detailed by various well-known meteorologists, particular attention being given to the remarkable storm of March 12 in its progress over the Continent. The tracks of all the storms of Europe during each month are shown by maps, and tables of figures are given of the means of the various meteorological elements for Germany and parts of the continent adjoining, from which the meteorology of a large portion of Europe could be graphically presented. We are much gratified to receive an intimation from the *Seewarte* that in future the *Monthly Reports* will be published regularly at the end of the second month after the one to which the Report relates. It would be a great boon if small maps accompanied the Report, showing the mean pressure, temperature, rainfall, and direction of wind, in a manner similar to what is so well done by the United States of America.

BALL LIGHTNING.—A very fine display of this interesting meteor was witnessed at Vence, in the south-east of France, on the night of March 21–22, by M. Ed. Blanc, of which an interesting detailed account has just appeared in the *Comptes Rendus* of the French Academy, p. 666. Toward midnight there was observed, about eleven miles north-east of Vence, a large black thundery cloud, in a state of extreme agitation, and continually raising and lowering its position. At the upper part of this cloud three or four balls of fire issued every two minutes, as if from the invisible centre of the cloud, diverging in all directions, and after running a course of from six to eight degrees, broke silently with effulgent brightness. Their apparent diameter, as seen at a distance of eleven miles, was about a degree. They were mostly of a reddish colour, a few, however, being of a yellowish tinge, but all of them assumed a white colour in the act of bursting. Their course, which was horizontal and parallel to the plane of the cloud, was relatively slow, not exceeding two degrees per second, and they bore a strong resemblance to immense soap-bubbles, both as regards apparent lightness and general appearance. From time to time a discharge of lightning passed through the cloud from above downwards, followed some seconds after by a dull rumbling sound. The cloud, with its fine display of fire-balls, took a course from east to west, passing about a league to the north of Vence. The glimmering of the lightning with its low dull thunderous sound continued for more than an hour, after which the sky became darker and darker; rain mixed with hailstones fell, and lightning, accompanied with thunder, furrowed the sky in all directions.

NOTES

THE President of the Royal Astronomical Society has announced that the Council of that Society have determined to advance the requisite funds to enable Mr. Gill to carry out his projected expedition to the island of Ascension to measure the parallax of Mars at the approaching opposition, in the expectation that they will be aided by Government or out of the Government grant to the Royal Society. At all events the Royal Astronomical Society will not allow the opportunity of making this important observation to be lost. Its duty in the matter was evident, and it has not hesitated for a moment in doing it. Mr. Gill will embark for the island of Ascension towards the end of next month.

SIR ROBERT CHRISTISON, who has been in failing health for some time, has resigned the Chair of Materia Medica in the University of Edinburgh, which he has held with such distinction since the year 1832. Sir Robert, before being appointed to the Chair he has now relinquished, had filled for ten years that of Medical Jurisprudence.

LAST Sunday evening the first of a course of eight lectures to working men on science and literature was delivered at the St. Alban's Schools, Holborn. The lecture was by Mr. R. Bowdler Sharpe, of the British Museum; the subject, "Birds of Prey and their Geographical Distribution." Mr. Mackonochie deserves the hearty thanks of all interested in the welfare of the working classes for having undertaken so liberal an enterprise.

THE Annual Meeting of the Yorkshire College of Science was held at Leeds on the 16th inst. A highly satisfactory report was presented, in which it was urged that the college should now apply for a charter of incorporation. The great desirability of establishing a classical side in the college was recognised in the report and by the president, Lord F. Cavendish, and other speakers, and there is every reason to hope that in no long time the Yorkshire College will be a flourishing rival of Owens College. The munificence of the Clothworkers' Company deserves all praise and imitation; its last gift to the College is one of 10,000*l*.

DR. JANSSEN has removed his photographic apparatus from the Boulevard Ornano to Meudon, where he is establishing, in barracks given by the French War Office, a permanent physical observatory at the expense of the Government.

ON April 23 next the Paris Academy of Sciences will hold its anniversary meeting for the distribution of prizes. M. Dumas will deliver a lecture on the two brothers Alexander and Adolphe Brogniard, both of them members of the Academy of Sciences. Admiral Paris will be in the chair.

THE Paris Physical Society held its anniversary meeting on April 5. Various apparatus were exhibited, including a number of radiometers, M. Bischoff's gas engine without refrigerator, and a Mouchat reflector for utilising the heat from the sun.

IT has been decided by the Committee of the French Sociétés Savants that special warnings should be sent to the coal pits when large depressions are foreseen, in order to suggest precautions against an escape of fire-damp. Many mining engineers believe that the system will be efficacious. Experience will soon settle the question.

THE U.S. Congress having appropriated 18,000 dollars for a Commission to report on the depredations of the Rocky Mountain locusts, the Secretary of the Interior has appointed as members of the Commission Prof. C. V. Riley, Dr. Cyrus Thomas, and Dr. A. S. Packard. The Commissioners have already mapped out their work for the season, and will direct their attention to insect enemies and parasites, mechanical means for the destruction of the pests, geographical distribution, agricultural bearings of the subject, anatomy and embryology, remedial measures and migrations, &c. Bulletins giving the results of the Commission's inquiries will be issued at intervals.

