THURSDAY, DECEMBER 25, 1873

## QUATERNIONS

A MATHEMATICIAN is one who endeavours to secure the greatest possible consistency in his thoughts and statements, by guiding the process of his reasoning into those well-worn tracks by which we pass from one relation among quantities to an equivalent relation. He who has kept his mind always in those paths which have never led him or anyone else to an inconsistent result, and has traversed them so often that the act of passage has become rather automatic than voluntary, is, and knows himself to be, an accomplished mathematician. The very important part played by calculation in modern mathematics and physics has led to the development of the popular idea of a mathematician as a calculator, far more expert, indeed, than any banker's clerk, but of course immeasurably inferior, both in resources and in accuracy, to what the "analytical engine" will be, if the late Mr. Babbage's design should ever be carried into execution.

But though much of the routine work of a mathematician is calculation, his proper work—that which constitutes him a mathematician—is the invention of methods. He is always inventing methods, some of them of no great value except for some purpose of his own; others, which shorten the labour of calculation, are eagerly adopted by all calculators. But the methods on which the mathematician is content to hang his reputation are generally those which he fancies will save him and all who come after him the labour of thinking about what has cost himself so much thought.

Now Quaternions, or the doctrine of Vectors, is a mathematical method, but it is a method of thinking, and not, at least for the present generation, a method of saving thought. It does not, like some more popular mathematical methods, encourage the hope that mathematicians may give their minds a holiday, by transferring all their work to their pens. It calls upon us at every step to form a mental image of the geometrical features represented by the symbols, so that in studying geometry by this method we have our minds engaged with geometrical ideas, and are not permitted to fancy ourselves geometers when we are only arithmeticians.

This demand for thought—for the continued construction of mental representations—is enough to account for the slow progress of the method among adult mathematicians. Two courses, however, are open to the cultivators of Quaternions: they may show how easily the principles of the method are acquired by those whose minds are still fresh, and in so doing they may prepare the way for the triumph of Quaternions in the next generation; or they may apply the method to those problems which the science of the day presents to us, and show how easily it arrives at those solutions which have been already expressed in ordinary mathematical language, and how it brings within our reach other problems, which the ordinary methods have hitherto abstained from attacking.

Sir W. R. Hamilton, when treating of the elements of the subject, was apt to become so fascinated by the metaphysical aspects of the method, that the mind of his disciple became impressed with the profundity, rather than the simplicity of his doctrines. Professors Kelland and Tait in the opening chapter (II.) of their recently published work* have, we think, successfully avoided this element of discouragement. They tell us at once what a vector is, and how to add vectors, and they do this in a way which is quite as intelligible to those who are just beginning to learn geometry as to the most expert mathematician.

The subject, like all other subjects, becomes more intricate as the student advances in it; but at the same time his ideas are becoming clearer and more firmly established as he works out the numerous examples and exercises which are placed before him.

The technical terms of the method—Scalar, Vector, Tensor, Versor—are introduced in their proper places, and their meaning is sufficiently illustrated to the beginner by the examples which he is expected to work out. The pride of the accomplished mathematician, however (for whom this book is not written), might have been somewhat mollified if somewhere in the book a few pages had been devoted to explaining to him the differences between the Quaternion methods and those which he has spent his life in mastering, and of which he has now become the slave. He is apt to be startled by finding that when one vector is multiplied into another at right angles to it, the product is still a vector, but at right angles to both. His only idea of a vector had been that of a line, and he had expected that when one vector was multiplied into another the result would be something of a different kind from a line, such, for instance, as a surface. Now if it had been pointed out to him in the chapter on vector multiplication that a surface is a vector, he would be saved from a painful mental shock, for a mathematician is as sensitive about "dimensions" as an English schoolboy is about "quantities."

The fact is, that even in the purely geometrical applications of the Quaternion method we meet with three different kinds of directed quantities: the vector proper, which represents transference from A to B; the area or "aperture," which is always understood to have a positive and a negative aspect, according to the direction in which it is swept out by the generating vector; and the versor, which represents turning round an axis.

The Quaternion ideas of these three quantities differ from the old ideas of the line, the surface, and the angle only by giving more prominence to the fact that each of them has a determinate *direction* as well as a determinate magnitude. When Euclid tells us to draw the line A B, he supposes it to be done by the motion of a point from A to B or from B to A. But when the line is once generated he makes no distinction between the results of these two operations, which, on Hamilton's system, are each the opposite of the other.

Surfaces also, according to Euclid, are generated by the motion of lines, so that the idea of motion is an old one, and we have only to take special note of the direction of the motion in order to raise Euclid's idea to the level of Hamilton's.

With respect to angles, Euclid appears to treat them as if they arose from the fortuitous concourse of right lines;

* "Introduction to Quaternions, with numerous Examples." By P. Kelland, F.R.S., formerly Fellow of Queen's College, Cambridge; and P. G. Tait, formerly Fellow of St. Peter's College, Cambridge; Professors in the Department of Mathematics in the University of Edinburgh. (Macmillan, 1873.)

but the unsatisfactory nature of this mode of treatment is shown by the fact that in all modern books on trigonometry an angle is represented as generated by motion round an axis in a definite direction.

There are thus three geometrical quantities having direction, and the more than magical power of the method of Quaternions resides in the spell by which these three orders of quantities are brought under the sway of the same system of operators.

The secret of this spell is twofold, and is symbolised by the vine-tendril and the mason's rule and square. The tendril of the vine teaches us the relation which must be maintained between the positive direction of translation along a line and the positive direction of rotation about that line. When we have not a vine-tendril to guide us, a corkscrew will do as well, or we may use a hop-tendril, provided we look at it not directly, but by reflexion in a mirror.

The mason's rule teaches us that the symbol, as written on paper, is not a real line, but a mere injunction, commanding us to measure out in a certain direction a vector of a length so many times that of the rule. Without the rule the symbol would have no definite meaning. Thus the rule is the unit of the Quaternion system, while the square *reminds* us that the right angle is the unit versor.

The doctrine of the unit is a necessary part of every exact science, but in Quaternions the application of the same operators to versors, vectors, and areas is utterly unintelligible without a clear understanding of the function of the unit in the science of measurement.

Whether, however, it is better to insinuate the true doctrine into the mind of the student by a graduated series of exercises, or to inculcate it upon him at once by dogmatic statements, is a question which can only be determined by the experience of a new generation, who shall have been born with the extraspatial unit ever present to their consciousness, and whose thoughts, guided by the vine-tendril along the Quaternion path, shall turn always to the right hand, and never to the left.

Prof. Kelland tells us in the preface to the work to which we have alluded that, whereas Sir W. R. Hamilton and Prof. Tait have written treatises on Quaternions for mathematicians, the time has come when it behoves some one to write for those who desire to become mathematicians. Whatever, therefore, advanced mathematicians may think of this book, they ought to reserve their judgment as to its difficulty till they have ascertained how it is assimilated by those for whom it is written—those in whom the desire to become mathematicians has not yet become alloyed with the consciousness that they are mathematicians. For while Prof. Kelland—as he has elsewhere told us—finds but little difficulty in teaching the elements of the doctrine of Vectors to his junior classes, Hamilton himself, the great master of the spell, when addressing mathematicians of established reputation, found, for his Quaternions, but few to praise and fewer still to love.

Prof. Kelland, by the clearness and orderliness of his statements, and by boldly getting rid of everything which is unnecessarily abstruse, has done more than any other man towards rendering the subject easy to the student, and reconciling even the case-hardened mathematician to the new method, as applied to geometrical questions of old-established truth.

The other aspect of Quaternions, as a method which every mathematician *must* learn in order to deal with the questions which the progress of physics brings every day into greater prominence, is hinted at by Prof. Tait in the last chapter of the book. He there introduces us to the linear and vector function of the first degree under its kinematical aspect of a homogeneous strain. The importance of functions of this kind may be gathered from the fact that a knowledge of their properties supplies the key to the theory of the stresses as well as the strains in solid bodies, and to that of the conduction of heat and electricity in bodies whose properties are different in different directions, to the phenomena exhibited by crystals in the magnetic field, to the thermo-electric properties of crystals, and to other sets of natural phenomena, one or more of which the scientific progress of every year brings before us.

But as we believe that Prof. Tait is about to bring out a new edition of his treatise on Quaternions, in which this higher aspect of the subject will be brought more prominently forward, we reserve our remarks on Quaternions as an instrument of physical research till we have the subject presented to us by Prof. Tait in a form which adequately represents its latest developments.

## MARKHAM'S "UNKNOWN REGION"

*The Threshold of the Unknown Region.* By Clements R. Markham, C.B., F.R.S., Secretary of the Royal Geographical Society, formerly of H.M. Arctic ship *Assistance.* (London: Sampson Low and Co., 1873).

HE must be a sorry story-teller who manages to make a traveller's tale uninteresting, especially if the traveller be a voyager, and still more if his voyages have led him into unknown regions. Of all forms of narrative we think it will be generally acknowledged that narratives of discovery are by far the most popular, as is testified by the abundance of this kind of literature, historical and fictitious, provided for the delectation of the young. No doubt this may be largely accounted for by the fact that a discoverer of new lands is continually unveiling the unknown to those who listen to his tale, thereby appealing to one of the strongest and most fruitful characteristics of the human mind, that of curiosity. Every step taken by a discoverer, every knot sailed by his "good ship," we know will lead him among fresh wonders. Once upon a time the Unknown Region—that is, the region unknown to those peoples who have had a thirst for knowledge to any fruitful extent—was in sooth wide enough, when first our Aryan forefathers left their eastern home, and had "all the world before them where to choose." Even four centuries ago the greater part of the earth waited the coming of the European descendants of those primitive discoverers who first turned their faces eagerly and inquisitively to the unknown west. But ever since then the boundary of the Unknown Region has been gradually pushed farther and farther back, until now there remains comparatively little to be found out in order to enable geographers to complete the configuration of the lands of the globe. The extent of our dwelling-place is now pretty well known, though there is yet abundance of work for many generations of explorers ere the contents of land and water be anything like fully disclosed.

Of all narratives of discovery, those relating to Arctic regions bear, in our estimation, the palm for intensity of interest, and we are sure there are many who think along with us in this matter. It would be difficult to say briefly why this is so. It may be mainly that there the mystery of the unknown, so far as relates to the surface of our globe, is concentrated. No doubt, also, there is a weird fascination around those eerie, rugged, ice-bound regions of the far north, which have been the scene of a greater number of deeds of heroic daring for noble and disinterested purposes, than any other region of the globe of equal extent. There is also a general though perhaps vague, yet we believe, well-founded belief, that within these regions lie solutions to many of the yet mysterious problems of science; that if once all the phenomena that lie within the yet unlifted veil were exposed and understood, they would afford us the means of tracing with something like certainty the history of our earth through many geological ages. In more senses than one, we are there on the threshold of the unknown.

There is somehow not the same attractiveness about Antarctic exploration, though, as Dr. Neumayer has well shown, it is certainly calculated to yield valuable results to Science, and indeed has already done so. This may partly arise from the scarcity in these regions of land and of life of all kinds, which are abundant enough in certain regions of the known north. Indeed, the tract around which the interest of Arctic discovery is concentrated may be regarded as but a continuation of the great American Continent.

We are sure that all who read this immensely interesting volume of Mr. Markham's will agree with what we have said. No more attractive subject for a work exists than the history of Arctic discovery; no man knows this subject better than Mr. Markham; and few could have written a volume on the subject more full of interest and of valuable information clearly arranged than the one before us. The object of the volume, Mr. Markham tells us, "is to give the public a correct knowledge of the whole line of frontier separating the known from the unknown region round the North Pole, to recall the stories of early voyagers, to narrate the recent efforts of gallant adventurers of various nationalities to cross the threshold, to set forth the arguments in favour of a renewal of Arctic exploration by England, and to enumerate, in detail, the valuable and important results to be derived from North Polar discovery." Mr. Markham's main design is evidently to show that the only certain gateway to the Pole is by the Smith Sound route, and this design he accomplishes in a way that cannot fail to convince any unprejudiced reader, by going over the whole story of Arctic discovery from the time that that hardy Norseman Lief, the son of Eric the Red, in 1001, made his abortive discovery of North America, down to the present year, when the world was astounded by the news of the discoveries and adventures of the ill-equipped but remarkably successful *Polaris* expedition. One's blood is once more stirred by the story of these fearless early English and Dutch adventurers, Burrough and Pett and Jackman and Barentz and Hudson and others, who dared to face the dangers of Arctic navigation in mere "cock-boats" of 20 and 40 and 80 and 100 tons. The story of Barentz and his companions especially is told with considerable fulness, and it is with a very strange kind of feeling that one reads of the discovery, in 1871, of the very hut in which these stout-hearted Dutchmen passed the winter of 1596-7, and goes over the long catalogue of "Barentz relics" found therein.

Mr. Markham recounts the principal attempts that have been made to pierce through the formidable barrier of ice that guards the North Pole. "There are three approaches by sea to this land-girt end of the earth: through the wide ocean between Norway and Greenland, through Davis' Strait, and through Behring's Strait—one wide portal and two narrow gates." At present no one seems to think of attempting the last-mentioned route, advocates of Arctic exploration being divided between the Spitzbergen route, as the wide sea between Greenland and Novaya Zemlya is called, and the Smith Sound route, the route through the winding passages that lie between Greenland and the American continent. Mr. Markham, in considerable detail, recounts the various expeditions which, from the days of Barentz down to our own time, have charged the barrier that hems the Pole between the east coast of Greenland and Novaya Zemlya. He states with perfect fairness and with all necessary fulness the progress made by each expedition, and the invariable result, so far as the attempt to approach the Pole is concerned, has been failure. The highest latitude attained by this route was that reached by the well-equipped sledge expedition of Parry in 1827, 82° 45′ N.; but the difficulties which the expedition had to encounter were so stupendous as, when combined with what is known of the conditions which influence the movements of the pack in this direction, to utterly forbid any hope of attaining the desired goal by the Spitzbergen route. The inevitable conclusion to be derived from the many fruitless attempts which have hitherto been made by this route is, "that by the Spitzbergen route, in a bad season, nothing whatever can be done; and in a favourable season a steamer may possibly press one or two, or even more degrees farther north than has hitherto been reached, and obtain some valuable deep-sea soundings and temperatures, but no other scientific results in the absence of land. The Spitzbergen route cannot be recommended, because there is no sure prospect of exploring an extensive unknown area, and because no valuable results in geology, botany, ethnology, or geodesy could be obtained under any circumstances." On this point Arctic authorities are all but unanimous, as they are also on the point that by the Smith Sound route a well-equipped Government expedition, if sent out next spring, would be almost certain to return within three years with the mystery of the "Polynia" cleared up, and with results in nearly all departments of Science not only invaluable from a purely scientific point of view, but of the highest practical importance. The very last attempt that has been made by the Smith Sound route seems to us to prove triumphantly that it would at present be folly to attempt to reach the pole by any other route, and that if the meagrely equipped and badly disciplined *Polaris* expedition accomplished so much in a very few days, an expedition such as Government will, we hope, feel bound to send out, will be sure to accomplish the remaining 400 or 500 miles that lie between Hall's farthest north point and the Pole.

True, there are a few unhealthy croakers, as there always have been, and will be, we fear, for many generations to come, who ask What is the good of incurring so much danger and expense, for the mere gratification of curiosity, or, at best, to satisfy the wishes of a few men of science? But we feel confident that the great body of the English people will ask no such questions, but would hail with enthusiasm the decision of the Government to crown the glory which England has hitherto gained in Arctic exploration by sending out one more expedition whose task it would be to return with the long-sought-for secret in its keeping. It is beginning to dawn upon the ordinary English mind that, after all, the apparently unpractical researches of scientific men are frequently pregnant with results of the most important practical bearing on the welfare of the country and the race.

As for the element of danger, Mr. Markham convincingly shows by unimpeachable statistics, that the loss of men by the Smith Sound route, from causes connected with the climate and the peculiarities of the service, is almost incredibly small. One of the most distinguished medical officers who has served in the Arctic regions declares, that "of all seas visited by men-of-war the Arctic have proved the most healthy. . . . The risk by climate and disease which is run in a voyage to the Arctic seas—such as a Royal Expedition necessitates—is not greater than that which a ship like the *Challenger* will incur in her voyage of discovery." The dangers, or rather difficulties, which have to be faced are only such as brave men are eager to confront, and the service is one which our naval officers and men glory in in time of peace, and is certainly an infinitely better use to put them to than to keep them idling at home or on foreign stations. As to the question of expense, the article in a recent number will show that the less said by Government on this score the better.