THE opening meeting of the Yorkshire Naturalists' Union (formerly known as the West Riding Consolidated Naturalists' Society) was held at Pontefract on Easter Monday, April 2, and proved a great success in every way. The Union is a confederation of twenty-four Natural History and Scientific Societies in Yorkshire, banded together for the purpose of holding each summer a combined series of excursions and meetings, of investigating the fauna and flora of the country, and of publishing the results. The union is divided into five sections, viz., vertebrate zoology, conchology, entomology, botany, and geology, which work on the principle of the British Association. This plan was tried for the first time at Pontefract, and so far as it went proved a decided success. The towns represented in the Union are Huddersfield (three societies), Heckmondwike, Clayton West, Barnsley, Wakefield, Ovenden, Stainland, Ripponden, Holmfirth, Liversedge, Rastrick, Mirfield, Honley, Middlestown, Paddock, Bradford, Leeds (two societies), Goole, York, Selby, and Sheffield, numbering in the aggregate nearly 1,200 members. The next meeting will be held at Wetherly, on Whit Monday, May 21.

AT the last meeting of the French Anthropological Society, a long report was read which showed that Druidism was not quite extinct in Britanny, some country people still adhering to Pagan practices in spite of the priests' exertions. It was noticed that the clergy were anxious to destroy menhirs and other similar relics. A petition has been sent to the ministry to put a stop to this iconoclastic zeal.

A WORK has just appeared in Berlin from the pen of Friedrich von Bärenbach, in which the author endeavours to show that the main features of the evolution theory were partially comprehended and advocated by Herder.

THE German Ornithological Society instituted, during the past year, an extensive series of observations by means of schedules, on the dates of nest-building, appearance of the young broods, movements of migratory birds, &c. The statistics resulting from the first year's observations are now being compiled and will shortly be issued in book form.

THE following College Lectures in the Natural Sciences will be given at Cambridge during Easter Term, 1877:—Gonville and Caius College: On Organic Analysis and Elementary Organic Chemistry, by Mr. Apjohn. Christ's College: On the Elements of Electricity and Magnetism, by Mr. Chrystal. St. John's College: On Chemistry, by Mr. Main. Instruction in Practical Chemistry will also be given. On Stratigraphical Geology, by Mr. Bonney; On Elementary Geology; On Palæontology, by Mr. Bonney. Trinity College: On Electricity (continued), by Mr. Trotter; Elementary Physics (Light, &c.), by Mr. Trotter; Vertebrate Embryology with Practical work, by Mr. Balfour; Practical Elementary Biology, by the Trinity Prælector in Physiology (Dr. Michael Foster). Sidney Sussex College: On the Morphology of Cryptogams, by Mr. Hicks. Downing College: On Chemistry, by Mr. Lewis; On Comparative Anatomy and Physiology, by Mr. Saunders.

THE Trieste papers describe an extensive stalactite cavern, consisting of several galleries, lately discovered in the neighbourhood of the city.

ANOTHER valuable addition has been made to the already enormous ethnographical treasures of the Berlin Museum by the purchase of the extensive collections of the African traveller, Piaggia. The explorer, Schweinfurth calls it the best collection of the kind in existence, and unrivalled in its special department. Although much larger sums were offered by speculators, Piaggia preferred to dispose of it for 75,000*l*. to the Berlin Museum, with the condition that it should be preserved in special apartments bearing his name.

FATHER SECCHI has invented a new electric seismograph with moving smoked paper, which indicates the direction, number, intensity, duration of the shocks, and many other details of great value in connection with seismography.

THE principal article in the April number of Petermann's *Mittheilungen* is on the condition of the bed of the Pacific Ocean, based on the researches of the *Tuscarora*, the *Challenger*, and the *Gazelle*. It is accompanied by a carefully prepared and unusually clear chart, showing by a variety of tints the results which have been obtained.

THE forthcoming number of the Italian geographical journal *Cosmos* will contain an article urging that Italy ought to take a part in Arctic exploration.

IT is stated that the Berlin gorilla, to which we have referred on more than one occasion, is to be brought to London during the present season.

THE annual session of the Congress of French Learned Societies took place at the Sorbonne on April 4, 5, 6, and 7. More than 1,000 *savants* from all parts of France, mostly professors in the several academies, were registered, 300 of whom belong to the scientific sections. M. Leverrier was the president of the scientific department. The question of weather warnings raised several interesting discussions. The final meeting took place as usual on the 7th, the minister for public instruction, M. Waddington, being in the chair. Gold medals were granted to M. Alluard, of the Puy de-Dôme Observatory; M. Tisserand, astronomer to the Observatory of Toulouse; Rollin, professor at Bordeaux for meteorology; Rouville, professor at Montpellier for geology; Grand-Eury, professor at the School of Mines at St. Etienne for geology. Nine silver medals were also granted to several provincial scientific men, and a number of similar distinctions to the members of the other sections.

THE Geographical Society of Paris held last week an extraordinary meeting for the purpose of procuring funds to build a large house for its own use to be ready by the time of the next International Exhibition. A sum of 300,000 francs is necessary, and will be raised by 1,000 bonds of 300 francs each.

M. LEVERRIER has been elected President of the Association Scientifique de France for the fifteenth time. The society spent about 1,200*l*. in scientific experiments last year.

WE have received from the United States Geological Survey a Hypsometric Map of the United States and a Drainage Map of Colorado.

NEWS has been again received at Munich after a long time, from the African traveller, Dr. Erwin v. Bary. He had safely returned to Ghât from his journey into the Valley Mihero. He is the first European who has visited the hot springs of Sebarbaret, and seen the crocodile-pond. Interesting geological and geognostic results, with a collection of many hitherto unknown plants have been gained from this journey. It was very dangerous owing to the war of the Asgar with the Hogar of Tuareg, and the traveller was in constant risk of attack. The sheikh of Tuareg, Jehenuchen, 102 years old, has lost two sons, so he is not easily propitiated. The murderer of the Dutch traveller, Alexandrine Tinne, whose unhappy fate excited European sympathy, goes about freely in Ghât. Dr. v. Bary will endeavour, notwithstanding the danger, to penetrate further into the country of the Tuareg, in order to prosecute his geological and botanical inquiries.

IN a recent note in *Poggendorff's Annalen* on Maxwell's electromagnetic theory of light, Dr. Fröhlich finds that the application of that theory to good electric conductors leads to results which are in direct contradiction with experience. It is not, however (he considers), to be therefore wholly rejected, as the researches of Boltzmann, Schiller, Silow, and Root show that its consequences agree with experience very well in the case of dielectrics (solid bodies, liquids, and gases). And the cause of its divergence in the case of metals may probably be found in the simplicity of the theory. The processes in the interior of metals are of course more complicated than those which occur in transparent or non-conducting dielectric media. And as little as the reflection of light on metallic surfaces can be deduced from the simple undulation theory, is it possible for Maxwell's theory to represent such complicated processes.

A CORRESPONDENCE has recently been going on in the *Journal of the Society of Arts* on the suitability of the leaves of the coffee plant as a substitute for tea. There is nothing new in this suggestion, for in Sumatra as well as in Jamaica coffee leaves are "cured" in a similar manner to those of tea in China for use in the production of a beverage. In some parts of India likewise the leaves are gathered, partially dried, fermented, and finally roasted in imitation of the commercial kinds of tea. Considering the composition of coffee leaves there can be no doubt that if properly and carefully cured they might in time become of some commercial value. Whether the husk which surrounds the coffee seed could also be so utilised is another question that has been raised. This coffee husk seems to be generally used in Arabia under the name of "kishr." In a letter on this subject in a recent number of the above journal a correspondent compares the capabilities of Ceylon as a coffee-producing country with that of Arabia, he says: "Ceylon being a damp climate and the coffee fruit succulent it is gathered when at maturity, otherwise like cherries, it would mould on the trees. It is then placed in heaps for a day or two and the pulp allowed to ferment, in which state it is removed by washing. The pulp so washed off is only fit for manure. On the other hand, the climate of Arabia being dry the fruit is allowed to ripen and drop off of itself. In this case the pulp and other coverings dry on the berry and are often not removed for months after. It is from these husks that the *kishr* is made, or, to speak more correctly, this husk is the *kishr*, a decoction of which is used generally as a beverage throughout Arabia. The parchment and silver skin of the coffee amount to a mere nothing, but the dried husk of the Arabian berry amounts on an average to twenty per cent. The Arabs make their kishr coffee or a decoction of these husks by bruising about a handful, which is put into hot water in an earthen pan, and placed over a slow fire. A few bruised cardamoms and a little dry cinnamon or ginger is added, the whole being allowed to simmer for about half an hour, when it is ready for use, and is described as a most agreeable beverage. A handful of husks thus treated yields about ten Arab coffee cups, which are about the size of two of our ordinary tea cups. The price of the dried coffee husk at Aden is about two shillings for twenty-eight pounds.

THE Italian Government have granted the sum of 6,000 francs for a special investigation of the natural history of Calabria. This part of Italy is only very imperfectly known; in fact its geognosy, its fauna and flora, both present and palæontological, are a *quasi terra ignota* to scientific research. The task has been confided to Messrs. Dr. Forsyth Mayor for the Palæontology and Zoology of Vertebrata, Dr. Cavanna for Zoology of Invertebrata, Dr. D. Stefani for Geology, and Dr. Arcangioli for Botany—all very earnest and able workers. We may, therefore, look forward with confidence and interest to the results of this expedition.

THE Russian Geographical Society has undertaken the publication of a most important work, being a description of the upper parts of the Oxus, of the Hindu-Kush, and Western Himalayas. The object of the publication is to collect all existing information on the peoples inhabiting the above-named countries —the cradle of the Aryan family. The information will be collected from the works of Burns, Wood, Ferrier, Cunningham, Shaw, Hayward, Abramof, Grébenkin, Kuhn, Sobolef, and Fedchenko, and also that obtained from Chinese sources by Klaproth, Rémusat, St. Jullien, Sakinf, Palladiz, &c. This compendium will be accompanied by an ethnographical map and vocabularies of local dialects, as well as by bibliographical notices scattered in many papers, especially English. The Committee intrusted by the Society with the discussion of this scheme will add to the work a general geographical sketch of the country. The work will be under the direction of Prof. J. P. Minayeff.

THE same Society is now preparing a scheme for the ethnographical and anthropological exploration of the Finnish tribes inhabiting the neighbourhoods of the Volga.