All these and many other points in connection with Arctic exploration will be found fully and clearly discussed in Mr. Markham's volume, in which the invaluable results, scientific and practical, in nearly all departments of Science to be obtained from a Government Expedition are set forth with great fulness, clearness, and force. The volume concludes with an account of the interview that took place last year between the Arctic deputation and Mr. Lowe, the result of which was such as to give good grounds for expecting that this year Government will feel bound to organise an adequate expedition to leave our shores next spring to find its way to the Pole by the Smith Sound route.

The numerous maps by which the volume is illustrated are beautifully drawn, and are of the greatest assistance in enabling the reader to understand the interesting story of Arctic discovery so well told by Mr. Markham. As a mere story the work is a masterly one; and if anyone wants to know within short space what has already been done in the discovery of the Arctic regions, what still remains to be done, and what results are to be expected from further exploration, he could not do better than ead Mr. Markham's "Threshold of the Unknown Region."

## OUR BOOK SHELF

*Annual Record of Science and Industry* for 1872; edited by Spencer F. Baird, with the assistance of eminent men of Science. (New York: Harper and Brothers, 1873.)

THE praise which we were able to bestow on the first of Prof. Baird's Annual Records, that for 1871, can be fully repeated with regard to its successor. The only method of "reviewing" a work of this kind, is to refer in general terms to its scope, and to the degree to which the compiler appears to have fulfilled the promises of his programme. On these points we can speak in the most favourable terms. As far as a cursory glance through the pages of the volume enables us to speak, we believe that purchasers of the book will find it a most useful addition to their library shelves. The paragraphs refer to the most noteworthy additions to scientific knowledge or observation made during the year, and have been compiled with commendable terseness and perspicuity from a large range of English, American, and Continental sources. A carefully *raisonné* table of contents, and an alphabetical index, will enable the student to turn without difficulty to any desired subject. Although absolute freedom from errors, typical and otherwise, can hardly be expected in a work with so large a scope, the American "Record" contrasts most favourably in this respect with some similar volumes published in this country. We do not know where to find a more complete record of the science of the year; and we shall hope to see a long series of these useful volumes.

*The Borderland of Science.* By Richard A. Proctor. (London: Smith, Elder, and Co. 1873.)

THESE Essays are reprinted from the *Cornhill Magazine*. The titles are as follows:—"The Herschels and the Star-Depths;" "A Voyage to the Sun;" "A Voyage to the Ringed Planet;" "A Giant Planet;" "Life in Mars;" "A Whewellite Essay on the Planet Mars;" "Meteors—Seed-bearing, and otherwise;" "A Recent Star-shower, and Star-showers generally;" "News from the Moon;" "Earthquakes;" "The Antarctic Regions:" "A Few Words about Coal;" "Notes on Flying and Flying-Machines;" "Gambling Superstitions;" "Coincidences and Superstitions;" "Notes on Ghosts and Goblins."

*Sommario delle Lezioni di Fisica*, date dal Professore Enrico Dal Pozzo di Mombello, nella Libera Universita di Perugia. (Foligno: Pietro Spariglia, 1873.)

GANOT'S Treatise on Physics has been translated into Italian and is no doubt largely used in the country; also in 1870 Prof. Cantoni, of Milan, published a course of Physical Lectures. The work before us by Prof. Dal Pozzo is to some extent based upon that of Cantoni; it is a summary of two courses of lectures delivered in the free University of Perugia. The University (founded in 1307) is one of the oldest in Europe, and possesses a good library, botanical gardens, and mineralogical collections. We cannot at this moment call to mind any scientific associations connected with the place, as with Pisa, Bologna, and Pavia. The town itself has been mentioned any time for two and twenty centuries, and it is a noted school of music.

We can scarcely judge of the science of Perugia from the work before us. The students must be very clear-headed men if they can follow Prof. Pozzo's arrangement. It is certainly most novel. It may have its advantages. He begins cleverly enough with an account of the "Energy of the Universe," embracing some general properties of bodies, actual and potential energy, conservation and dissipation of energy. The author uses the terms *forza attiva* and *forza di positione*, in place of our more usual terms. We are glad to find him acquainted with the works of Thomson, Balfour Stewart and Rankine. The lecture on Energy is followed by one on the Dynamical Theory; which embraces to some extent the relations of different forces, and the "varied modality" of chemical, thermical, and electrical action. The next lecture relates to Molecular Dynamics. Then in succession:—Electromotive force produced by Chemical Action, by Heat, by mechanical means, and by Induction. Mutual action of Currents and Magnets, Terrestrial Magnetism, Polar Auroræ; Atmospheric Electricity; Diamagnetism; Rhumkorff's Coil; Winds; Marine Currents; the Sun; the Doctrine of La Place; the Doctrine of Lyell; Thermogenesis; Atmolysis and Osmosis; Capillarity; the Doctrine of Mayer. The second course treats of electricity, undulations, sonority, musical timbre, echoes, photometry, dispersion and the spectroscope, chromatism, vision, luminous undulations, diffraction, polarisation, radiant heat, action of electricity on organic bodies, the muscular current, electrical nervous phenomena, electrical fishes.

The arrangement is really wonderful. What can possibly warrant the following order for lectures:—diamagnetism, Rhumkorff's coil, winds, marine currents; or again—thermogenesis, atmolysis, capillarity? One lecture ends with "Che cosí mirabilmente si svolgono dall' evoluzione Darwinianæ;" and the next commences "E impossible proseguire un corso di Fisica e piu ancora quella parte, che tratta delle azioni senza prima definire le parole, atomo, molecula." The Prof. Pozzo can scarcely be expected to lecture on all science: to pass from the sun to an atom, from Darwinism to electro-dynamics, from geology to elliptical polarisation. If he is, the system is a bad one, and his students may get a smattering of many things, and know nothing well. Mechanical philosophy seems to be almost ignored. The book is devoid of mathematics, and without woodcuts; and we imagine the youth of Perugia must yawn over it; and, if the lectures are as dry as the book, spend much of the time which ought to be given to physics in saying "felicissima notte" to each other. G. F. R.

## LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

### Proposed Alterations in the Medical Curriculum

THE remarks made in your number of December 18 by my friend Prof. Balfour are founded on the mistake he has made in supposing that it is proposed to abolish the regulation requiring attendance on the courses of lectures on Botany and Zoology. There is no question raised between mere examining boards and teaching institutions, between compulsory and optional attendance on professors' lectures. It is simply that the candidate for medical degrees be allowed to take the examination in Zoology and Botany earlier than is at present permitted. At present the examination in these subjects in Edinburgh University is fixed by ordinance at the end of the second of the four years of medical study, and in this University, while the Botany comes at that time, the Zoology is actually not till the end of the third year, so that our case is even worse than that of Edinburgh. Prof. Balfour says, "The student might be encouraged to take his science examination at an early period of his curriculum, say at the end of his first year of study." That is exactly the result practically aimed at here, and I am quite at one with him on the subject. But why prevent the student from taking the examination in Botany and Zoology before entering on his medical curriculum proper, if he has attended the professor's class and is ready for it? Very few would at present do so, as it would imply a preliminary year of attendance at the Universities to obtain the courses of Zoology and Botany. But is it not a very desirable thing, from every point of view, to encourage this? So far from lowering the standard in these subjects, or promoting cramming, it would do exactly the reverse. It would enable real study to take the place of the cramming which is inevitable when these subjects are left over to be mixed up with medical studies proper.

For some time there has been a strong feeling here that the examination in Zoology and Botany should take place not later than the end of the first year, and the Lord Rector of our University in taking this matter up, instead of tinkering as to particular dates, has announced the sound general principle that the student should be encouraged to take the subjects of Botany and Zoology before beginning his medical curriculum proper, with the view both of promoting a more real study of these sciences, and of clearing the subsequent medical curriculum for a more real study of the subjects which belong to it. I see nothing in the resolutions which our distinguished Lord Rector has laid before the University Court either suggesting or implying abolition of compulsory attendance on the professors' courses of Zoology and Botany, and Prof. Balfour might well have taken it for granted that the mere fact of the proposal emanating from Prof. Huxley is security enough that the object could not possibly be to lower the position of the natural sciences or to promote cramming instead of real study. Our Lord Rector has as yet only intimated his resolutions, but when the oracle speaks we shall no doubt hear such good reasons for them that even so enthusiastic a botanist as Prof. Balfour will have his alarm turned into joy.

Will any of those who are so strong on the point of compulsory attendance on courses of Zoology and Botany tell us why they do not say a word for Natural Philosophy? Including such subjects as heat, light, electricity, hydrostatics, pneumatics, optics, acoustics, it is surely of more importance than either of the other two, whether regarded educationally or in its bearing on modern medicine. Yet in the Scotch Universities there is no compulsion to attend a course of lectures on Natural Philosophy, and it is relegated to the preliminary examination in general education. The day is past for laying on additional compulsory courses of lectures, but it is surely not too much to say that the student might be allowed to profess and be examined in Natural Philosophy instead of one of the other two.

Aberdeen University, Dec. 20 JOHN STRUTHERS

### The Distribution of Volcanoes

SOME of the correspondence in your paper has latterly been so caustic, that timid people may be pardoned for shrinking from writing letters which bring down upon them the hammers of scorn and contempt so vigorously.

Notwithstanding this, the discussion between Mr. Mallet and Dr. Forbes about volcanoes tempts me to write to you on a side issue of that controversy in which I have been interested for some time. What I have to say may not be new, although I believe it to be so. At all events it is not commented upon in the books accessible to me. I will premise that, caring little for laurels of any kind but a good deal for instruction, that if it be discovered that what I say is stale and old, I hope I may be treated as an ignorant scholar, willing to learn, and not as a rival to be crushed, and further, that my results having been obtained independently, they support and make more sure the position of my predecessors.

You were good enough, some months ago, to print some letters of mine on the current elevation of the circumpolar regions of the earth. I have since accumulated much new matter on this subject, which will be shortly published in part in the Journal of the Geographical Society. The general result of my inquiry is, that all the large land surfaces of the earth, the large continental and insular surfaces, are more or less in process of gradual or rapid elevation. There are a few small areas of depression on the outskirts and borders of the great land-masses, but these are very local and unimportant. And with this slight exception the continents of North and South America, Asia, Europe, Africa, and Australia, are all more or less rising. This rise of the land-surfaces necessitates a corresponding sinking, either an absolute or a relative sinking, in the surfaces covered with water. It is comparatively easy to test where a land surface is gradually protruding from the water. It is not such a simple matter always to know whether this rise is relative or absolute, for the same effect may be produced by the sinking of the sea-floor as by the actual rising of the land. One thing only we know, that when our measure is water, there must be a corresponding sinking either relative or absolute where there is a rising elsewhere. Direct evidence of the sinking of the sea-bottom is not very easy to find, but such does exist. Students are familiar with the facts collected by Darwin and others, showing from the growth of coral islands, &c., that the Pacific is an area of depression; other evidence consists in the disappearance of well-known rocks, the vigias of navigators in different parts of the greater oceans. From this and other evidence, I am very well satisfied that not only the Pacific, but also the North and South Atlantic and the Indian Oceans, are areas of depression.

Having thus roughly mapped out the world, it becomes an interesting problem to correlate the distribution of volcanoes with that of the rising and sinking land. If the older theory of volcanoes be the true one, that they are the direct results of the eruptive forces of the interior of the earth, we ought surely to meet with them in profusion in those large areas where we know the earth to be relatively rising, where in fact the eruptive force of which volcanoes are the supposed violent proofs is concentrated. Is this so? On the contrary; and it is this that forms the burden of my present letter. The fact is that we shall search in vain among the large areas of upheaval except along their boundaries and fringes for any active volcanoes. Take the northern circumpolar region, the most typical area of rising land in the world, and there is absolutely no volcano in it. The Iceland volcanoes and Jan Mayen happen to be outside the area of upheaval, and in a part of the Atlantic which is notoriously sinking. North America, another large area of rising land, is similarly bare of volcanoes. So is South America, save on the very verge of the Pacific, and that part of the Pacific which I believe to be sinking most rapidly. Australia is probably now rising faster than any area in the world save Spitzbergen, and there we have no volcanoes. Europe is similarly free except in that part of it which is sinking, namely, the Mediterranean border. Lastly, there is the vast continent of Asia, a large part of whose northern surface seems, from all the evidence we can collect, to have been quite recently under water and to be still rising. About Asia I wish to enlarge somewhat.

It was one of the peculiar fancies of Alexander Humboldt, the great authority on the Physical Geography of Asia, that there was a large active volcanic region in the Altai Mountains, &c., and he brought together a great deal of plausible matter to support this view.

As this volcanic region would be in the midst of one of the largest areas of elevation on the earth's surface, it would conflict materially with the evidence elsewhere and with the theory of the distribution of volcanoes for which I am arguing. Luckily for me it has been recently shown, so far as the negative results of those who have been to find Humboldt's volcanoes and have not found them, goes, that is, so far as the only scientific witnesses who have surveyed the region may be allowed to dogmatise, that Humboldt was entirely mistaken. I will quote the accounts of the Russian surveyors as they have been translated for the Geographical Society.

"It now remained for me," says Semenof, "to prove by actual observation the existence or otherwise of volcanic phenomena in Djungaria and in the Celestial Mountains, to which Humboldt in his works so often alludes. I started on my journey, firmly persuaded that I should find the conjectured volcanoes, or at all events some volcanic forms, and sought diligently (as Schrenck did on Lake Ala-kul) to establish the correctness of Humboldt's surmises with respect to the existence of volcanic phenomena in Central Asia, by which confirmation I knew a traveller would gain greater credit than by any incomplete refutation of the supposition. I was even aware that Humboldt was rather displeased with the researches of Schrenck, who clearly showed that the island of Aral-Tübe on Lake Ala-kul was not of volcanic origin. The opinions entertained by Humboldt on the subject of the existence of volcanoes in Djungaria were favourite ones with him, and I regret that I was not able to confirm his cherished theory. Kullok Peak, another of Humboldt's mistaken volcanoes, was found to have no volcanic origin whatever. The hot springs and the non-congelation of Lake Issyk-kul were not accompanied by any volcanic forms in the Tian Shan; and furthermore, all the native accounts of phenomena which from their description might be supposed to be volcanic proved unfounded, and were at once disposed of on my examination of the localities where they were declared to occur. The result, therefore, of my researches on this point was that I became convinced of the complete absence of volcanoes, typical volcanic phenomena, or even volcanic forms, throughout the Celestial Mountains. It is true that there existed in Djungaria at one period some solfatara, or smoking apertures, from which there was a discharge and deposit of sulphur, and that some of these fissures, out of which the Chinese obtain sulphur, emit smoke even at the present day. But a careful inspection of one of the extinguished pits satisfied me that, at all events in that case, there was no volcanic affinity. In the neighbourhood of the pits discovered by me in the Kater Mountains and in the Ili Valley, I could trace no volcanic forms. . . . The whole process of the formation of sulphur can then in my opinion be reasonably explained by the combustion of some coal seams in this basin, which would at once set at rest the question of supposed volcanic agency. . . . The observation of a single portion of the Tian Shan visited by me cannot serve as positive evidence of the absence of volcanoes and volcanic forms in other parts of this mountain chain. My conclusions on this question generally have already been made public in the letter referred to, but I must likewise observe in addition that all Asiatic accounts of phenomena which might be volcanic in appearance should be treated by men of science with great circumspection, as many of these accounts have already proved fallacious. I would here also remark that the impression produced on me personally by Djungaria and the Tian Shan leaves great doubts in my mind as to the existence of volcanoes in this part of Asia; and as I am the only traveller who has visited the Tian Shan, I cannot accept the belief in their existence as an axiom requiring no proof or confirmation. My conclusion on this point, though only negative, is one of the most important results of my journey." ("Djungaria and the Celestial Mountains," by P. P. Semenof, Journal of the Royal Geographical Society, 35-213.) Again, I will quote a later traveller, Mr. Severkof. He says—"There are no volcanic formations in the western portions of the Tian Shan which I surveyed. From eastern sources, Humboldt refers to evidences of volcanic action farther south in the Ak-tan, but even these are doubtful. Fire may be produced in the mountains even by the ignition of the seams of coal as well as of the carburetted hydrogen gas filling the caverns of the seams. This conjecture is supported by the circumstance that Messrs. Bagaslouski and Lehmann discovered, on their journey to Bockhara, a burning seam of coal in the mountains of the upper Zaraphan, a little to the south of the Ak-tan. Speaking generally of volcanic action in the Tian Shan and the surrounding regions, the geological surveys hitherto made from Khantengir (east of Issyk-kul, near the sources of the Tonta, Djergalan, Tekes, and Kegen) to the extreme western limits of the system, have given only negative results. To the east of Khantengir there are again seams of coal—for instance, at Kuldja, and perhaps also at Urumchi—the ignition of which is quite sufficient to create explosive gases. Whether the seams of coal were ignited at Urumchi by volcanic agency, or accidentally at their denudations, is a question that cannot be settled without close observation. It can only be said that the demonstrations in favour of volcanic action adduced by Humboldt are not sufficient proof of the volcanic origin of the Tian Shan, excepting only as regards the lava which, according to Chinese records, flowed from the Peshan mountain during the 6th century. But a single crater—even if the fact of its existence in an extensive mountain system extending, as the Tian Shan does, for 3,000 versts, can be proved—does not make the whole of the range volcanic. (Severkof's "Journey to the western portion of the Tian Shan," Royal Geographical Journal, 40, 395-6.)