AT the last meeting, March 14, of the Russian Geographical Society, Lieut. Onatsévich gave an account of his geographical work during 1874 to 1876 in North-eastern Siberia and the Sea of Okhotsk. The most interesting part of his account was that devoted to the attempt he made in the clipper *Vsadnik* to reach Wrangell Land through Behring Strait. Under lat. 67° the ship met, however, with a thick impenetrable barrier of ice, and was compelled to take a westerly course. In this direction, also, she soon met with ice and was forced to return. Lieut. Onatsévich then cruised about in the open parts of the ocean, making a series of very valuable measurements of depths, temperature of water, &c. He noticed thus the existence of a warm current which, after running through Behring Strait, takes a westerly direction. A great number of very valuable maps and of profiles of the sea-bottom were exhibited during the reading of the paper.

WE have received the Annual Report of the Goole Scientific Society. Some very good papers have been read at the meetings and an attempt has been made to systematically work out the natural history of the neighbourhood.

THE slab of sandstone, from Corncockle quarries, with the impression of footprints, which lately came into the possession of Mr. M'Meekan, Dumfries, has just been acquired by the Museum of Science and Art in Edinburgh. This slab is an unusually interesting one, as it has the impressions of two distinct footprints on it—*Chelichnus ambiguus* and *Herpetichnus sauroplesius* —Jardine ("Ichnology of Annandale"). On none of the slabs in the collection of the late Sir William Jardine, which is now in the Museum in Edinburgh, are to be found the footprints of two different animals, although both the above-mentioned footprints occur on separate slabs.

THE additions to the Zoological Society's Gardens during the past week include a Bennett's Wallaby (*Halmaturus bennetti*) from King's Island, presented by Miss E. Woollatt; a Malabar Green Bulbul (*Phyllornis aurifrons*) from India, presented by Mrs. Arabin, F.Z.S.; two Smooth Newts (*Triton tæniatus*), European, presented by Master G. L. Sclater; eighteen Red-crested Whistling Ducks (*Fuligula rufina*), four Spotted-billed Ducks (*Anas pæcilorhyncha*), a Ring-necked Parrakeet (*Palæornis torquata*) from India, a Green Monkey (*Cercopithecus callitrichus*) from West Africa, a Brown Capuchin (*Cebus fatuellus*), two Scaly Doves (*Scardafella squamosa*), a Great American Egret (*Ardea egretta*) from South America, a White-fronted Guan (*Penelope jacucaca*), a White eye-browed Guan (*Penelope superciliaris*) from South East Brazil, deposited; an Impeyan Pheasant (*Lophophorus impeyanus*) from the Himalayas, two Siamese Pheasants (*Euplocamus prælatus*) from Siam, purchased; two Alpine Marmots (*Arctomys marmotta*), European, received in exchange; a Chinchilla (*Chinchilla lanigera*) born in the Gardens.

SCIENTIFIC SERIALS

American Journal of Science and Arts, March.—In memoriam Fielding Bradford Meek.—Notes on the age of the Rocky Mountains in Colorado, by A. C. Peale.—On some points in connection with vegetation, by S. H. Gilbert.—Apparatus for quantitative fat extraction; composition of the sweet potato; composition of maize fodder, by S. W. Johnson.—Meteoric stone of Rochester, Fulton Co. Indiana, by C. U. Shepard.—Examination of the Waconda meteoric stone, Bates County meteoric iron, and Rockingham County meteoric iron, by J. Lawrence Smith.—Certain features of the valleys or water-courses of Southern Long Island, by Elias Lewis.

Poggendorff's Annalen der Physik und Chemie, No. 1, 1877.—Measurements of diamagneto electric induction currents, by MM. Töpler and Ettingshausen.—On the absorption of radiant heat by aqueous vapour, by M. Haga.—On the dependence of galvanic resistance on current-strength, and Edlund's theory of diaphragm-currents, by M. Dorn.—On the intensity of fluorescence-light, by M. Lommel.—Remarks on Maxwell's electromagnetic theory of light, by M. Fröhlich.—New method of determining exactly the fusing-point of metals and of other matters which are bad conductors of heat, by M. Himly.—On the electric resistance of liquids under high pressure, by M. Herwig.—A perfectly air-tight barometer quickly, easily, and cheaply made without boiling, by M. Bohn.—On diffusion, and the question whether glass is impenetrable for gases, by M. Quincke.—On the polarised light of the rainbow, by M. Dechant.—On ardennite, and a method for separation of vanadic acid from argillaceous earth and iron oxide, by M. Bettendorff.—On the composition of pyrite of cobalt and allied minerals, by M. Rammelsberg.—On the Torricellian vacuum, by M. Moser.—Experiments with the radiometer, by M. Neesen.—Researches on the motions of radiating and irradiated bodies, by M. Zöllner.—On the determination of the principal and focal points of a lens-system, by M. Hoppe.—On thermo-electric determinations of temperature, by M. Rosenthal.—On the nature of gas-molecules, by M. Boltzmann.

Beiblätter zu den Annalen der Physik und Chemie, Band i. Stück 2.—We note here a useful paper on recent experiments with the radiometer and their explanation; also a doctorate-dissertation by M. Lorentz, on the theory of reflection and refraction of light.

From the *Naturforscher* (February) we note the following papers: On the most refrangible part of the solar spectrum, by T. L. Soret.—On the distribution of the electric current in conductors under decomposition, by R. Lenz.—On the southern shore of the northern diluvial sea, by Herr Credner.—On the mixed occurrence of different vegetations, by Oscar Drude.—On the nature of the substance which emits light in the flames of hydrocarbons, by Karl Heumann.—On a prehistoric steppe in the Prussian province of Saxony, by A. Nehring.—On the history of Tertiary deposits in South-eastern Europe, by M. Tournoüer.—On the differences in the chemical structure and in the digestion of higher and lower animals, by F. Hoppe-Seyler.—On a relation of chemical structure to the power of polarising light, by G. J. W. Bremer.—On the conduction of heat by liquids of different densities, by E. Sacher.—On the behaviour of palladium in the alcohol flame, by F. Wöhler.