This evidence, to my mind, completely refutes Humboldt, and makes it very clear that his volcanic region is non-existent. With the disappearance of this, disappears the only exception I know to the rule that volcanoes, instead of being found chiefly on areas of elevation, are invariably found in areas of depression, or on or close to the boundary lines which separate them from the areas of elevation. The meaning of this lesson, as I read it, I will reserve for another letter.

In conclusion, I wish to thank one of your correspondents in Tasmania for the fact he communicated to you about the rise of that island. I shall be very grateful to anyone who will send me other facts about areas of upheaval and subsidence, and their communications shall be cheerfully acknowledged when I publish them.

Derby House, Eccles HENRY H. HOWORTH

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## Spectra of Shooting Stars

It may interest observers of shooting stars who attempt to obtain views of their spectra by the use of suitably adapted meteor-spectroscopes to indicate a peculiarity which seems to distinguish the larger meteors of the December star-shower, radiating annually from the direction of a point near $\theta$ Geminorum on the nights of the 10th, 11th, and 12th of December. Two such small bolides of this stream which appeared to me on December 9th, 1864, and on Thursday night last, the 11th inst., were characterised by a beautiful pale-green colour, like that of the thallium flame in purity of tint, but perhaps of a slightly paler or lighter hue, and it remained uniform like the brightness of these meteors as long as they remained in sight, strongly suggesting that either copper, barium, thallium, silver, or some other element giving, in some of its combinations, an intensely green spectrum, was undergoing vivid ignition in their flame. As each of these bright meteors presented a sensibly round disc (the first several times brighter, and the second a little brighter than the planet Jupiter), without visible sparks or train of any other colour than that of the head which could give rise to the green colour by the effect of contrast, and yet the green hue was much more distinct than I have noticed in any other meteors, not omitting some bright ones accompanied by very ruddy streaks in the principal displays of November 14, it appears to be a distinguishing feature of the brighter meteors of the annual star-shower of December, to which it would be very useful on occasions of its future return to direct particular attention. The meteors of this star-shower are, however, seldom of very considerable brightness, and the occurrence of one such during its recent appearance not improbably marked its return during the present year with somewhat more than ordinary intensity. The meteor was simultaneously observed at Glasgow and at Newcastle upon Tyne, and its apparent paths among the constellations at those places, directed from the usual radiant point in Gemini, with the duration of its flight, will enable the real height and the speed of motion of one of the principal meteors of the shower to be pretty exactly ascertained.

During many hours of repeated observations under the most favourable conditions of the sky on the nights between the 23rd and the 30th ult., and again on the 5th of this month, when observers for the return of the shower of meteors belonging to Biela's comet were on the watch for its appearance at different places in England, Scotland and Ireland, the reports of their observations which have hitherto been communicated to the Luminous Meteor Committee of the British Association have been entirely negative, scarcely a single meteor of the few which were observed being recognised as belonging to the well-known radiant-point of the shower, which was so conspicuous last year in Andromeda. At various times during the night of the 27th of November itself, when the sky was generally clear, no meteors of this description were visible, and their absence on all the other nights when the state of the sky permitted a watch to be kept for them scarcely leaves any reasonable grounds for the supposition that even a comparatively insignificant return of last year's meteor-showers of the 24th and 27th of November has this year been visible in England on the same or on any very nearly adjacent dates.

A. S. HERSCHEL

Newcastle-on-Tyne

### Meteor Shower

FROM the reported weather in England it seems improbable that the Geminid meteor shower was well observed in England, and as the return was rather above the average a few particulars of what was seen here may at least be interesting.

The nights of the 10th and 11th, when the watch was kept, were exceedingly clear. Except for a quarter of an hour at the commencement of the first watch there was only one observer, then there were two. The position taken was a window, N.E., whence all was visible from about 3° from the zenith to the hills opposite (perhaps 10° or 15°), behind which only one meteor disappeared, whilst only one was noticed whose course was part hidden by the roof. The average per hour on the $1\frac{1}{2}$ hours' watch on the 10th must have been about 38, and on the 2 hours' watch on the 11th, 60. But the rate in the second hour was much in excess of the first; taking the two thus the result is, from 10–11, about 30, from 11–12 about 88. In all probability the rate would have not been much below in the morning hours, but having a cold I did not stop longer.

The brightness was, I think, rather below the average, but as tabulated it was as follows:—

| | | |
|---|---|---|
| Bright as | Jupiter | 1 |
| ,, | Sirius | 2 |
| ,, | 1 magn. * | 9 |
| ,, | 2 ,, | 17 |
| ,, | 3 ,, | 10 |
| ,, | 4 ,, | 23 |
| ,, | 5 ,, | 2 |

A comparison with the radiant points in Mr. R. P. Grey's list makes it seem that the meteors were distributed over at least *nine*, and that two of these are ones not included by him. Of these one seems pretty certainly fixed about R.A. 57° N.δ 6°, and to this I have assigned 14 on the two nights. The other is more doubtful, two nearly parallel meteors appeared on the 10th, opposite in direction to the others; their point may be about R.A. 275° N.δ. 60°.

An apparent discrepancy in the total seen and the tabulated numbers is explained by the fact that some meteors were not well enough seen to be entered. But on the regular watch of the 11th I had the unusual success of entering every one seen, in consequence I believe of the position I had assumed, *i.e.* seeing less than half the heavens and *lying* on my back. Several cases of almost, or perfectly, simultaneous meteors appeared, but of these only 4 pairs were from the same radiant.

J. EDMUND CLARK

Heidelberg, Dec. 16

## THE LATE PROFESSOR DE LA RIVE

SWITZERLAND has in one month been shorn of two of her most distinguished ornaments. De La Rive and Agassiz have died within a fortnight of each other, and the "Académie des Sciences" has thus been deprived in the same month of a fourth of its Foreign Associates. Agassiz will no doubt find, both in Switzerland and America, more than one pen competent to describe his labours in the field of science; but a few lines on the life and researches of de la Rive are due to this distinguished philosopher, and will be read with interest in this country, which he has often visited, and in which he had many friends.

Born at Geneva in 1801, of an old family closely connected with Cavour, Auguste de la Rive inherited from his father the love of science in general, and more especially of electricity. After going through the usual course of studies with brilliant success, he was, at the early age of twenty-two, called to the Chair of Natural Philosophy in the Academy of Geneva, and took his seat amongst the distinguished men of that city.

Although de la Rive devoted his time principally to the study of the different branches of electricity and their numerous applications, his acquirements were not limited to that department of science. During the earlier part of his career the subject of specific heat, more particularly applied to gases, and a series of experiments on the temperature of the crust of the earth, were published by him conjointly with a friend and colleague. But electricity remained his favourite study to the end of his life. The treatise he published between the years 1853 and 1858, in three large octavo volumes on the subject of electricity, translated into English by Mr. C. Walker, F.R.S., and the numerous original articles which appeared in the well-known monthly journal, *Les Archives d'Electricité*, for many years under the direction of de la Rive, afford ample proof of the extent of his information on all subjects connected with his favourite pursuit. His original memoirs on electro-dynamics, magnetism, the connection of magnetism with electricity, the nature of the voltaic arc, and on the propagation of electricity in the interior of bodies, more especially through extremely rarefied media, and others too numerous to be quoted, ensured him a high European reputation, to which was soon added the title of Member or Correspondent of almost every scientific body in Europe. In 1840 he was named Correspondent of the French Académie des Sciences; in 1846, Foreign Member of the Royal Society, and finally in 1864 he was elected Foreign Associate of the Académie des Sciences, the highest honour to which a man of science can aspire.

It was de la Rive who first conceived the idea of applying the force of electricity, through the means of alkaline solutions, to the gilding of silver and brass, and he thus laid down the groundwork of the principle by which thanks to the practical improvements introduced soon after by Messrs. Elkington and Ruolz, electric gilding has gradually superseded the deleterious process of gilding by mercury. It was on this occasion that the grand prize of 3,000 fr. was awarded to de la Rive by the French Academie des Sciences.

A long and patient study of the phenomena which accompany the aurora borealis, and of their apparent connection, both with the properties exhibited by the flame of the Voltaic arc when under the influence of a magnet, and with the passage of the electric fluid through extremely rarefied gases, gradually led de la Rive to a new theory on the electric origin of the aurora. His theory was illustrated, and to a certain extent rendered plausible, by a series of beautiful experiments, reproducing in the lecture-room, through artificial means, the varied phenomena which characterise the aurora. These experiments were made first at Geneva, and some time after repeated at Paris before some of the most distinguished members of the French Institute.

But de la Rive's acquirements were not limited to science. The noble use he made of his fortune, the well-known hospitality which rendered his country house near Geneva for nearly forty years a centre of attraction to the most distinguished scientific and literary society of Europe, the high tone of his character, and the many services he rendered his country, more particularly when called upon in 1860 to use the influence of his name and position in obtaining from the English Government an effectual support for Switzerland against the threatened danger of French aggression, have secured to his memory a popularity which will long survive him.

## *VIVISECTION*

THE advance of culture has brought with it an increased tenderness, and a more solicitous regard for the feelings of others, a regard extending slowly but surely to the feelings of animals also. It is to Science that this advance is mainly due. Only by gaining clear conceptions of natural sequences can men be brought to repress their native tendency to inflict pain as an exertion of power, or to feel ashamed of their thoughtless indifference when they see pain inflicted by others. It is demonstrable that Ignorance has ever been the most potent ally of Cruelty—on the small scale of boys torturing animals, and on the large scale of priests torturing heretics. The boy can only be made to feel that his act is vicious by having a vivid imagination of the fact that the animal organism is constructed like his own, and that the animal suffers as he suffers. The holy inquisitor, or enthroned persecutor, can only be made to see that his attempt to combat heresy by an *auto-da-fè*, is flagrantly at variance with all psychological experience. If the vast cruelties of persecuting "fanatics" have become intolerable in modern society, it is assuredly from no dogmatic teaching, no insistence on charity and love, but wholly from a moral enlightenment coming with a larger and more accurate understanding of natural sequences.

Not only has Science been a great agent in evolving the sympathies, and creating the intense desire to avoid giving pain, it has also created the means of alleviating pain. Is not the whole skill of the surgeon and the physician devoted to this end? How comes it, then, that physiologists who have to supply the surgeon and physician with accurate data, which they can only reach through Experiment, are supposed to be less sympathetic, less careful of the feelings of animals, than other men? A candid person would at once admit that this was not so; would admit that physiologists are quite as unwilling to inflict *unnecessary* pain as men of other classes. But because Vivisection is one of the branches of physiological Experiment, and because when the details of such vivisections are reported, the public reading these, and wholly unacquainted both with the purpose and the procedure, is shocked at what seems needless cruelty, a cry of indignation naturally escapes, and the experimenter is regarded as indifferent to the sufferings of animals.

Every thinking man will admit that the feeling which prompts this indignant cry is highly laudable, and every man who understands the real case will declare that this feeling is misguided by ignorance. For what is the fact? The fact is, that in the vast majority of experiments no pain is inflicted, the operations that are painful being performed under chloroform, and thus the animal which has undergone an operation which would have killed it, had it not been insensible, awakens from the coma and begins tranquilly eating the food before it, as if nothing but a sleep had gone before! In some cases, indeed, pain *is* unavoidable; in some it is part of the phenomenon investigated. But this procedure is not chosen in wantonness, or the thoughtlessness of cruelty. The operation is justified by its purpose. If the tender surgeon inflicts pain, it is to save pain; if the physiologist inflicts pain, it is to widen knowledge, and thus alleviate pain on a wide scale. This is very different from the pain inflicted for the sake of *sport*; very different from the measureless misery of wars, inflicted to gratify national vanity or commercial greed. The physiologist does not inflict pain for his own pleasure; he overcomes his repugnance to it, as he overcomes his repugnance to the sights of the amphitheatre and hospital, nerved by a sense of ulterior good.

Here we meet the question raised by "X.," whether man is justified in inflicting pain on animals to secure the good of fellow-men? I unhesitatingly answer, Yes. It is quite certain that man does assume and assert supremacy, eating, subduing, and exterminating animals, according to his needs; and I would ask whether human life would be practicable on this globe on other conditions? Why, there is seldom a spade thrust into the earth that does not cut some worm into writhing halves. If this be excused as a painful necessity, then also must vivisection be excused as a painful necessity; if the one is necessary to food, the other is necessary to knowledge. The physiologist is the judge of the necessity; on him rests the responsibility.

And now a word on the particular experiments which called forth X.'s protest. Obviously, since testing sensibility was the very purpose in view, Prof. Goltz, Prof. Foster, and myself were forced either to forego the inquiry, or to inflict more or less pain, and (if need were) excessive pain. Perhaps X. will say that such an inquiry ought not to have been pursued at such a cost. We thought otherwise. The point cannot be argued now; but I would illustrate what has been just said, by informing X. that even here anæsthetics were used where they could be used—when I removed the skin from the legs or the body of the frogs, or took out their brains, the animals were wholly insensible; and dreadful as it may seem to read of their limbs being pricked, and burned, we are assured that no pain whatever, not even the feeling of contact, was felt by the frogs.

In conclusion, I would urge upon the opponents of Vivisection, that it would be but fair to credit physiologists with the same repugnance to the infliction of pain as animates all enlightened classes; and to consider that if the repugnance is overcome in the pursuit of physiological knowledge, it does not the less exist, nor the less guide their conduct in other cases. For myself, I may be permitted to add that so far from acknowledging indifference to the feelings of animals, my sympathies are unusually active in the direction of animals; and it was my inability to witness pain which prevented my pursuing the profession of a surgeon. Nevertheless, I have performed hundreds of experiments; and in the very rare cases where great pain was inevitable, the performance has been very distressing; but in all cases I should vehemently protest against the accusation that it was indifference or cruelty which enabled the experiments to be performed.

It is but right that I should acknowledge that Prof. Foster's communication of December 11 has shown me the error of my interpretation of his hypothesis.

GEORGE HENRY LEWES

I WISH briefly to point out the grounds upon which persons who are every bit as tender-hearted and as sympathetic with Nature as any ante-vivisectionist may claim to be, justify what X. condemns. In order that a part of the order of Nature may be ascertained, it is necessary that vivisection be largely practised. Those who practise it do so under a sense of solemn and even sacred responsibility. To suggest the word "cruelty" in connection with their proceedings is an injustice which only profound ignorance and inability to realise the motives of other men can excuse. There is no lack of sympathy with the probable sufferings of animals experimented upon in the mind of the physiologist. He suffers with them, and, as I know of one eminent experimenter, is sometimes disabled by emotion from continuing a research. But the recognition of a higher duty than regard to his own transient impulses or the brief sufferings of a lower animal usually completely controls the experimenter's thought and action, and the mutual suffering of both vivisector and vivisected becomes a sacrifice offered up on the altar of Science. My conviction is that, especially in dealing with such animals as the dog, the experimenter is no less constrained to inflict suffering at which his feelings revolt, by the presence of a noble ulterior motive, than is the surgeon who does not flinch from subjecting his brother-man to the certainty of the direst pain and the imminent risk of death.

No one has a right to *assume* that any other man, still less a whole body of men, is so fiendish as to take any pleasure in the evidences of an animal's sufferings, or so dull as not himself to feel distress when viewing those sufferings. If man is willing to suffer this mental pain for a high end, may he not exact some contribution from the animal world, who after all will benefit as well as he by the progress of Science. It is futile to bewail "the tremendous cost" at which such progress is made. Nature is inconceivably costly, if we choose to put things in that way, for no progress is made without endless suffering and immense destruction. Our very dinner-tables reek with the evidences of "the tremendous cost"—the pangs of slaughtered sheep, the groans of over-worked horses, the disfigurement of Nature's sacred face by agriculture—by which our corporeal means of progress is attained. And are we to be so inconsistent as to refuse to undertake the very highest occupation of humanity, the ascertainment of the order of Nature, because it adds to this "cost" of our existence?

The attempt to raise the question of the "rights" of the animal world in this connection seems to me to involve a very large assumption. I am not prepared to admit that animals have *any* "rights" in the sense that men have them. I could never subject a human being to vivisection for the purposes of scientific progress for much the same reason that, if starving among the Arctic snows, I should feel bound to starve with my companion, rather than kill and feed on him. The recognition of the inviolability of one's fellow-man except under conditions authorised by the community, is the very foundation of human society, and our relations to animals cannot in the remotest degree be assimilated to the relation thus established between man and man. Our conduct towards animals, as towards other living and even inanimate things, must be determined in quite a different way, and by very different reasons. It is, I am inclined to believe, solely the consideration of how we ourselves are affected—whether injuriously or beneficially—by any particular line of conduct towards beings other than men, that can be allowed to guide us in such matters. Anything of the nature of cruelty is obviously thus condemned, and all wanton disrespect to the persons of both living and inanimate things, no less so.

Whilst thus refusing to admit anything like the "right" claimed by man from man, for lower animals, we are not led to regard them with less affection, nor to treat them with diminished tenderness. The conviction that they are ours with which to do what seems good to us, must even increase our disposition to kindly treatment.

Let cases of cruelty, whether from man to man, to woman or child, to horse, fox, or dog, rabbit or frog, be searched out, exposed, and the perpetrator condemned; but unless such persons as X. are prepared to accuse such men as Michael Foster and George Henry Lewes of specific acts of cruelty, they are not justified in making physiology the text for heart-rending appeals to a public imperfectly acquainted with the facts.

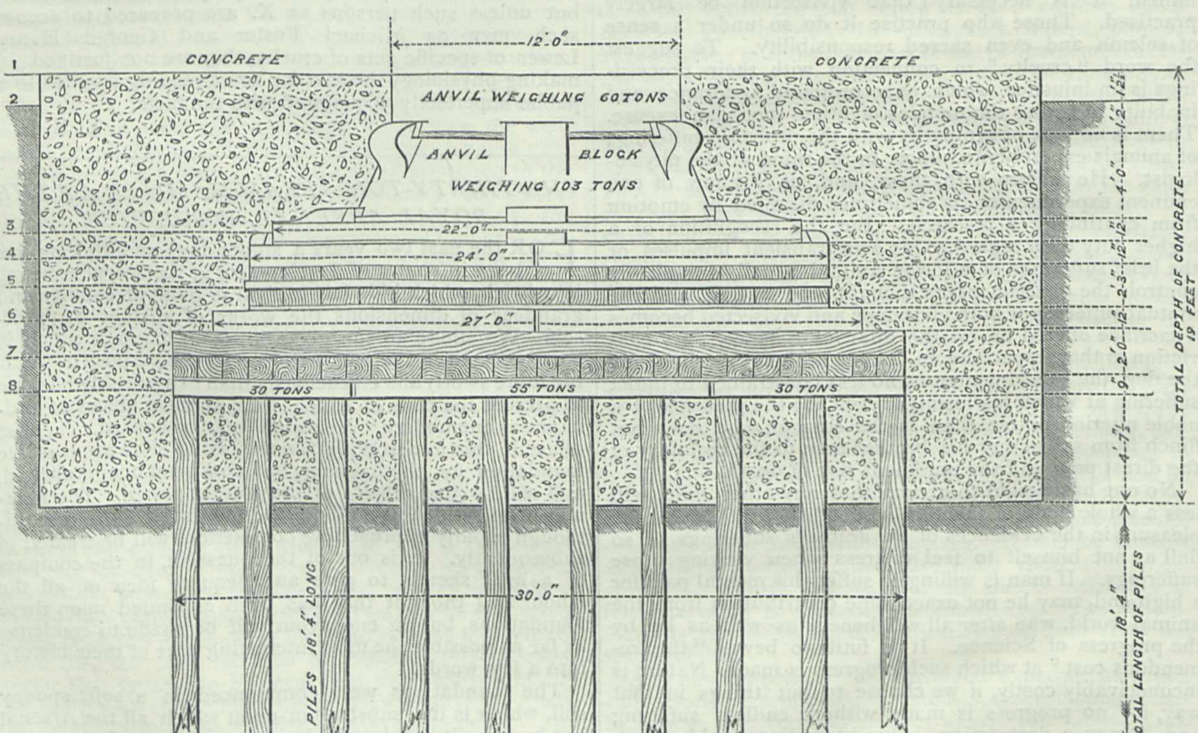
E. R. L.

## THE THIRTY-TON STEAM-HAMMER AT THE ROYAL ARSENAL, WOOLWICH

FOR the past two years a stupendous undertaking has been in course of development at the Royal Arsenal, Woolwich, which bids fair to rival in point of solidity and grandeur of dimensions the works of ancient Egypt itself. We allude to the gigantic steam-hammer which is being erected in the gun factories, for the purpose of welding more swiftly and efficaciously than can possibly be done at present the coils of which such massive pieces of ordnance as our modern "Woolwich Infants" consist. The first phase in this undertaking, viz. the laying of an appropriate foundation for the hammer, has now been accomplished, and will be the subject of the present paper. The hammer itself, which is still in an unfinished condition, although rapidly approaching completion, will be treated of subsequently. It is out of the question, in the compass of a brief sketch, to give an adequate idea of all the labour and thought that has been expended upon these foundations, but an endeavour will be made to condense as far as possible the most interesting part of their history into a few words.

The foundations were commenced in a soft, spongy soil, which is the substratum upon which all the Arsenal has been built. A hundred piles of pine-wood shod with iron a foot square each, were driven into the earth so as to form an area of thirty feet square; and when the heads were sawn off to an even surface, their average length was 18 feet 4 inches. Concrete was then filled in all round to the top of the piles, and three cast-iron plates, weighing respectively 30, 55, and 30 tons, were placed upon the heads of the piles. But before proceeding further with the building up of the foundations, we must describe the nature of the castings alluded to. They were all run in the foundry of the Royal Gun Factories, and consisted of about one-fifth of Calder pig-iron to four-fifths of scrap metal containing old broken-up shell, and shot, &c. The metal, after being taken from a number of cupolas in which it was melted, was collected in huge reservoirs, called "sows," and kept in a liquid state during the time necessarily occupied in filling the sows by a quantity of firewood being piled on top, which of course was continually in a state of ignition. This process occupied some eight or ten hours. At a given signal the sows were tapped, and the iron run out into open sand moulds in the floor of the foundry. The removal of these gigantic castings to their destination was a matter involving considerable difficulty. Two sets of worn-out gun-trucks were laid down upon either side of the road, and planks of African oak, placed longitudinally upon these, thus forming a rude railway. Rollers consisting of the unworked tubes of guns were then obtained from the gun factories, and laid across the planks. A sleigh, composed of two massive bars of wrought-iron turned up in front, and attached together by baulks of timber, was then placed upon the rollers, and surmounted first by the cast-iron plate to be carried, then by a movable or revolving crane. The sleigh being drawn forwards by a crab-winch and tackling, as the rollers were successively passed over the crane lifted up those that were behind, and, swinging round, deposited them in front, presenting a fresh rolling surface upon each occasion. Thus the plates were each slowly moved from the foundry to the foundation pit. But there was another difficulty. As it was necessary to have "joggles," or projections npon the summit of several of the plates for the superincumbent ones to rest within, and in open castings it was impossible to cast them upon an upper surface, the joggles had to be formed upon the lower surface, and the plates to be reversed in position afterwards. This was done by casting trunnions upon the edges of the plates, nearer one end than the other, and then swinging the plates over the foundation pit by these trunnions, until the heavier half descended, drawing back the heavier portion by a crab-winch, and finally permitting the lighter portion gradually to descend, the trunnion supports being withdrawn, and the edge of the plate resting on the ground forming a fulcrum. The trunnions do not appear in our engraving, but the joggles may be seen upon the three upper sets of castings.

We will now revert to the laying of the foundations. Over the whole extent of the lower plates a thin layer of rock-elm planks was laid, this being the most indestructible kind of wood known, it being necessary to




Foundations for 30-ton Steam Hammer.

1, Proposed floor; 2, Present ground line; 3, Single block weighing 98 tons; 4, Two weighing 65 tons each; 5, Oak stumps on end with band; 6, Two blocks of 75 tons each; 7, Oak baulks crossed; 8, Three blocks.

produce a perfectly even surface for the baulks of timber which come next. These were of oak, thirty feet long, and a foot square. Upon the baulks of oak rest two more plates of cast-iron, twenty-seven feet long, and thirteen feet six inches wide, and weighing each seventy-five tons. They are connected by huge dove-tails cast into the metal itself, as are also the two lower ones, and all the other plates which are in the same horizontal plane. A liquid called "grouting," formed of very thin watery concrete, is poured in between the joints of the plates so as to fill up all interstices, and holes are made in several places through the castings, so as to admit of the grouting freely percolating everywhere. Upon the two plates are more planks of rock-elm, and then a layer of oak stumps two feet three inches long, placed upright, and surrounded by a band of wrought-iron, six inches wide by two inches thick. All the remainder of the foundation pit was filled in with concrete as the work gradually proceeded upwards. Upon the oak stumps are two plates, weighing each sixty-five tons, and forming a square of twenty-four feet. A thin layer of rock-elm planks separates them from a huge single casting, twenty-two feet square, and weighing very nearly 100 tons. Wedges within the joggles of the 65-ton plates fix firmly the single one above, and it in its turn supports the enormous anvil block weighing 103 tons, over which will come the anvil itself, but that is not yet in position. The anvil block was cast in a closed mould, which rested upon a substratum of coke and bricks with passages left filled with straw for the exit of the gas generated; it took, nevertheless, *six months* to cool, and could not be removed until after the manufacture and removal of several subsequent castings. Such is a short review of the principal features in the construction of these foundations; all other information as to details in dimensions, &c., may be obtained from the accompanying engraving. About 660 tons of metal have been made use of in completing them.

## THE COMMON FROG*

### VII.

THE skull of the frog presents numerous points of interest, but only four of these can be here referred to, as other matters demand our attention.

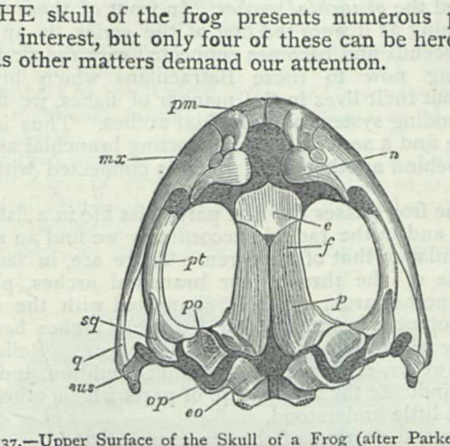


FIG. 37.—Upper Surface of the Skull of a Frog (after Parker). *e*, os en ceinture, or girdle-bone ; *eo*, exoccipital ; *f*, frontal part of frontoparietal bone ; *mx*, maxillary bone ; *n*, nasal ; *op*, opisthotic ; *p*, parietal part of fronto-parietal bone ; *pm*, pre-maxilla ; *po*, pro-otic ; *pt*, pterygoid ; *q*, quadrato-jugal ; *sq*, squamosal ; *sus*, suspensorium of lower jaw.

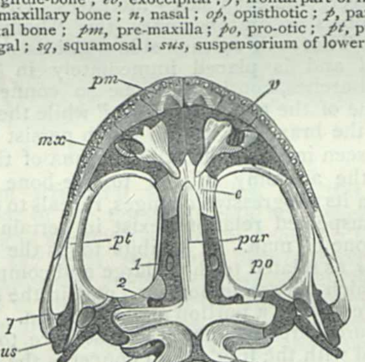


FIG. 38.—Under Surface of the Skull of a Frog (after Parker). *e*, girdle-bone; *eo*, exoccipital ; *mx*, maxilla ; *par*, parasphenoid ; *pm*, pre-maxilla ; *po*, pro-otic ; *pt*, pterygoid ; *q*, quadrato-jugal ; *sus*, suspensorium of lower jaw, the lower end of which represents the quadrate bone ; *v*, vomer ; 1, optic foramen ; 2, foramen ovale ; 3, condyloid foramen.

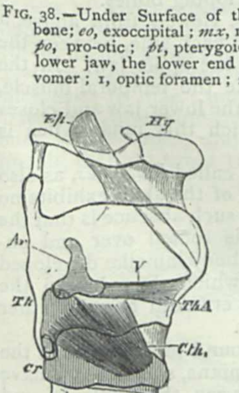


FIG. 39.

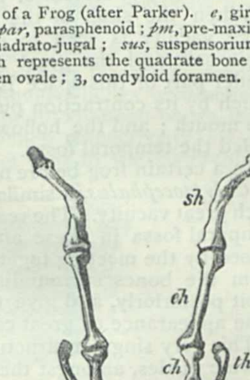


FIG. 40.

FIG. 39.—Diagram of the Larynx of Man, the thyroid cartilage being supposed to be transparent, and allowing the right arytenoid cartilage (*Ar*), vocal ligament (*V*), and thyro-arytenoid muscle (*Th A*), the upper part of the cricoid cartilage (*Cr*), and the attachment of the epiglottis (*Ep*), to be seen. *C th*, the right cricothyroid muscle ; *Tr*, the trachea ; *Hy*, the body of the hyoid bone. The right lesser cornu appears as a very small process, extending upwards and backwards from the body of the hyoid behind the letters *Hy*, and in front of the Epiglottis. The right great cornu is shown extending backwards from the body of the Hyoid and terminating beneath the letters *Ep*

FIG. 40—Extracranial portion of hyoidean apparatus of Dog, front views *sh*, stylohyal ; *eh*, epihyal ; *ch*, ceratohyal (these three constitute the "anterior cornu") ; *bh*, basihyal, or "body" of hyoid ; *th*, thyrohyal, or "posterior cornu." (From Flower's "Osteology.")

* Continued from p. 110.

The first of these four relates to its mode of articulation with the vertebral column. As has been said the first vertebra presents a pair of concavities to the skull. The skull develops from its hinder (or occipital) region a cor-

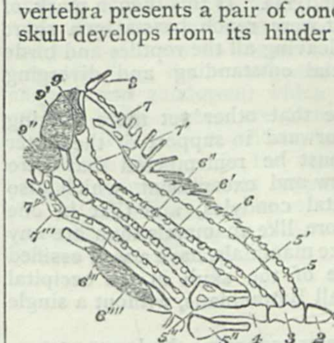


FIG. 41.

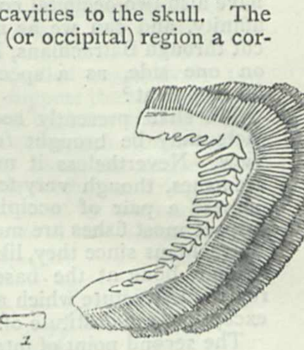


FIG. 42.

FIG. 41.—Skeleton of left series of Branchial Arches of a Perch, seen from above. 1, glosso-hyal ; 2, 3, and 4, basi-branchials ; 5, hypo-branchials ; 6, cerato-branchials ; 7, epi-branchials ; 8, styliform pharyngo-branchials ; 9, pharyngo-branchials ; 6'''', inferior pharyngeal bone ; 9' and 9'', superior pharyngeal bones ; 5, 6, 7, and 8, first branchial arch ; 5', 6', 7, and 9, second branchial arch ; 5'', 6'', 7'', and 9', third branchial arch ; 5'', 6''', and 7''', fourth branchial arch ; 6'''', fifth branchial arch.