The *Archives des Sciences Physiques et Naturelles* (January), contains the following original papers:—On the tendrils of climbing plants, by Casimir de Candolle (see our note on this paper).—On the origin of the ancient alluvium, by Ernest Favre.—On static electricity, by E. Mascart.—Description of *Niphargus puteanus*, var. Forellii, by Aloïs Humbert (see our note on this paper).—Some researches made in the physiological laboratory of Geneva; on the formation of pepsine before and after death, by Prof. Schiff.—Note on the effect of the irritation of a nerve through which a constant electric current is passing, by Dr. B. F. Lautenbach.

The *Journal of the Russian Chemical and Physical Societies* (vol. viii., part 9, December, 1876), contains the following papers:—On the action of bromine upon acetone, by N. Sokolowsky.—Synthesis of α oxybutyric acid, by S. Przibytek.—On the pinacoline of methylethyl-acetone, by G. Lawrinowich.—On the synthesis and properties of diallyl-carbinol, by M. Saytzew.—On the action of the iodides of ethyl and allyl upon formiate of ethyl, by the same and J. Kanonnikow.—On the synthesis and the properties of dimethylallyl carbinol, by the same and M. Michail.—Theoretical researches concerning the distribution of static electricity on the surface of conductors constituted of heterogeneous parts, by D. Bobylew.—On electric rays, by O. Chwolson.

Reale Istituto Lombardo di Scienze e Lettere, Rendiconti, vol. x. fasc. 2.—On the co-ordinates of points and of lines in a plane, and of points and planes in space (continued), by M. Casorati.—Case of mammary hypertrophy, by M. Scarenzio.—Results of observations on the amplitude of the daily oscillations of the magnetic needle in 1875 and 1876, at the Observatory of Brera, in Milan, by M. Schiaparelli.—On some differential equations with algebraic integral, by M. Brioschi.

SOCIETIES AND ACADEMIES

London

Royal Society, March 8.—"Notes on Physical Geology," by the Rev. Samuel Haughton, M.D. Dublin, D.C.L. Oxon., F.R.S., Professor of Geology in the University of Dublin.

No. I.—*Preliminary Formulæ relating to the Internal Change of Position of the Earth's Axis, arising from Elevations and Depressions caused by Geological Changes.*

In this paper the author proves the following preliminary formulæ, necessary for the further discussion of his subject:—

$$-\tan 2\theta = 935{\cdot}6\,\rho \sin 2\lambda \quad . \quad . \quad . \quad . \quad (1)$$

where ρ is the ratio of the weight of an elevated mass to the weight of the whole earth;

λ is the latitude at which the elevation takes place, and
θ is the final displacement of the earth's axis of rotation.

$$-r\theta = 14{\cdot}11\,(\cos^3\lambda' - \cos^3\lambda) \quad . \quad . \quad . \quad (2)$$

where $r\theta$ is the displacement of the pole in English miles, caused by a continental slip of 5° longitude in breadth, and lying between the higher and lower latitudes of λ and λ'.

In proving the equations the author distinguishes between three level surfaces, viz.—

1. The surface of the sea.
2. The zero surface of the solid earth.
3. The zero surface, corrected for the weight of the ocean.

The zero plane, from which the elevations are measured, is the surface of the ellipsoid similar to the sea surface, and containing the same volume as the total solid matter of the globe. It is thus found, assuming the mean height of the continents above the sea-level at about 1,000 feet, and the mean depth of the ocean at about two miles, we have, in miles,

$$x = \frac{2{\cdot}2\,L}{W + L}.$$

where x is the height of the zero plane above the present mean sea-bottom, and L, W are the areas of land and water;

L = 52 millions of square miles.
W = 145 ,, ,,

Substituting we find—

$$x = 0{\cdot}58 \text{ mile.}$$

The zero plane, therefore, or original surface of the solid earth, before it became wrinkled by geological forces, lies at a depth of 1·42 mile below the sea-level. In using the equations we must therefore write—

Elevation = + 1·62 mile (continent).
Depression = − 0·58 ,, (ocean).

In calculating the motion of the pole caused by the ocean excavations, the weight of the sea-water must be considered, and, by chance, it happens that the weight of the sea-water somewhat more than counter-balances the weight of the surface-rock excavated; so that the depression of the ocean-bottoms of the earth beneath the zero plane have had little or no effect in shifting the position of the pole.

Assuming 1·026 and 2·75 as the densities of sea-water and surface-rock, we have for the excess of weight of water added above that of rock excavated; expressed in depth of rock, in miles—

$$\frac{2 \times 1{\cdot}026 - 0{\cdot}58 \times 2{\cdot}75}{2{\cdot}75} = 0{\cdot}17 \text{ mile.}$$

The introduction of the weight of the sea will thus give us (raising the zero plane by 0·17 of a mile)—

Elevation = + 1·45 mile (continent),
Depression = 0·00 ,, (ocean).

No. II.—*On the Amount of Shifting of the Earth's Axis, already caused by the Elevation of the existing Continents.*

Having shown in the preceding note that the motion of the earth's axis caused by the geological wrinkling of the earth's surface depends (in consequence of the weight of the sea-water) only on the continents, it remains to calculate the numerical amount of change of axis produced by each of the existing continents.

For this purpose the author selects the following meridians for the co-ordinates Y and X of the motion:—

	°		
Greenwich	0	...	+ Y
Rangoon	90	...	− X
Behring's Strait	180	...	− Y
Yucatan	270	...	+ X

Reckoning the longitudes eastward, round the whole circumference of the earth, the equation (2) gives—

$$r\theta = -\ 14{\cdot}11\,(\cos^3\lambda' - \cos^3\lambda),$$

in which the meridian of each 5° of longitude is used, λ' and λ being the lowest and highest degrees of latitude of the land on each meridian.

The expression $\cos^3\lambda' - \cos^3\lambda$ is found by observation on the globe, and resolved into its components X and Y, regarding the North Pole as the axis moved.

The equation (2) is then used (by quadratures) to determine the total effect of each continent taken separately. The tables of quadratures are given in the paper, and the final results are—

Displacement of North Pole caused by each continent.

	Towards Greenwich. Mile.	Towards Behring's Strait. Mile.	Towards Yucatan. Mile.	Towards Rangoon. Mile.
Europe and Asia	—	58·7	199·4	—
Africa	—	26·9	—	1·7
North America	15·2	—	—	105·5
South America	19·9	—	35·1	
Australia, &c.	—	30·2	—	30.2

The power of Europe and Asia in moving the pole is partly due to the extension of this continent along the parallel of 45°, which is the most effective latitude. The actual effect produced by Europe and Asia was not much less than that of our imaginary continent (Note I.), occupying one eighth part of the surface of the globe.

The foregoing results are positive, and the motions of the pole indicated must have actually occurred when the existing continents were formed. But simultaneously with these elevations depressions must have gone on elsewhere, continents disappearing beneath the sea and sinking to the zero plane, while other continents were rising. It is to be noticed that although the excavation of the sea-bottom to its present depth below the zero plane, corrected for the weight of the ocean, produces no motion in the pole, yet that the depression of a continent down to the zero plane produces a motion of pole equal and opposite to that produced by its elevation. I have calculated the hypothetical effects of the depression of imaginary continents occupying the sites of the present Pacific Ocean, with the following results:—

North Pacific Ocean (depressed).

Towards Yucatan	3·4 miles.
Towards Behring's Straits	250·6 „

South Pacific Ocean (depressed).

Towards Rangoon	156·2 miles.
Towards Greenwich	238·2 „

The total effect of a continent equal to the North Pacific would be—

$$\sqrt{X^2 + Y^2} = 250·6 \text{ miles.}$$

$$\frac{X}{Y} = \tan(\phi),\ \phi = 0° 47' \text{ E. of } 180°.$$

The total effect of a continent equal to the South Pacific Ocean would be—

$$\sqrt{X^2 + Y^2} = 201·8 \text{ miles.}$$

$$\frac{X}{Y} = \tan(\phi),\ \phi = 23° 17' \text{ E. of Greenwich.}$$

Geological Society, March 21.—Prof. P. Martin Duncan, F.R.S., president, in the chair.—William B. Coltman, William James Grimshaw, and Alexander Ross were elected Fellows of the Society.—The following communications were read:—On the strata and their fossil contents between the Borrowdale series of the North of England and the Coniston flags, by Prof. Robert Harkness, F.R.S., Cork, and H. Alleyne Nicholson, F.R.S.E., Professor in St. Andrew's. The object of this paper was the investigation of the strata between the great volcanic series of the Lake-district, the Borrowdale rocks, and the sedimentary rocks called Coniston Flags by Prof. Sedgwick. The Borrowdale series, the Green Slates and Porphyries of Sedgwick, are underlain by the Skiddaw Slates, forming the base of the Silurian series, and equivalent in age to the Arenig rocks of Wales, according to their fossil contents. The Borrowdale rocks consist of ashes and breccias, alternating with ancient lavas, and are partly subaërial, partly submarine. They contain no fossils except in a band of calcareous ashes near the summit of the group, which is followed by the Coniston Limestone, with or without the intervention of a bed of trap. The fossils are of Bala types. Sometimes this band is recognisable, with no traces of fossils except cavities filled with peroxide of iron. The authors regard this as proving the prevalence of volcanic activity in the Lake District up to the later portion of the Bala period. The deposits specially discussed in the paper sent lie, apparently quite conformably, upon the Borrowdale rocks, and are grouped by the authors as follows, in ascending order:—(1) Dufton Shales; (2) Coniston Limestones and Shales; (3) Graptolitic Mudstones or Skelgill beds; (4) Knock beds. The "Dufton Shales" are a well-marked but locally distributed group of muddy deposits, especially well developed in the Silurian area underlying the cross Fell range, where they are seen in four principal exposures, and their thickness probably exceeds 300 feet. They are richly fossiliferous. The "Coniston Limestone" has long been recognised as the best-defined division of the Lower Silurian rocks of the north of England. The "Graptolitic Mudstones" overlie the Coniston Limestone, wherever the summit of the latter is to be seen. Besides Graptolites, they contain many other fossils, including Corals, Brachiopods, Cephalopods, and Crustaceans; and from the consideration of the whole fauna, the authors are led to believe that the position of these deposits must correspond either with the highest beds of the Bala series or with the lower portion of the Llandovery group. The Graptolitic Mudstones are succeeded by the "Knock beds," so called from their great development in Swindale Beck, near Knock. Wherever they occur they consist chiefly of pale green, fine-grained slates, very ashy in appearance, and presenting many dendrites, and frequently crystals of cubic pyrites. There is no evidence of unconformity between them and the underlying Mudstones.—On a new area of Upper Cambrian Rocks in South Shropshire, with the description of a new fauna, by C. Callaway, F.G.S. The purpose of the author was to prove that certain olive, micaceous, thin-bedded shales exposed at Shineton, near Cressage, and covering an area of eight miles in length by two in the greatest breadth, which had been mapped as Caradoc in the survey, were of Tremadoc age. They were seen clearly to underlie the Hoar Edge Grit, the lowest beds in the district, with Caradoc fossils; and no rock distinctly underlying the shales could be detected. The evidence for their age was chiefly palæontological. With the exception of *Asaphus homfrayi*, a Tremadoc form, the species are new. Genera such as *Olenus*, *Conocoryphe*, *Obolella*, and *Lingulella* suggested a very low horizon, but two Asaphoid forms (though not typical *Asaphi*) pointed in an opposite direction. Corroborative evidence was found in a correlation of the shales at Shineton with the *Dictyonema*-shales at Pedwardine and Malvern.