FIG. 42.—First three Branchial Arches from the left side of a Perch. On the outer (convex) side of each branchial arch the series of closely-set gill filaments (or leaflets or lamellæ) are seen to be attached. On the inner (concave) side of the first branchial arch are the series of elongated processes (supporting minute denticles) which help to prevent particles of food, or other foreign bodies, passing from the mouth to the gill chamber.

responding pair of articular convexities or "condyles." Now in this matter the frog differs from both birds and

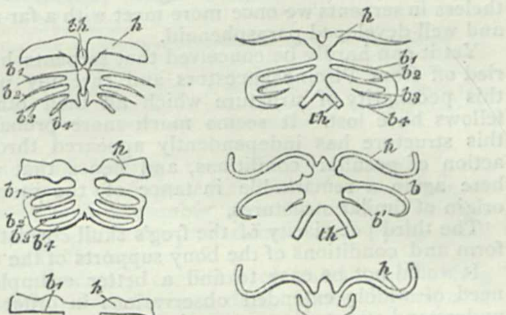


FIG. 43.—Diagram of the changes undergone by the hyoid in a Frog in passing from the Tadpole stage to the adult condition (constructed from Parker's Memoir). Uppermost left-hand figure, the youngest condition ; lowest right-hand figure, the adult. *h*, the hyoidean arch, ultimately the corniculum ; *b¹*—*b⁴*, the four branchial arches which become gradually atrophied, the cornua (or thyro-hyal), *th* being their representative in the adult ; *b'*, another branchial rudiment ; *bh*, the body of the hyoid.

reptiles, every member of those classes possessing a single median (occipital) condyle for articulation with the vertebral column.

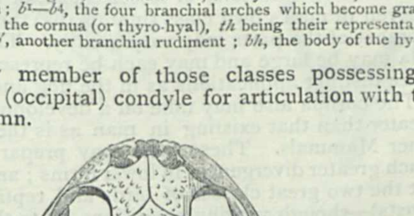


FIG. 44.—Dorsal view of skull of *Pelobates*, showing bony lamellæ behind the orbits.

Yet every member of the frog class, not only every toad and newt, but also every species of the Ophiomorpha, and even every one of the long extinct Labyrinthodons (with the doubtful exception of the probably immature and larval *Archegosaurus*) has a similar pair of occipital condyles. The interesting matter is that man and all beasts have also two occipital condyles. Is this then a mark of affinity, and can we, as it were, reach beasts by a short cut through Batrachians, leaving all the reptiles and birds on one side, as a special outstanding and diverging development?

We shall presently see that other yet more striking facts may be brought forward in support of the latter view. Nevertheless it must be remembered that there are fishes, thongh very few and exceptional, which also possess a pair of occipital condyles, and that in one respect most fishes are more like mammals than are any Batrachians since they, like mammals, have a well ossified median bone at the base of the skull in the occipital region, a structure which all Batrachians, without a single exception, are destitute of.

The second point of interest concerns the lower part, or base, of the skull, which exhibits a striking agreement with the same part as developed in bony fishes.

This agreement consists in the fact that the middle of the floor of the skull is not formed as in all beasts, birds, and reptiles, by a deposition of bony substance in pre-existing gristle (ossification of cartilage), to which name *Basi-sphenoid* is applied, but, as in bony fishes, by a great bone called *Parasphenoid*, which shoots forwards and also extends backwards to the hinder end of the skull floor, but is formed by the deposition of bony substance in pre-existing membrane. (Fig. 38, *par.*)

Although this great membrane bone is constant in Batrachians and bony fishes, and is represented, if at all, only by minute rudiments in higher vertebrates; nevertheless in serpents we once more meet with a far-reaching and well-developed parasphenoid.

Yet it can hardlv be conceived that serpents have carried off from Piscine ancestors and carefully preserved this peculiarity of structure which all their other class fellows have lost. It seems much more probable that this structure has independently appeared through the action of peculiar conditions, and hence that we have here again a remarkable instance of the independent origin of similar structures.

The third peculiarity of the frog's skull consists in the form and conditions of the bony supports of the tongue.

It would not be easy to find a better example of the need of widely extended observations in order duly to understand structures apparently very simple indeed.

The bone of the tongue in man—the *os hyoides**—is a small structure, and one to all appearance of little significance. It is placed at the root of the tongue and above the larynx, and consists of a body with a pair of processes on each side, one large (the posterior or great cornu), and one small (the anterior or lesser cornu, or corniculum).

Even in man's own class (mammalia) the relative development of the parts may vary greatly. Thus the cornicula may be large and may each be represented by two or three distinct applications as in the dog and horse.

The cornua also may take on a development very much greater than that existing in man as is the case in some other Mammals. These facts may prepare us to expect much greater divergences in lower forms; and yet throughout the two great classes of birds and reptiles (as well as beasts)—though varying conditions as to the proportions of the parts present themselves—the os hyoides continues essentially the same in structure, and even in the adult frog this bone exhibits nothing but a rather wide "body" with two long and slender "cornicula" and a pair of shorter "cornua."

Let us now pass for a moment to the other end of the vertebrate sub-kingdom. We find in fishes a complex framework for the support of the gills, or structures, by which they effect their aquatic respiration. This framework consists of a number of arches (placed in series one behind another) extending on each side of the throat upwards towards the backbone, and supporting on their outer sides the gills or branchia, on which account they are called the *branchial arches*. In front of these arches and forming as it were the first of the series, is an arch which ascends and becomes connected with the skull.

Turning now to those Batrachians which breathe throughout their lives in the manner of fishes, we find a corresponding system of branchial arches. Thus in the Siren we find a series of gill-supporting branchial arches, placed behind another arch which is connected with the skull.

But the frog passes the first part of its life in a fish-like manner, and in the tadpole accordingly we find an apparatus similar to that of the Siren. There are, in fact, on each side of the throat, four branchial arches, placed behind another arch, which is connected with the skull. As development proceeds these *branchial* arches become gradually absorbed and all but disappear. Relics of them, however, exist even in the adult condition, and thus serve to indicate the true nature of parts which otherwise would be little understood.

The central portion of the structure—that from which arches diverge on each side—increases in relative as well as absolute size, and becomes the "body" of the *os hyoides*. That arch on each side which is connected with the skull and is placed immediately in front of the branchial arches, continues to be so connected and becomes one of the two "cornicula," while the rudimentary relics of the branchial arches which persist become what we have seen in the adult as the cornua of the *os hyoides*.

Thus the anatomy of the tongue-bone of the frog, studied in its progressive changes, reveals to us that otherwise unsuspected relations exist in certain parts of the tongue-bone of man. It exhibits to us the coruna of his *os hyoides* as related to those large and complex branchial arches which play so important a part in the fish and form so relatively large a portion of its skeleton.

The fourth circumstance (the last here to be noticed) connected with the frog's skull concerns the relative position and size of certain of its enveloping bones.

When the skull of the frog is viewed from above, a large vacuity is seen to exist on each side, between the brain-case and the great arch of the upper jaw. In the hinder part of this space is situate the temporal muscle, which by its contraction pulls up the lower jaw and closes the mouth; and the hollow in which this muscle lies is called the temporal fossa.

In a certain frog before noticed, called *Pelobates*, as also in *Calyptocephalus*, a similar view of the skull exhibits no such great vacuity. The reason of such absence is that the temporal fossa in these animals is roofed over and enclosed by the meeting together of bony lamellæ developed from the bones surrounding it, which thus bound the orbit posteriorly, and give to the cranium an altogether false appearance of great capacity.

This very singular structure is found to exist also in the marine turtles, amongst the Chelonians, and here we have another striking resemblance between the Chelonia and the Anoura, apparently reinforcing the argument for the existence of real affinity derived from the presence of such bony dorsal shields in both those two orders. The importance of this character might seem the more unquestionable, since no other reptiles and no birds or beasts whatever were known to exhibit a similar structure.

Quite recently, however, Prof Alphonse Milne-Edwards has described a beast from Africa (*Lophiomys*) belonging to the Rodent (rat, rabbit, and squirrel) order, which has a skull, the temporal fossa of which is similarly enclosed by bony plates.

This unexpected discovery completely destroys any weight which might be attached to this character as an evidence of genetic affinity. It does so because it is inconceivable this Rodent should have directly descended

* So named from its resemblance to the Greek letter υ.

from a common progenitor of frogs and of Chelonians through a line of ancestors which never lost this cranial shield, though the ancestors of all other beasts, all birds, and all reptiles, except turtles, *did* lose it. It is inconceivable, for if it were true a variety of the lowest mammals (Marsupials * and Monotremes †) must have less diverged from the ancient common stock than have the members of the Rodent order, and nevertheless these lowest mammals exhibit no trace whatever of such a cranial shield.

Here then we have an undoubted example of the independent origin of structures so similar that at first sight their similarity might well have been deemed a conclusive evidence of affinity.

Here, also, we have a memorable caution against hasty

FIG. 45.—External form of *Lophiomys*.

inferences from structural similarities. If this resemblance and that of the dorsal shields are, when taken together, no signs whatever of special genetic affinity—it is difficult to say what structural likenesses are to be deemed unquestionable evidences of a common ancestry.

Passing now to the skeleton of the limbs, we come to a character of great significance, as it is one which serves to distinguish all the limbed species of the frog's class from lower vertebrates. The character is very significant, because all Batrachians, in spite of their numerous and important fish affinities, differ from all fishes, and agree with all higher classes in that they—if they have limbs at all—have them divided into those very typical segments which exist in man; namely, shoulder-bones, arm-bones, wrist-bones, and hand-bones; and into haunch-bones, leg-bones, ankle-bones, and foot-bones respectively. It is difficult, then, to avoid the belief that in the Batrachian

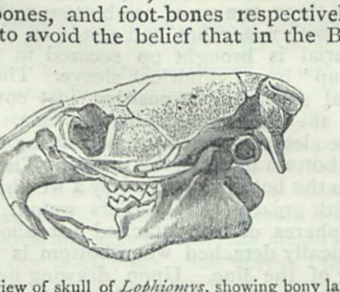


FIG. 46.—Lateral view of skull of *Lophiomys*, showing bony lamellæ behind the orbit.

class we come upon the first appearance of vertebrate limbs, differentiated in a fashion which thenceforward becomes universal.

The bones of the wrist in the frog, again, present a nearer resemblance to those in man than do those of most reptiles, and this is still more the case in some other members of the frog's class, *e.g. Salamandra* and other Efts. Nevertheless, there are certain reptiles, and, strange to say, they are once more Chelonians, which agree in this resemblance—as may be seen in the hand of the tortoise—*Chelydra serpentina.*

* *i.e.* opossums, kangaroos, &c.
† The Ornithorhynchus and Echidna.

The bones of the fingers show, moreover, a greater likeness, in certain respects, to those of beasts than to those of reptiles. No finger has a greater number of joints than three, while, in some lizards, the fourth digit may have as many as five joints.

In the frog the wrist-bones (called respectively the magnum and unciforme) which support the third, fourth, and the little fingers, are formed together into a single ossicle. The same condition, however, sometimes occurs even in the orang. On the other hand, the single bone which in man and beasts supports both the "ring" and the "little" fingers, may be represented by two ossicles in the frog's class (or *e.g.* in *Salamandra*) and in some reptiles (as in *e.g. Chelydra*).

FIG. 47.

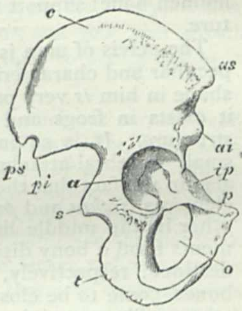




FIG. 48.

FIG. 47.—Dorsal surface of skeleton of right hand of the Tortoise, *Chelydra* (after Gegenbaur). *c*, cuneiforme; *in*, intermedium (or centrale); *l*, lunare; $m^1$—$m^5$, metacarpals; *r*, radius; *s*, scaphoides; *u*, ulna; 1—5, the five distal carpals, namely—1, trapezium; 2, trapezoides; 3, magnum; 4 and 5, divided unciforme.

FIG. 48.—Outer side of right os innominatum of Man. *a*, acetabulum; *ai*, anterior inferior spinous process of the ilium; *as*, anterior superior spinous process of the ilium; *c*, crest of the ilium; *ip*, ilio-pectineal eminence; *o*, obdurator foramen; *p*, pubis—its horizontal ramus; posterior inferior spinous process; *ps*, posterior superior spinous process; *s*, spine of the ischium; *t*, tuberosity of the ischium.

No member of the frog's class which has an arm at all, bears less than two fingers (as does *Proteus*) upon it. Thus we meet with a number as small as that which is developed amongst beasts in ruminants, but not so small a number as in the horse.

In the rudimentary condition of its thumb the frog participates in a very common defect, since this member

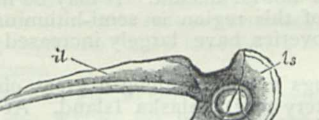




FIG. 49.

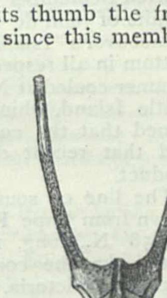


FIG. 50.

FIG. 49.—Right side of Pelvis of Frog. *il*, ilium; *is*, ischium; *p*, pubis The three bones meet at the uppper margin of the acetabulum.

FIG. 50.—Dorsal view of pelvis of Frog, showing the narrow ends of the ilia for attachment to the backbone, and also the close approximation of the acetabula.

is absent in very many forms. It is so even in creatures as highly organised and as like man in bodily structure as monkeys, since both the spider-monkeys of America and certain long-tailed monkeys (*Colobi*) of Africa, are thumbless.

In man, when standing, the weight of the body is transferred to the limbs by a large bony girdle, which, from its basin-like shape, is called the *pelvis*, This basin consists of the two haunch bones which meet together in front, but behind are separated by the lower part of the backbone (called the sacrum), to which the haunch bones are attached, and which forms the hinder portion of the pelvis. The pelvis has a depression, or "socket," on each side, into which fits the head of one of the thigh bones. Each "haunch bone" consists of three parts, which are, in man, primitively distinct, but afterwards anchylose together, and all three elements (in each haunch bone) take a share in the formation of the bony thigh-socket, or *acetabulum*. These three elements are named—1, *ilium*; 2, *ischiam*; and 3, *pubis*. It is the ilium which is adjoined to the sacrum. The pubis, in man, meets its fellow of the opposite side in the middle line in the front of the body. The two ischia (one to each haunch bone) support man's body when in a sitting posture.

The pelvis of man is often quoted as one of the most peculiar and characteristic parts of his skeleton, and its shape in him *is* very peculiar. Nevertheless the pelvis as it exists in frogs and toads is a far more exceptional structure. It is so in the extraordinary elongation, yet small vertebral attachment, of the haunch bones *ilia*, as also in the fact that these bones as well as the other pelvic elements (*ischia* and *pubes*) are all closely applied to each other in the middle line of the body. Thus these elements form a bony disc, and the two sockets (*acetabula*) destined, respectively, for the heads of the two thigh bones, come to be closely approximated one against the other. The great elongation and small attachments of the ilia allow the pelvis as a whole to be bent upon the backbone. Thus the hinder part of the body is moveable and forms as it were an additional common root segment for the two limbs.

St. George Mivart

(*To be continued.*)

## *SOUNDINGS IN THE NORTH PACIFIC*

Over a year ago the United States Congress authorised preliminary measures for laying a submarine cable from the west coast of America to Japan. The United States steamer *Tuscarora*, then on duty off the Isthmus of Darien, was despatched on this business, and started September 22, 1873, from San Francisco for the Straits of Juan de Fuca. Reconnaissances off Victoria, Vancouver's Island, discovered a gradually shelving bottom in all respects suitable for a cable landing. The steamer coaled at Nanaimo. Coal is also found at Newcastle Island, which is not far distant. It may be mentioned that the coal of this region is semi-bituminous, and that recent discoveries have largely increased its product.

The line of soundings extended along a great circle drawn from Cape Flattery to Oonalaska Island. At lat. 53° 58′ N., long. 153° W., within about 400 miles of Oonalaska, the coal was exhausted, and the vessel returned to Victoria. The ocean bed sank rapidly from Cape Flattery to lat. 48° 54′ N., long. 126° 21′ W., then rapidly and steadily to lat. 49° 26′ N., long. 128° 37′ W., then more rapidly to lat. 49° 46′ N., long. 129° 27′ W., at which point the depression was 1,452 fathoms. Thence a peak rose in the sea bottom, with a summit at 1,007 fathoms depth, in lat 51° 40′ N. long, 137° 32′ W. Its rise was fully as rapid as the depression preceding it, and the depression beyond it, the side being equally steep, was somewhat greater. The slope after the western bottom of this submarine mountain was reached was exceedingly gradual, and somewhat undulating. Perhaps the following estimates, roughly made from a sketch, will give a clearer notion of the ground surveyed. At about 100 miles from Cape Flattery, depth about 400 fathoms; at 150 miles, 1,000 fathoms; 170 miles, 1,400 fathoms; 200 miles, 1,000 fathoms; 300 miles, 1,600 fathoms; 400, 1,900 fathoms; 500, 2,000 fathoms; 600, 2,000 fathoms; 700, 2,100 fathoms; 800, 2,200 fathoms; 900, 2,300 fathoms; 1,000, 2,300 fathoms; 1,100, 2,500 fathoms.

During soundings on the return voyage to San Francisco, another submarine mountain was discovered in lat. 41° 30′ N., long. 127° 11′ W., the depth at its summit, which the sounding instruments showed to be of a rocky character, being only 996 fathoms. Around it, at distances of 20 miles, the depth was between 1,600 and 1,700 fathoms.

The water temperatures along the line of soundings for the cable, at depths of over 1,000 fathoms, varied from 0° 45′ C. to 2° 43′ C.; surface, 10° 35′ C. to 14° 15′ C. In lat. 53° 58′ N., long. 153° 00′ W., the increase from 50 fathoms to surface, was gradual; but at 50, 100 and 200 fathoms the same temperature was found as at 2,500 fathoms.

The conclusion has been reached in the course of a series of observations made during the return voyage, and subsequently, that what is known as the "California coast current," is really a warm, and not as hitherto supposed, a cold stream. The observations determined the existence of a warm current, presumably a continuation of the "Great Japanese Circle Current," setting toward the south and east, of a surface temperature averaging 15° C., between the positions lat. 48° 36′ N., long. 126° 36′ W., and lat. 50° 34′ N., long. 131° 38′ W. Outside of this current the temperature was but 10° C. Its width, between what is known as "Fleurier's Whirlpool" and the coast of California, is about 700 miles; its depth in lat. 44° 54′ N., long. 125° 13′ W. is about 200 ft.; its speed, one to two knots per hour. Under-currents below this stream have been determined, setting to the north and west. The counter-current does not appear to extend more than 30 to 35 miles from shore, moving at a half to one knot per hour, with a depth of 200 to 300 fathoms.

The expedition was equipped with a great variety of sounding apparatus, of which only a few instruments gave perfect satisfaction, and several proved quite useless. The vessel carried 32,000 fathoms line, of which 21,000 were 1¼ in., carbonised. Among the satisfactory instruments, Prof. Thomson's is mentioned. This is worked by hand, winding No. 22 piano wire, capable of resisting a strain of 200 pounds. It has a registering indicator and a dynamometer attached. For bringing up material from the bottom, Belknap's cylinder, No. 2, gave the best results, the lower half of the cylinder being usually filled with about three ounces of sea-bottom material, and the upper half with water that had rested on the sea-bottom. The material is brought up secured in the case of a "Sand's cup" by a cylindrical sleeve. The latter is held by a spiral spring, in a position just covering a small orifice in the hollow cylindrical case. On striking bottom, the sleeve is forced up, permitting the material of the ocean bottom to enter the orifice. The instrument is driven into the bottom material by a weight which carries it down with great velocity. This weight, consisting of two hemispheres of iron attached just above the spring, is automatically detached when bottom is struck, by the slackening of the line. Upon drawing up the line, the spiral spring again forces the sleeve down, covering the orifice. The material drawn from the greatest depths was the usual chalky, pasty mud, smooth and homogeneous, rarely containing sand, chiefly composed of casings of diatoms and foraminifers, with here and there the spiculæ and siliceous skeletons of the smaller sponges and *polycystina*.

Although the expedition met for the most part with unsettled and unfavourable weather which interfered with its work, that which it has accomplished is regarded as eminently satisfactory. There is little doubt but that the route upon which the soundings have been made, will be the one selected for the cable; and next spring the work will be extended from the point at which it was discontinued.

## NOTES

To the large number of his palæontological discoveries Prof. Owen has quite recently added that of a most peculiar bird from the London clay of Sheppey, which he has named *Odontopteryx toliapica*. This new form, known only from the skull, though perfectly ornithic in general structure, and exhibiting many of the characters of the Steganopodes (Gannets and Cormorants), presents a peculiarity not found in any existing bird. The trenchant margins of the bones of both jaws, instead of being simple, are provided with long conical bony processes, like the serrations in a coarse saw. The posterior of these serrations, which are alone preserved, are directed somewhat forwards; the anterior were probably less inclined, or even directed backwards like the homologous horny processes in the Goosander. The theoretical importance of this new form is great; for it is as good an example as can be brought forward of the loss in modern times, from a persistent type of animals, of a well-developed specialised structure. Many who criticise the evolution hypothesis appear to assume that progress, or what is the same thing, development in the individual of a maximum number of specialised organs, is an indispensable element of the Darwinian hypothesis. Such, however, is certainly not the case after a certain degree of elaboration has been reached. For, taking *Odontopteryx* as an example, it is evident that though this bird had in the struggle for existence acquired a dentigerous mouth, in which point it was in advance of all other members of the bird type, nevertheless its being thus able to obtain food which others could not hold, did not render it in the least less liable to be exterminated by many of the other accidents associated with existence. The upheaval of the sea-bottom, for instance, in its accustomed haunts, would have been destructive to it as to any other of its kind, and probably more so; for the specialisation of the jaws is certain to have been attended with a similar modification in the limbs, resulting in the loss of the power of flight, which would not allow of its removing to a new locality on the change in the physical geography of its home. So with the equally modified Moa, Dodo and Auk, the term of existence of the *Odontopteryx* was a short one, because the tendency of its development was too much towards a degree of uniformity in surrounding circumstances, which the human mind alone knows is not justified by facts.

THE autumn show of the larger fungi at the Royal Horticultural Society has so steadily increased in interest and popularity, that it is intended to considerably extend it next year (1874). The following extract from the recently issued official schedule states the classes which are admissible, and the number and value of the prizes, which are entirely open to all competitors:—Wednesday, Oct. 7.—Class 1, Collection of Fungi, arranged according to their botanical affinities. Neat arrangement and correct nomenclature will be taken into account in awarding the prizes. The edible and poisonous species are to be so marked on their respective labels; the edible species being named on white labels, the poisonous on red ditto, the rest on yellow ditto. Prizes: 5*l*., 3*l*., 2*l*. Class 2, Collection of Edible Fungi. These should be shown, when possible, in juxtaposition with specimens of similar but noxious species. Prizes: 3*l*., 2*l*., 1*l*. Class 3, Collection of New or Rare Fungi. Prizes: 3*l*., 2*l*., 1*l*. Class 4, Cultivated Edible Fungi. This class is intended for species likely to be useful as esculents, but which are not now known in the cultivated state. Prizes: 3*l*., 2*l*., 1*l*.

THE following has been announced as the Cambridge Natural Science Tripos:—First Class.—Martin, Christ's; Balfour, Trinity; (a) Bettany, Caius; (a) Hartog, Trinity; (a) Sollas, John's; Koch, John's—those marked (a) being equal in merit. Second Class.—(a) Balderston, Caius; (a) Davies, John's; (a) Jukes-Browne, John's; (a) Ogilvie, Trinity; (a) Salomons, Caius; Coe, Sidney; Ds. Fletcher, St. Peter's; Ds. Myers, Trinity: Symons, Trinity; Ds. Vinter, Caius; Ds. Yonge, Trinity Hall, the last six equal in merit as well as the first five Third Class.—Ds. Hawker, Trinity; Lighton, Trinity, equal. The undermentioned acquitted themselves so as to deserve an ordinary degree:—Crallen, Emmanuel; Mogg, Pembroke; Slater, St. Catharine's.

MR. ROBERT E. BAYNES, B.A., Wadham College, has been elected to a Lee's Readership in Physics at Christ Church, Oxford. Mr. Baynes gained a First-Class in Mathematical Moderations in Trinity Term 1871; and a First-Class in the School of Natural Science, Michaelmas Term 1872. The stipend of the Lee's Reader is 300*l*. per annum for the first four years after election, 400*l*. for the next three years, and 500*l*. after seventh year from election. He has also a right to occupy rooms in college rent free.

AMONG the more important of the numerous current publications of the United States Hydrographical Office, under Commodore Wyman, is the first volume of a "Coast Pilot" of the coast of Brazil, prepared by Lieutenant Gorringe, and covering the region from Cape Orange to Rio Janeiro, forming a volume of nearly 400 pages, in which the peculiarities of that portion of the coast are detailed with great minuteness, and accompanied by numerous profile sketches of the shores as observable from the vessel at sea. Another report of a very practical bearing is the result of the observations made by the United States steamer *Narraganset* during a cruise between Honolulu and Sidney, conducted between July 6 and September 7, 1872. The points visited were Christmas Island, the Gilbert group, Mulgrave Islands, the Disappointment and Duff Islands, and the Vanikoro Islands.

THE Council of the Society of Arts have given notice of their intention to provide a short course of lectures suitable for a juvenile auditory during the Christmas holidays. For this purpose arrangements have been made with Mr. Frank Buckland, M.A., Her Majesty's Iespector of Salmon Fisheries, to deliver two lectures "On the Structure and Habits of Beasts, Birds, and Fishes, as showing Beauty and Design," on Friday, January 2, and Friday, January 9, at 8 P.M. The lectures will be illustrated by specimens. It is intended to make every effort to obtain an entirely juvenile audience, and the notice in the Society's *Journal* impresses strongly upon the members the fact that only children, not adults, are wanted. The plan is, as far as the Society of Arts is concerned, quite a new one; though the Royal Institution have before now had courses of juvenile lectures.

WE are glad to hear that the course of lectures by Mr. J. E. Taylor, F.G.S., F.L.S., at Ipswich, on "Physical Geography and Geology," has been so successful that the place of meeting has had to be changed to a larger building. The average attendance, we believe, has been 500.

"THE Fifth Annual Report of the Trustees of the Peabody Academy of Science for the year 1872" (Salem, U.S.) is a very cheerful one. The collections in the museum of the Academy are mainly in Natural History and Archæology, and to both departments very large additions were made during the year 1872; the museum, indeed, promises to become one of the most valuable collections in the United States. By the indefatigable researches of Dr. C. C. Abbott a collection of 3,000 implements of the stone age has been brought together, all obtained from the immediate vicinity of Trenton, N.J., on the banks of the Delaware and adjoining fields and hills. The greater part of the present Report is occupied by a number of papers by Mr. A. S. Packard, jun., the Curator of the Articulates. These papers are:—"Synopsis of the Thysanura of the Essex County, Mass., with descriptions of a few extralimital forms," "Descriptions of New American Phalænidæ," "Notes on North American Moths of the Families Phalænidæ and Pyralidæ in the British Museum," "On the Cave Fauna of Indiana," and "Record of American Entomology for 1872."

THE *Dundee Advertiser* is a daily paper of wide circulation and of considerable influence in the north, and is, therefore, we presume, able to keep a competent "London Correspondent." That gentleman, however, in writing in a recent number of the *Advertiser* about Mr. Prestwich's paper on tunnelling the Channel, is made to make the extraordinary statement that "in order to get under the chalk to the *Palæogovic* rocks the Company would have to go to a *depth of ten miles* on either side!" We had recently occasion to point out that science is at a discount in Dundee.

THE Bordeaux district branch of the French Association for the Promotion of Science has resolved to hold its meetings weekly on Mondays.

GOVERNMENT has sanctioned the appointment of a Professor of Physical Science at the Madras Presidency College, on a salary of 500 rs., rising to 700 rs. per month.

THE New York papers have lately contained quite a number of articles urging the propriety of establishing an Aquarium in Central Park, on the same scale as that at Brighton.

WE learn from *La Revue Scientifique* that two specimens of the Ibis, a bird found only in Egypt and at the mouths of the Danube, were recently shot by a hunter in the department of the Somme.

WE can only briefly refer to the following new books and new editions:—"Where there's a Will there's a Way; or, Science in the Cottage" (Hardwicke), is the title of a little volume by Mr. James Cash, containing an interesting collection of lives of persons in humble life who have to some purpose pursued the study of science, especially of Natural History.—"Mountain, Meadow, and Mere, a series of Outdoor Sketches of Sport, Scenery, Adventures, and Natural History," by Mr. G. C. Davies (Henry S. King & Co.), is a series of articles which originally appeared in the *Field* and some magazines. The sketches are generally graphic and racy, and contain information that, we should think, would be valuable to sportsmen of various kinds, with occasional observations on the natural history of the districts referred to by the author.—Mr. John Murray has just published third editions of Mr. H. W. Bates' "Naturalist on the River Amazons," and Mr. J. G. Bertram's interesting work, "The Harvest of the Sea, including Sketches of Fisheries and Fisher Folk." The latter work, which has been the means of doing good service to our fisheries, has been revised, and a considerable amount of new matter added.

A *Times* telegram dated Rome, Dec. 20, states that Colonel Gordon, who has accepted from the Khédive the leadership of a scientific expedition into Upper Egypt, is furnished by his Highness with a credit of 100,000*l*.

WE are glad to hear that a Section for Microscopical Investigation has been formed in connection with the Leeds Naturalists' Field Club and Scientific Association, one of the most efficient of local scientific societies. An excellent microscope has been purchased by liberal subscriptions among the members.

WE have received the Report of the 16th Session, 1872-3, of the Birkenhead Literary and Scientific Society, which numbers 134 members. The Report, among other papers, contains an address by the President, the Rev. G. H. Hopkins, on "the Insufficiency of Facts to establish a Scientific Law," characterised by considerable acuteness and knowledge. A paper read before this Society by Dr. Ricketts, F.G.S., on "Fissures, Faults, Contortions, and Slaty Cleavage," has been printed in a separate form.

THE Annual Report for 1872 of the Birmingham Natural History and Microscopical Society, is on the whole very satisfactory. Prefixed to the Report is a very able and extremely interesting address by the retiring President, the Rev. H. W. Crosskey, F.G.S., on some of the general principles on which geology as a science depends. Some of his illustrations are very forcible and ingenious.

THE Mining Commission, consisting of Savot Bey and Osman Bey, sent into the district of Lom, in the Danubian viceroyalty of Turkey in Europe, has been compelled, on account of the winter, to bring its labours to a close. It has, however, discovered two good coal mines, one ten and the other twenty miles from Lom. There are other mines of iron, copper, and bitumen.

ON November 26, at 11 P.M., a smart shock of earthquake was felt at Prevesa, in European Turkey. Though reported to have been violent, the shock only lasted a few seconds and did no damage. The earthquake of November 10, in Anatolia, extended to Ak Hissar, where it did some damage, and also in the village of Suleimanieh. On October 11, there was a slight shock at Lima, in Peru.

THE following statistics relating to Swedish Universities are from the *Medical Record*:—In the University of Upsala there are 52 ordinary and 2 extraordinary professors, 24 ordinary and 2 extraordinary assistant-professors, and other teachers, making a total of 109 persons engaged in instruction. The number of pupils is 1,607, of whom 172 belong to the faculty of medicine. The University of Lund has 64 teachers, including 28 ordinary and 1 extraordinary professor, and 28 ordinary assistant-professors. There are 545 students, of whom 33 are medical.