Anthropological Institute, April 10.—Mr. John Evans, F.R.S., president, in the chair.—The president exhibited two stone instruments from Sandoway District, North Burmah.—Some flint arrow-heads, scrapers, &c., from Ditchley, Oxon, were exhibited by Capt. Harold Dillon.—A paper on some rude stone monuments in North Wales was read by Mr. A. L. Lewis. The chief point of interest being the existence, hitherto, we believe, unnoticed, of single outlying stones on the north-east of the circle near Penmaunmawr which is thus shown to conform to and to lend further confirmation to the rule found by him to exist generally in British circles of a special reference to the north-east by outlying stones or otherwise.—The director read a paper by the Rev. W. Ross, F.S.A. Scotland, on some curious coincidences in Celtic and Maori vocabulary.—Papers were also read by the director, on Australian aboriginal languages, traditions, &c., by Messrs. Greenway, McDonald, Rowlay, Malone, and Dr. Creed, communicated by Mr. William Ridley, M.A., through the Colonial Office.—Col. A. Lane Fox, F.R.S., Messrs. Hyde Clarke, Walhouse, Moggridge, Park-Harrison, and the president, took part in the discussion.

Royal Microscopical Society, April 4.—H. C. Sorby, F.R.S., president, in the chair.—The following papers were read:—On the variability of the chlorophyll bands in the spectrum, by Mr. Thomas Palmer, in which he described the various effects produced by solutions in alcohol, &c., and by treatment with acids and alkalis.—On the mineralogical constitution and microscopical characters of the whetstones of Belgium, by M. l'Abbé Rénard, of Louvain.—On the microscopical character of Krupp's "silicate cotton," by Mr. H. J. Slack, and on the lower Silurian lavas of Cumberland, by Mr. Clifton Ward, in which it was shown that the difference between ancient and modern lavas was not so great as was usually supposed, their actual constituents being very nearly the same, though apparently they differed owing to conditions which had produced metamorphosis in the earlier series.

Physical Society, March 17.—Prof. G. C. Foster, president, in the chair.—Mr. W. S. Seaton was elected a member of the society. Mr. Spottiswoode exhibited some experiments on the stratification of the electric discharge in vacuum tubes, and described his attempts to produce the effects as obtained by Mr. Gassiot and Mr. de la Rue, with batteries of several thousand cells, by means of the induction coil. An account of his experiments has already been given in our pages.—Capt. Abney, R.E., then read a paper on the photographic image, prefacing it by a brief account of the two theories, the chemical and the physical, which are held regarding it. On the former, a molecule of bromide of silver is split up into sub-bromide and bromine, the latter of which is absorbed; and on the latter theory, light acts mechanically on the molecule, shifting the positions of the atoms. Poitevin has done much to confirm the former of these by placing a film of silver iodide in contact with a silver plate, when he succeeded in obtaining an image on the film of iodide and one on the silver plate produced by the liberated iodine. Capt. Abney has performed the following experiments : a portion of a dry plate which had been exposed, was wet with a sensitive collodion emulsion of bromide of silver, and developed by the alkaline method; the films were separated from the glass and from each other by means of gelatinised paper, and were found to bear images: and the same result was obtained when the emulsion was added after exposure, development, and fixing. These experiments entirely disprove the supposition that only those molecules acted on by light are reduced. If the two films be separated by a thick layer of albumen, the lower picture develops as a negative, and the upper as a positive. Capt. Abney is now engaged in an attempt to determine the attraction exercised by the sub-bromide, and this it is hoped, will do much towards the complete solution of the problem of the photographic image.—Mr. O. J. Lodge proposed a modification of Mance's method for determining the intensity of an electric current. This method, of which Wheatstone's Bridge is an application, depends upon the fact that if three conductors be united at a point A, and their extremities B C and D be united by three wires, B C, C D, D B, the resistance of B C will be independent of that of A D if A B is to A C as B D is to C D. In the arrangement proposed by Mr. Lodge, four wires are joined in the form of a square, and the circuit can be completed across one diagonal by means of a key, and in the other diagonal is included a condenser and a galvanometer, with a long fine wire. The greatest sensitiveness is obtained when the resistances in the four sides are equal. A great advantage of this method consists in the fact that it is equally applicable to the measurement of small and great resistances. Mr. Lodge then showed a modified form of Daniell's cell, capable of giving a constant current for a considerable period. A glass cell half filled with dilute sulphuric acid, contains two vertical glass tubes one of which, open at both ends, is traversed by a zinc rod, while the other is closed at its lower end, and contains cupric sulphate, from which rises a copper wire. The portion of the glass tube projecting above the acid is sufficiently moist to enable the current to traverse its surface while the zinc sulphate is prevented from reacting on the copper.