THE *Journal of the Society of Arts* informs us that from a recent report to the Congress by the Inspector-general of Public Instruction in Chili, some idea of the educational condition of that republic may be formed. There are 1,190 schools in Chili, of which 726 are public and 464 private. It appears from the latest census that the population of the towns is 520,668, being at the rate of one school for every 1,769 inhabitants; and in the country, with a population of 1,298,560, there would be one school for every 3,020 inhabitants. In 1872 these schools were attended by 82,162 children and young persons of both sexes, and the amount expended by the Government for education purposes amounted to 414,127 piastres. The number of teachers in the primary schools was 1,544, of which 896 were male and 657 female teachers.

ACCORDING to the "Reports of the Mining Surveyors and Registrars," the yield of gold in the colony of Victoria for the quarter ending June 30, was:—from Alluviums 123,643 oz. 6 dwt.; from quartz reefs, 159,604 oz. 17 dwt; total 283,248 oz. 3 dwt.

WE have received No. 3 of Albert Müller's "Contributions to Entomological Bibliography," up to 1862.

THE additions to the Zoological Society's Gardens during the last week include an Alpaca (*Lama pacos*) from Peru, and a Pileated Parraket (*Platycerus pileatus*) from Australia, purchased; a Violaceous Plaintain-cutter (*Musophaga violacea*) from West Africa, received in exchange; a Puma (*Felis concolor*) from America, and two Tuberculated Iguanas (*Iguana tuberculata*) from the West Indies, deposited.

## SCIENTIFIC SERIALS

THE *Journal of the Franklin Institute*, November 1873.—In this number Mr. Richards, mechanical engineer, communicates the first part of a treatise on "The Principles of Shop Manipulation for Engineering Apprentices;" the points dealt with being these: plans of studying (and here he advocates the order, first, machine functions, next, plans or adaptations of machines, third, construction of machines), nature of mechanical engineering, engineering as a calling, and the conditions of apprenticeship.—Dr. Coolley, in a lecture-extract, shows how convection may be usefully applied in detection of heat. He has an instrument somewhat like a Coulomb electrometer; in a glass case, a thin glass tube with black pith ball at one end is suspended horizontally by a silk fibre over a graduated disc. A heated body is introduced near the ball, which immediately swings towards it; while a cold body will repel the ball; these effects being due to air currents. The experiments Dr. Coolley makes, show that this forms a very sensitive thermoscope.—An account is furnished of the Cleveland Waterworks Tunnel, just completed, and which is similar to the one at Chicago. The shore section and lake section were carried on simultaneously, 40 ft. to 70 ft. below the bottom of the lake; the starting-points being a mile and a quarter apart. The work was somewhat disturbed by quicksands, but the sections met on an exact level. The capacity of the tunnel is 60 to 70 million gallons daily; though the average daily consumption is at present only about 6 million gallons.—A new process is described for utilising coal waste. The inventor uses, as a cement, only yellow clay with some milk of lime, but no bituminous or resinous matter; merely waterproofing the surface with a solution of rosin. From first to last no handling is required; and the lumps are delivered, in shape and size like hen's eggs. The process is highly commended.—We find notes on American machinery abroad, friction of screw propellers in water, &c., and, among other novelties of construction described, a planing bar, a compound beam engine, an antifriction journal, an irrigating machine, and a new optical toy (Prof. Dolbear).

*Annalen der Chemie und Pharmacie.* Band 169, Heft 1, u. 2. —We notice that in this number Liebig's name disappears from the list of editors, and the title is changed to *Justus Liebig's Annalen der Chemie und Pharmacie.* The following papers are published:—Hubner and Post on the constitution of bromtoluol in relation to its hydrogen atoms. The authors give a collection of minor papers by various authors, dealing with the substitution of different hydrogen atoms in the formula by various radicles.—On the estimation of nitrogen, by S. W. Johnson. The author finds that a mixture of sulphate or carbonate of sodium with slaked lime can be employed instead of the soda-lime usually used in Varrentrapp's and Will's processes. The mixture, when heated, of course, yields sodic hydrate and sulphate or carbonate of calcium. Experiments made with such mixtures are described.—On the nitro derivatives of naphthalin, by F. Beilstein and A. Kuhlberg. The mono-, di-, and tri-nitro compounds are described.—On atacamite, by E. Ludwig. The author proposes some alteration in the ideas of the constitution of this mineral advocated by Rammelsberg and others, his suggestions being based upon the way in which the substance gives up its water at different temperatures; he also makes some suggestions as to formula of brochantite.—On the action of sulphocarbonyl chloride on amidogen compounds, by B. Rathke and P. Schäfer.—Note on a polyacetone, by W. Heintz.—On the production of talanin by means of potassic cyanide, and on a by product of the reaction by W. Heintz. The author gives details of the preparation of alanin, the by product is lactyt-urea.—On the constitution of natural silicates, by Dr. K. Haushofer, is a lengthy paper dealing with the probable constitutional and graphic formulæ of these bodies.—On the polyolenes and on the change of ethylene into ethyl alcohol, by W. Goriainow and A. Butlerow.—On protein substances, by H. Hlasiwetz and J. Habermann.—On the compounds of the camphor group, by J. Kachler. The author describes pimelinic acid, $C_7H_{12}O_4$, and many of its salts. —On the isomers of amylene obtained from the amylic alcohol of fermentation, by F. Flavitzky.—On the synthesis of anthracene and dimethyl-anthracene, by W. A. van Dorp.—On cœrulignon and its derivatives, by C. Lieberman. The author regards cœrulignon as a quinone.—On pentabrom resorcin and pentabromorcin, by C. Lieberman and A. Dittler.—The number concludes with an abstract from M. L. d'Henry's late paper in the *Comptes Rendus*, on the use of the sodium flame for observing litmus tints in alkalimetry.

*Verhandlungen der k. k. geologischen Reichsanstalt.* Nos. 1 to 6. (1873.) Amongst many other papers of interest contained in these numbers of the Proceedings we note the following:—On the occurrence of a new genus and new species of palm seed-vessel (*Lepidocaryopsis Westphaleni*) in the cretaceous sandstone of Kaunitz in Bohemia, by D. Stur.—Notices of the earthquake at Vienna on the 3rd January, by Dr. G. Stache.—Hugo Rittler's sketches of the rothliegende in the environs of Rossitz, by D. Stur.—On the analogies of the three carboniferous resins, anthracox, middletonite, and tasmanite, and their probable origin, by O. Feistmantel.—On the geological position and distribution of the silicified woods in Bohemia, by the same author.—The usual literary notices and other matters accompany each part of the Proceedings.

*Ocean Highways*, December. This number commences with an appreciative memoir of the late Sir Robert Maclure. An article entitled "The Straits of Magellan" contains some very interesting information concerning the little known region in that quarter of the world, and what has been done recently for the settlement of the mainland-coast of the straits. The paper recommends to emigrants Sandy Point, the Chilian settlement at which most of the steamers touch on their way to and from the West Coast, and which "is admirably situated on Brunswick Peninsula, nearly on the line of demarcation between the dense forests which cover the whole western end of the Straits, and the naked, rolling Pampas, which spread uninterruptedly northward to the very shores of the river Plate."—H. H. Giglio sends a letter, with some remarks from Dr. Beccari, on the latter's Exploration of Papuasia. Three small maps of parts of New Guinea illustrate the discoveries of Beccari, D'Albertis, Moresby, Cerruti, and Meyer.

## SOCIETIES AND ACADEMIES

### LONDON

Royal Society, Dec. 11.—"On the Action of Heat on Gravitating Masses," by William Crookes, F.R.S.

The experiments recorded in this paper have arisen from observations made when using the vacuum-balance, described by the author in his paper "On the Atomic Weight of Thallium,"* for weighing substances which were of a higher temperature than the surrounding air and the weights. There appeared to be a diminution of the force of gravitation, and experiments were instituted to render the action more sensible, and to eliminate sources of error.

After discussing the explanations which may be given of these actions, and showing that they cannot be due to air-currents, the author refers to evidences of this repulsive action of heat, and attractive action of cold, in nature. In that portion of the sun's radiation which is called heat, we have the radial repulsive force possessing successive propagation required to explain the phenomena of comets and the shape and changes of the nebulæ. To compare small things with great (to argue from pieces of straw up to heavenly bodies), it is not improbable that the attraction now shown to exist between a cold and a warm body will equally prevail when, for the temperature of melting ice is substituted the cold of space, for a pith ball a celestial sphere, and for an artificial vacuum a stellar void. In the radiant molecular energy of cosmical masses may at last be found that "agent acting constantly according to certain laws," which Newton held to be the cause of gravity.

Dec. 18.—"On Double Refraction in a Viscous Fluid in motion," by Prof. J. Clerk Maxwell, F.R.S.

According to Poisson's † theory of the internal friction of fluids, a viscous fluid behaves as an elastic solid would do if it were periodically liquefied for an instant and solidified again, so that at each fresh start it becomes for the moment like an elastic solid free from strain. The state of strain of certain transparent bodies may be investigated by means of their action on polarised light. This action was observed by Brewster, and was shown by Fresnel to be an instance of double refraction.

In 1866 I made some attempts to ascertain whether the state of strain in a viscous fluid in motion could be detected by its action on polarised light. I had a cylindrical box with a glass bottom. Within this box a solid cylinder could be made to rotate. The fluid to be examined was placed in the annular space

* Phil. Trans. 1872.

† Journal de l'Ecole Polytechnique, tome xiii. cah. xx (1829).

between this cylinder and the sides of the box. Polarised light was thrown up through the fluid parallel to the axis, and the inner cylinder was then made to rotate. I was unable to obtain any result with solution of gum or syrup of sugar, though I observed an effect on polarised light when I compressed some Canada balsam which had become very thick and almost solid in a bottle.

It is easy, however, to observe the effect in Canada balsam, which is so fluid that it very rapidly assumes a level surface after being disturbed. Put some Canada balsam in a wide-mouthed square bottle; let light, polarised in a vertical plane, be transmitted through the fluid; observe the light through a Nicol's prism, and turn the prism so as to cut off the light; insert a spatula into the Canada balsam in a vertical plane passing through the eye. Whenever the spatula is moved up or down in the fluid, the light reappears on both sides of the spatula; this continues only so long as the spatula is in motion. As soon as the motion stops, the light disappears, and that so quickly that I have hitherto been unable to determine the rate of relaxation of that state of strain which the light indicates.

If the motion of the spatula in its own plane, instead of being in the plane of polarisation, is inclined 45° to it, no effect is observed, showing that the axes of strain are inclined 45° to the plane of shearing, as indicated by the theory.

I am not aware that this method of rendering visible the state of strain of a viscous fluid has been hitherto employed; but it appears capable of furnishing important information as to the nature of viscosity in different substances.

Among transparent solids there is considerable diversity in their action on polarised light. If a small portion is cut from a piece of unannealed glass at a place where the strain is uniform, the effect on polarised light vanishes as soon as the glass is relieved from the stress caused by the unequal contraction of the parts surrounding it.

But if a plate of gelatine is allowed to dry under longitudinal tension, a small piece cut out of it exhibits the same effect on light as it did before, showing that a state of strain can exist without the action of stress. A film of gutta percha which has been stretched in one direction has a similar action on light. If a circular piece is cut out of such a stretched film and warmed, it contracts in the direction in which the stretching took place.

The body of a sea-nettle has all the appearance of a transparent jelly, and at one time I thought that the spontaneous contractions of the living animal might be rendered visible by means of polarised light transmitted through its body. But I found that even a very considerable pressure applied to the sides of the sea-nettle produced no effect on polarised light, and I thus found, what I might have learned by dissection, that the sea-nettle is not a true jelly, but consists of cells filled with fluid.

On the other hand, the crystalline lens of the eye, as Brewster observed, has a strong action on polarised light when strained, either by external pressure, or by the unequal contraction of its parts as it becomes dry.

I have enumerated these instances of the application of polarised light to the study of the structure of solid bodies as suggestions with respect to the application of the same method to liquids so as to determine whether a given liquid differs from a solid in having a very small "rigidity," or in having a small "time of relaxation,"* or in both ways. Those which, like Canada balsam, act strongly on polarised light, have probably a small "rigidity," but a sensible "time of relaxation." Those which do not show this action are probably much more "rigid," and owe their fluidity to the smallness of their "time of relaxation."

"On the Period of Hemispherical Excess of Sun-spots, and the 26-day Period of Terrestrial Magnetism." By J. A. Broun, F.R.S.

It appears from the interesting communication to the Royal Society, June 19, by Messrs. De La Rue, Stewart, and Loewy,† that the difference of the area of spots on the visible northern and southern quarter-spheres of the sun seems, during periods of considerable solar disturbance, to obey a law such that the difference is a maximum in the same quarter-sphere during several successive rotations of the sun, the difference being a maximum alternately in the northern and southern hemispheres; the time from maximum to maximum, for the same hemisphere, being variable between 18 and 32 days, but having a mean value of about 25·2 days.

It occurs at once that if the variations of the mean terrestrial magnetic force are connected in any way with the solar spots, or the causes which produce them, we might here find some explanation of the magnetic period of 26 days, the difference of spot area in one hemisphere from that in the other being related to a difference of the solar magnetic action.

In order to determine whether such a connection existed, I projected first the curves of excess of spot-area given in the paper of Messrs. De La Rue, Stewart, and Loewy, and below them the daily mean horizontal force of the earth's magnetism during the same periods. The conclusion from these projections is, that there is *no relation whatever between the two classes of curves.* The maxima and minima of the one agree in no ways with those of the other; the greatest excesses of sun-spot area in the one hemisphere over those in the other occur when the earth's magnetic force is the most constant; the greatest variations of the earth's magnetic force from the mean occur in several instances when the sun-spot area is equal in the two visible quarter-spheres.

It should be remembered, in considering the curves of sun-spot excess, that the minima and maxima are in some cases only relative; sometimes the one, sometimes the other being really cases in which there is neither maximum nor minimum; that is to say, cases in which the sun-spot area is equal, or nearly so in the two visible quarter-spheres.

It would be hasty to conclude from this comparison that the variations of the mean magnetic force are really unconnected with the mode of distribution of the sun-spots. Other methods of grouping the spots may perhaps be employed with advantage relatively to this and other questions, for example, were the position of the centre of gravity of the sun-spots determined for the visible quarter-spheres and hemisphere, giving each spot a spot-weight in proportion to its area, the variation of these positions in latitude and longitude and their weights, might give a more satisfactory base for this comparison and for other deductions.

It will be obvious also that this investigation refers only to one *visible* hemisphere of the sun; an approximation to the spot-distribution on the other hemisphere will, however, be frequently possible.

"On the Nervous System of *Actinia*," Part I., by Prof. P. Martin Duncan, F.R.S.

"On certain Discrepancies in the published numerical value of $\pi$," by William Shanks.

**Mathematical Society**, Dec. 11.—Prof. Cayley, F.R.S., V.P., in the chair.—Prof. Clifford gave an account of his paper on the graphic representation of the harmonic components of a periodic motion. The paper was an application of a theorem of Fourier's, which asserts that any motion having the period P may be decomposed into simple harmonic motions having periods P, $\frac{1}{2}$ P, $\frac{1}{3}$ P, &c., and assigns the amplitudes and phases of these motions by means of definite integrals.—Prof. Cayley next spoke on the subject of Steiner's surface. The author stated that he had constructed a model and drawings of the symmetrical form of Steiner's surface, viz. that wherein the four singular tangent planes form a regular tetrahedron, and consequently the three nodal lines (being the lines joining the middle points of opposite edges) a system of rectangular axes at the centre of the tetrahedron. He then described the general form of the surface, and finally discussed its analytical theory.—Lord Rayleigh, Mr. Roberts, Prof. Clifford, and Prof. Cayley made further extempore communications to the Society.

**Linnean Society**, Dec. 18.—G. Bentham, F.R.S., president, in the chair.—Dr. Hooker exhibited a magnificent zoophyte from Bermuda, sent by General Lefroy; also a six-lobed Seychelles cocoa-nut (*Lodoicea Seychellarum*) and two tazzas made from the shell of a Seychelles cocoa-nut sent from the Seychelles by Mr. Swinburne Ward to the Kew Museum; also some small boxes from Mauritius and Madagascar made from some grass-haulm; and two walking-sticks from Bermuda made of the "cedar-wood" of commerce (*Juniperus bermudiana*).—Mr. Bowring exhibited an inflorescence of an orchid with a remarkable smell, probably a *Bulbophyllum*.—The following papers were then read, viz.:—"Contributions to the Botany of the *Challenger* Expedition," No. 2, by H. N. Moseley, M.A. On the Vegetation of Bermuda and the surrounding sea. About 160 species of flower-

* The "time of relaxation" of a substance strained in a given manner is the time required for the complete relaxation of the strain, supposing the rate of relaxation to remain the same as at the beginning of this time.

† Proc. Royal Soc. vol. xxi. p. 399.

ing plants were gathered on the island; but of these, not more than 100 were certainly native. Those of West-Indian origin were probably brought, as Grisebach had suggested, by the Gulf-stream or by cyclones, there being no winds blowing directly from the American coast which would be likely to carry seeds, which might, however, be conveyed from the Continent by migratory birds. A note by Prof. Thiselton Dyer appended to the paper stated that 162 species sent over by Mr. Moseley had been determined at the Kew Herbarium, of which 71 belong to the Old World, while 2, an *Erythræa* and a *Spiranthes*, were plants hitherto known as confined to single localities in the United States.—"Changes in the Vegetation of South Africa, caused by the introduction of the Merino Sheep," by Dr. Shaw. The original vegetation of the colony is being in many places destroyed or rapidly deteriorated by over-stocking and by the accidental introduction of various weeds. Among the most important of the latter is the *Xanthium spinosum*, introduced from Europe, the achenes of which cling to the wool with such tenacity that it is almost impossible to detach them, and render it almost unsaleable. It spreads with such rapidity that in some parts legislative enactments have been passed for its extirpation; and where this is not done, it almost usurps the place of the more useful vegetation. The president stated that the *Xanthium* has in the same manner deteriorated the pastures in Queensland; whilst in the south of Europe, where it is equally abundant, it does not appear to cause such injurious results. Though generally distributed through Europe, the plant is probably of Chilian origin.—Extract from a letter from Osbert Salvin, F.R.S., to Dr. Hooker, dated Guatemala, Oct. 6. Mr. Salvin is engaged in collecting plants on the slopes of the Volcan de Fuego, 5,000 ft. in elevation, and within an easy ride of a volcano 13,000 ft. above the level of the sea. He hopes to secure all the plants between the elevations of 3,500 and 8,500 ft. Many of the species appear to have a vertical range of as much as from 2,000 to 3,000 ft.

**Meteorological Society**, Dec. 19.—Dr. R. J. Mann, president, in the chair.—The following papers were read:—"On an improved form of aneroid for determining heights with a means of adjusting the altitude scale for various temperatures," by Mr. Rogers Field. In this aneroid the scale is adjustable for different temperatures. The principle of the adjustment depends on the fact that when the scale is shifted it becomes inaccurate for the temperature for which it was laid down, and therefore practically accurate for some other temperature, so that the scale has only to be shifted into certain different fixed positions to obtain a series of different scales suitable for different temperatures of the air.—"On the North Atlantic hurricane of August 20 to 24, 1873, which did much damage at Halifax, Nova Scotia, and elsewhere," by Capt. H. Toynbee, F.R.A.S. The author alluded to various data which had come into the Meteorological Office respecting this gale, especially to a chart of its track, and important remarks from Mr. J. R. H. Macfarlane, R.N., Naval Sub-Lieut. H.M.S. *Plover*. This data proved that it was a hurricane, and its route was traced from a position to the south-east of Bermuda to Halifax, showing its probable track for four days. The author then went on to say that if the circular theory for hurricanes were correct, little more could be done, though it would be very interesting to trace so hard a gale from its formation to its breaking up. But he said if Mr. Meldrum's "Notes on the form of Cyclones in the Southern Indian Ocean"* were correct, then it was incumbent on the meteorologists of the northern hemisphere to institute a similar inquiry, as the form of cyclones in the southern hemisphere worked out from facts by Mr. Meldrum, made it necessary to modify the rules in use amongst seamen for avoiding their centres. An enlarged copy of Meldrum's diagram (reversed to adapt it to the northern hemisphere) was exhibited. The paper concluded with a suggestion that the August gale of 1873 would afford the means for inquiry into the shape of the northern hemisphere cyclones, and that data for that month should be collected from all parts of the North Atlantic, and worked up into daily synoptic charts, which suggestion the author hoped would be carried out either by America or England.—On a mercurial barometer for the use of travellers, filled by the spiral-cord method, by Staff-Commander C. George, R.N.

**Geologists' Association**, Dec. 5.—Henry Woodward, F.R.S., president, in the chair.—"On the Yorkshire Oolites," by W. T. Hudleston, F.G.S. The district occupied by beds of Oolitic age in north-east Yorkshire, constitutes a mass of elevated land divided into two very unequal lobes by a triangular depressed area known as the Vale of Pickering, towards which the beds incline. A diagonal of thirty-one miles, from N.E. to S.W., exhibits the beds of the Moorland range resting on the Lias of Robin Hood's Bay, whence they incline towards the Vale of Pickering, newer beds being continually met with as far as the "Kimmeridge Clay" of the vale. Crossing this vale towards the Howardian Hills, the previous beds or their equivalents are repeated in inverse order, until the Lias of the Vale of York is reached. Dealing with the Lower Oolites only, the group is essentially arenaceous. At the eastern termination of the moorland range (coast section) these beds have a thickness of 700 ft., mostly sands and shales, nearly devoid of marine mollusca, but rich in plant remains. There are, however, four distinct zones of marine life (well pointed out by Dr. Wright in 1859) which may be made out on the coast and identified in the transverse valleys of the moorland range. (1) The Dogger and its associated Land-rock, magnificently developed at Blue Wyke a sandy oolite, altered into an iron-stone, calcic carbonate being replaced by ferrous carbonate in the case of the shells, the original material being now replaced by siderite, very unequally developed, sometimes resting on 40 ft. of "striatulus beds," sometimes directly on the Upper Lias. (2) "The Millepore Bed." At the point of their maximum development 300 ft. of sands and shales intervene between the Dogger and this bed, which, north of Scarborough, is usually an arenaceous ironstone, but a few miles south of that town becomes the most important calcareous member of the Lower Oolites. (3) 100 ft. of sands succeed and then we have the "Scarborough Limestone" series, consisting of grey marly limestones alternating with marly shales and varying in thickness from 50 ft. at Mundall to 3 ft. at Gristhorp (distance 9 miles). Above the Scarborough Limestone series occurs 160 feet of shales and sandstones; some of these beds exhibit casts of myaciform shells. (4) The fourth fossiliferous zone is usually referred to the cornbrash. More complete marine conditions are apparent. Brachiopoda are abundant. *Ammonites Herveyi* plentiful in this bed, which yielded a fine suite of fossils. It forms the last of the Lower Oolites. In the inland chain south-west of the Vale of Pickering, the Lower Oolites are much attenuated, amounting to no more than 150 feet in the Derwent Valley. The types, too, are much altered.

**Chemical Society**, Dec. 18.—Dr. Odling, F.R.S., president, in the chair.—A paper on the preparation of standard trial plates to be used in verifying the composition of the coinage was read by the author, Mr. W. C. Roberts, Chemist of the Royal Mint. After giving a sketch of the variation in composition of the English gold and silver coins from the earliest times, he noticed the various trial plates which had been prepared since 1660, showing that they sometimes varied considerably from the standard of 916·66 parts in 1,000 for the gold and 925·0 for the silver. He then proceeded to describe the process employed and the difficulties to be overcome in the preparation of the new standard trial plates. These were exhibited at the meeting, and also a magnificent specimen of pure crystallised gold.—Researches on the action of the couple on organic bodies, Part iv., on iodide of allyl, by Dr. G. H. Gladstone and Mr. A. Tribe, being a continuation of their investigations on this subject.—On tetranickelous phosphide, by Dr. R. Schenck.—On ferrous anhydrosulphate, by Mr. T. Bolas. The compound, which is crystalline, is precipitated on mixing an aqueous solution of green vitriol with about nine times its volume of concentrated sulphuric acid.—On the hydrochloride of narceine, by Dr. C. R. A. Wright.

**Royal Horticultural Sociey**, Dec. 3.—Scientific Committee.—A. Smee, F.R.S., in the chair.—Dr. Masters, F.R.S., exhibited part of a poplar (sent by Mr. G. T. Saul), which, while apparently healthy, had during the past summer, within twenty-four hours, shed the whole of its leaves and never recovered. The Rev. M. J. Berkeley pointed out that the specimen was visibly attacked by fungus mycelium. No doubt, the tree had long been diseased unsuspected; the healthy bark would probably be reduced to a narrow strip, and when this failed the tree would die apparently quite suddenly.—Prof. Thiselton Dyer exhibited a drawing of a luminous *Didymium* from St. Kitt's.—Mr. McLachlan, F.L.S., inquired as to the possibility of introducing humble-bees into New Zealand; the red clover, which had also been introduced, was not fertilised for the want of them

* Mr. Meldrum's paper has been published as "Non-official, No. 7" by the Committee of the Royal Society who manage the Meteorological Office.

The chairman thought there could be no difficulty about it; the Rev. Mr. Cotton had taken bees out to New Zealand by keeping them at a low temperature, and consequently in a dormant condition, by means of ice.—Mr. McLachlan further wished the opinion of the committee with respect to another New Zealand inquiry by Captain Hutton; Aphides were now becoming very common in New Zealand, but were probably not indigenous. Could the golden-winged fly (*Chrysopa*) be advantageously introduced to check them. The chairman thought that it would be far better to send out dormant lady-birds (*Coccinella*). Mr. Wilson, F.R.S., pointed out the necessity of caution in these introductions; sparrows and hares were far from a boon in Australia.—Prof. Thiselton Dyer read a letter from Mr. Scott, F.R.S., Director of the Meteorological Office, with respect to a change in the climate of Scotland recently insisted on by Mr. McNab. He stated that it was an opinion too general to be lightly disregarded that our winters are warmer and summers cooler, on an average, than in the last century, but did not know where to find records which could be quoted with confidence in a discussion of the question.—Dr. Voelcker, F.R.S., mentioned that there was no doubt that it was quite possible to make wine from grapes ripened in this country; the often-repeated argument that our summers must be cooler because wine was not now made was manifestly fallacious.—Mr. A. W. Bennett, F.L.S., communicated a paper on pollen-eating flies of the group *Syrphidæ*.—Mr. Baker, F.L.S., sent capsules of *Lilium auratum* and *L. speciosum*.

**Anthropological Institute**, Dec. 9.—Mr. F. G. H. Price, F.G.S., in the chair.—Mr. J. Park Harrison gave a detailed description of two incised tablets, from Easter Island in the South Pacific, discovered by the French missionaries in one of the stone houses supposed to be formerly occupied by the chiefs. The signs appeared to be principally iconographic and to represent forms of life and incidents connected with islands several thousand miles to the west.—Prof. T. McK. Hughes described the results of his exploration of the rock-shelter known as Cave Ha, near Giggleswick, Settle, Yorkshire. In the upper deposits flakes and scrapers of chert and flint and other ancient remains in stone and iron were mixed up with the most recent works of art by the operations of badgers, rabbits, &c. In these beds the bones were found by Prof. Busk to be all of recent species, still, or till quite lately, common in the district. In the older deposits, which were composed chiefly of angular fragments of limestone, and, therefore, were not disturbed by burrowing animals, the remains of bear occurred associated with ox, goat or sheep, and dog; but as yet no traces of men. A point to which the author called special attention was the explanation found here of the occurrence in many ossiferous caves of such immense quantities of the bones of mice. The floor was in places strewn with broken up pellets of owls with here and there a few retaining their form, which, when the hair had decomposed away would exactly correspond to the layers and little bunches of the bones of mice in the underlying beds.—Prof. Hughes also read a joint paper by himself and Rev. D. R. Thomas, "On the occurrence of Felstone implements, of the Le Moustier type, in Pontnewydd Cave near St. Asaph, North Wales," After explaining by reference to sections, the position of the cave and of the deposits in it, the authors described a series of implements of felstone as similar to the common forms of Le Moustier as would be expected, allowing for the difference of material. They exhibited also a collection of bones from the same deposit which were referred by Prof. Busk to *Ursus spelæus*, *U. ferox*, *Hyæna spelæa*, *Rhinoceros hemistœchus*, and others, including a human molar which Prof. Busk pointed out was remarkable for its large size. As the rock, of which the implements were manufactured, occurred in that river basin in the boulder clay only, as the implements seemed to have been made from fragments such as occur in the drift, and are found associated with remanié drift mixed with tumble from the roof of the cave, the authors inferred that the deposit was post-glacial, while the forms of the implements, and the animal remains found with them would refer the beds to the earliest cave deposit in which human remains have been found.—A communication was made by Prof. Busk on a human fibula of unusual formation discovered in Victoria Cave, Settle, Yorkshire. The fragment lay at a considerable depth in the cave and beneath a thick layer of Boulder Clay, and was associated with bones of the two large species of cave Bear, *Hyæna*, *Rhinoceros tichorhinus*, *Bison* and *Cervus*. From its position, accompaniments, and other considerations, the deposit in which the specimen was found, had been regarded as of pre-glacial age.

**The London Anthropological Society**, Dec. 2.—Dr. R. S. Charnock, president, in the chair.—Causes which determine the Rise and Fall of Nations, by T. Inman, M.D. The paper embraced the whole historical range.—Western Anthropologists and Extra Western Communities, by J. Kaines, D.Sc. The paper shows what should be the moral attitude of the more civilised to the less civilised—what the latter has to teach the former—and the evils of western contact with the backward races.

**Photographic Society**, Dec. 9.—J. Spiller, F.C.S., V.P., in the chair.—On photo-collotype printing, by Capt. J. Waterhouse. The author recommended the use of citric acid as a clearing agent.—Lieut. Chermside, R.E., read a paper on photography in the Arctic Regions. Mr. Chermside accompanied Mr. Leigh Smith in his Arctic expedition last summer. The temperature at which pictures were actually taken was rarely less than 32° Fahr., but much difficulty was experienced in maintaining the solutions in proper order during excessive cold. The author gave some practical advice on the subject of overcoming actual difficulties inherent to photographic manipulations in high latitudes.

PARIS

**Academy of Sciences**, Dec. 15.—M. de Quatrefages, president, in the chair.—The following papers were read:—On the laws of the magnetisation of steel by currents, by M. Jamin.—An answer to a note read by M. Trécul at the meeting of the Dec. 8, by M. Pasteur. This was a reply to M. Trécul's criticism on the author's note on beer and displayed considerable acrimony, M. Pasteur of course sustained his well-known views of the nature of ferments.—M. Berthelot presented some new remarks on the nature of the chemical elements, which however could not be read on account of want of time. The author, it may be stated, admits the possibility of the elements being modifications of a fundamental substance, and stated that nothing renders it improbable that a discovery like that of the voltaic current might not give us power to still further simplify matter. His paper concluded thus:—We shall only be too happy if Mr. Lockyer, guided by stellar spectral analysis, can shed a new light upon these questions, and continue to investigate problems raised now forty years ago by M. Dumas in a work (*Leçons de Philosophie Chimique*) which has contributed so much to our scientific education.—Researches on new butyl derivatives by M. A. Cahours. The author dealt with the aluminium silicon tin and mercury compounds of butyl.—On the propagation of the *Phylloxera*, by M. H. Marès.—Report on Mr. Douglas Galton's paper "On the Construction of Hospitals," by M. Larrey, and General Morin:—Valuation in mechanical units of the quantity of electricity produced by an element in a battery, by M. Branly.—Hybernation of the *Phylloxera* on the branches and leaves of the vine, by M. Max. Cornu.—Action of the volcanic earth of the solfatara of Pouzzoles on the diseases of the vine, by M. S. De Luca.—On certain morphological changes observed in the genus *Cypripedium*, by M. R. Guérin.

## BOOKS RECEIVED

AMERICAN.—Catalogue of Stars observed in the United States Observatory, 1845–71: Rear-Admiral Sands (Washington).—Daily Bulletin of Weather Reports for September 1872: War Department (Washington).—Annual Record of Science and Industry: Dr. Spencer F. Baird (Harper, New York).—Elements of Logarithms: Pierce (Ginn Bros.).

FOREIGN.—Annalen der Sternwarte in Leiden: Dr. F. Kaiser (Nijkoff).—Somario delle Lezioni di Fisica: Prof. Mombello (Foligno).—Zoologische Studien auf Capri: Dr. Theodore Eimer (Engelmann, Leipzig).

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