Victoria (Philosophical) Institute, April 18.—Rev. R. Thornton, D.D., vice-president, in the chair.—A paper on recent Assyrian research, and the light it threw on civilisation at the time of Abraham, was read by the Rev. H. G. Tomkins.

MANCHESTER

Literary and Philosophical Society, March 20.—Mr. E. W. Binney, F.R.S., president, in the chair.—On the action of sea-water upon lead and copper, by Mr. William H. Watson, F.C.S. Communicated by Dr. R. Angus Smith, F.R.S.—Note on the Upper Coal Measures of Canobie, Dumfriesshire, by Mr. E. W. Binney, president, F.R.S.—Losses and gains in the death-toll of England and Wales during the last thirty years, by Mr. Arthur Ransome, M.D.

PARIS

Academy of Sciences, April 9.—M. Peligot in the chair.—The following papers were read:—On the possibility of deducing from one only of the laws of Kepler the principle of attraction, by M. Bertrand.—Some of the fundamental data of thermo-chemistry, by M. Berthelot. He deals with the heat of formation of sulphurous acid and the compounds formed by bromine and iodine with hydrogen and oxygen.—On a theorem relative to the expansion of vapours without external work (continued), by M. Hirn.—Morphological relations between the antheridia and the sporules developed in the verticillate ramification of a particular form of *Batrachospermum moniliforme*, by M. Sirodot.—Substitution of chlorophyll for salts of copper ordinarily used in preparation and conservation of fruits and green vegetables, by M. Guillemare. This is based on three facts: (1) the chlorophyll of vegetables disappears in boiling; (2) vegetable fibre and its feculant matter put in contact, through washing, with dissolved chlorophyll, is saturated with it near 100;° (3) vegetables wholly or half saturated with chlorophyll, in washing, thenceforth retains, in boiling, this green matter.—On the presence of zinc in the bodies of animals and in plants, by MM. Lechartier and Bellamy. A man's liver weighing 1,780 grammes contained 2 centigrammes of oxide of zinc; 913 grammes muscular tissue of ox contained 3 centigrammes; 1,152 grammes of hens' eggs 2 centigrammes. Zinc was found also in grains of wheat, American maize, barley, winter vetches, and white beans; while beet, the stems of maize, green clover and its seed did not contain it in perceptible quantity. These facts have an important bearing on toxicological researches.—Discovery of a Gallo-Roman port and a Gaulish port, dated by a study of the layers of mud, in the neighbourhood of Saint Nazaire, by M. Bertrand. M. Gervais added some details.—Reconstitution of French wine-growing by sulphocarbonate of potassium, by M. Mouillefert.—Results obtained in the treatment of phylloxerised vines by alkaline sulphocarbonates, applied by means of the distributing pale, by M. Gueyrand.—Note on a new mode of manufacture of sulphides, carbonates, and alkaline sulphocarbonates, by M. Vincent. He utilises the reactions produced in making beet sugar to prepare sulphide of barium. This, mixed with sulphate of potash, gives by double decomposition sulphate of baryta and sulphide of potassium, and the latter, submitted to the action of carbonic acid gives carbonate of potassium. M. Vincent extends his method to manufacture of sulphocarbonate, which he can obtain at 50 francs the kilogramme instead of 120, which it has lately cost.—List of thirty new nebulæ discovered and observed at the observatory of Marseilles, by M. Stephan.—On a modification in the employment of electricity considered as agent of galvanic deposits and chemical decompositions, by M. Thenard. Instead of having only one bath with the two anodes, the conditions being those of small electric resistance and maximum effort, he has several, connecting their anodes like the elements of a battery connected for tension. The quantity of deposited copper increases with the number of baths.—New method for establishing the equivalent in volumes of vaporisable substances, by M. Troost. Given an inclosure filled with vapour of hydrate of chloral, then if the water is always combined, the atmosphere will behave as if it were dry in presence of a body capable of yielding water; if the water is simply in mixture the atmosphere will act as if saturated. Now the former occurs, and this confirms M. Dumas' hypothesis as against that of M. Naumann. The method may have other applications.—On the oxidation of metallic sulphides, by M. De Clermont.—Decomposition of liquid organic substances by the electric spark, with production of fundamental carburets of hydrogen, by M. Truchot.—On the existence of veins of bitumen in granite in the environs of Clermont Ferrand, by M. Julien.—New experiments on the toxical action attributed to copper and to substances containing copper in combination, by M. Galippe. These confirm former conclusions.—Note on the first phenomena of the development of sea-urchins (*Echinus miliaris*), by M. Giard.—M. Chasles presented (from M. Riccardi) the first part of a work called *La Biblioteca matematica Italiana*, which is to be a bibliography of all Italian works on mathematics from the earliest times to the beginning of the nineteenth century.

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