THURSDAY, MAY 20, 1880

THE SCIENCE OF LANGUAGE

Introduction to the Science of Language. By A. H. Sayce, Deputy Professor of Comparative Philology in the University of Oxford. Two vols. (London: Kegan Paul and Co., 1880.)

THIS admirable treatise may be broadly described as the fitting complement and sequel to the author's "Principles of Comparative Philology." The method and theories of that work, as he is careful to remind us in the preface, form the solid basis of the present, and it is not saying too much to add that both together stand unrivalled as the most systematic and exhaustive treatise on the Science of Language in its present state that has yet appeared in our literature. At the same time the present work is sufficiently complete in itself to be read with pleasure and studied with profit by those who may be unacquainted with its forerunner, though this must still remain indispensable to a thorough grasp of the subject.

The author shrewdly remarks (i. 159) that "the comparative philologist should not introduce the frame of mind of the specialist into his comparative inquiries. The specialist who takes up comparative philology as a subsidiary pursuit is likely to spoil it in the taking." Being thus forewarned against an obvious danger, he has not yielded to the temptation of giving undue prominence to any particular branch, nor has he allowed his personal partiality for Assyrian studies in any way to interfere with the broad and catholic spirit pervading the whole work. This catholic spirit, constituting one of its special merits, is everywhere conspicuous, and nowhere more so than in his comprehensive classification of comparative philology into the three great divisions of phonology, sematology, and morphology (i., 141). This classification at once gives its due position to that more spiritual, though hitherto almost totally neglected, aspect of the subject which deals with the inner meaning, as phonology does with the outward or material sound of words. The difficulties associated with this branch, for which the happy term sematology is here adopted, are fully recognised; its somewhat vague and uncertain character, and the intricate psychological phenomena surrounding it, all receive due prominence. But a limit is assigned to the arbitrary and to the element of chance, and if a science of sematology is not already established on a solid basis, the course that research must take in this direction is at all events ably foreshadowed. The delicate modifications of meaning that words undergo in their historic life must be carefully noted, the general causes underlying them analysed and formulated, significant change reduced to definite principle and broadly generalised.

His philosophic classification of his subject enables the writer satisfactorily to settle a point still much discussed by philologists. Whether language is to be grouped with the natural or historical sciences is a question which, he justly remarks, has arisen from the partial views that have been taken of its true character. Speech is not mere sound, nor even articulate sound alone, for many animals can articulate, but articulate sound significant. *Terminus*, said the schoolmen, *est vox significans*, and for Mr. Sayce the terminus or "word," as here used, is speech, for the isolated term has no independent or abstract existence, and the unit of speech is not the word, but the sentence. It thus becomes impossible to separate the sound from its meaning, phonology from sematology. But phonology, or the outward aspect of language, is confessedly physiological, and subject to purely physical or natural laws, while sematology is essentially historical. And so the whole difficulty is solved; for "if we claim for the science of language in general the rank of a historical science, it is only because the meaning, rather than the sound, is the essence of speech, and phonology the handmaid and instrument rather than the equivalent of glottology" (i. 165). But "the method pursued by the science of language is the method of physical science; and this, combined with the fact that the laws of sound are also physical . . . has occasioned the belief that the science of language is a physical science. But such a view results in identifying phonology and glottology, in making a subordinate science equivalent to the higher one, and in ignoring all those questions as to the nature and origin of language which are of supreme importance to the philosophy of speech" (*ib.*).

In the chapter devoted to the morphology of speech the attempt made by Hovelacque and some other recent writers to identify polysynthesis with agglutination receives no countenance. That attempt could obviously lead to nothing but hopeless confusion, for "the conception of the sentence that underlies the polysynthetic dialects is the precise converse of that which underlies the isolating or the agglutinative groups" (i. 126). This question has been elsewhere dealt with somewhat fully by this writer,[1] and it is to him a source of no little satisfaction to find his views here so fully endorsed. At the same time it seems difficult to accept the author's theory that polysynthesis is "the undeveloped sentence of primitive speech," and that "the polysynthetic languages of America preserve the beginnings of grammar, just as the Bushman dialects have preserved the beginnings of phonetic utterance" (ii. 216). For it is hard to believe that primeval man began to speak in "sesquipedalia verba," and in any case the presence of true pronouns in these lengthy sentence-words is alone sufficient to show that polysynthesis is itself a development, the outcome of slow fusion and of long ages of gradual phonetic decay. The Bushman clicks form very probably a connecting-link between articulate and inarticulate utterance. But the pronoun in all languages stands on a far higher relative level; it cannot be conceived as a primordial cut-and-dry invention, for it is an abstraction of a high order, whereas the first beginnings of speech must all have been made up of the crudest concrete concepts combined with involuntary or mechanical ejaculations.

But one of the peculiar charms of the present work is the extreme fairness of the author, who is always ready to recognise the cogency of objections to favourite theories, so that the reader feels that both sides of the question have been fairly placed before him. A good instance occurs at p. 209 of vol. i., where the weakness of Sagard's

[1] In Appendix to the "Central and South America" of "Stanford's Compendium."

testimony to the evanescent character of the Huron language is frankly acknowleged. Many other moot questions are touched with great impartiality, and it is well remarked that divergence of opinion is a healthy sign of life and scientific progress; for "it is only by the conflict and discussion of theories that truth can finally be reached, and the many controversies excited by the science of language show how broadly and deeply the foundations of the science are being laid" (i. 87).

A statement, however, is made a little further back which will perhaps cause some surprise, as tending to shake these very foundations and call in question conclusions that seemed almost universally accepted. The theory of evolution, which may be said to underlie all modern thought, and which has already passed almost beyond the pale of discussion, has naturally tended to remove much of the confusion previously associated with the various conflicting opinions entertained regarding the origin of human speech. For if true at all it is evident that this great principle must be of universal application, and when applied to language the inference was irresistible that there can be no immutable types of speech, any more than there are immutable animal and vegetable species. Hence the necessary conclusion that all present forms of speech are modifications of previously existing forms, that, however slowly, all are continually shifting, possibly retrograding under unfavourable conditions, but in the normal state advancing, for the history of evolution is on the whole the history of progress. A careful study of the texture of speech seemed fully to confirm these *à priori* deductions, and a general consensus was thus arrived at that there must have been some hypothetical root-state out of which language was slowly evolved, passing successively through lower to higher types, from the isolating to the polysynthetic, agglutinating, incorporating, inflectional, and analytic orders.

But in seeming opposition to these views the author holds that it cannot be proved that the primæval root-language ever existed, and that "equally unproved is the belief that isolating dialects develop into agglutinative, and agglutinative into inflectional" (p. 75). And at p. 131, while admitting the general doctrine of evolution, he seems still to argue for the immutability of linguistic types, though his language is here somewhat deficient in its usual clearness and point. "The Finnic idioms," he writes, "have become so nearly inflectional as to have led a recent scholar to suggest their relationship to our Aryan group; nevertheless they have never cleared the magical frontier between flection and agglutination, hard as it may be to define, since to pass from agglutination to inflection is to revolutionise the whole system of thought and language and the basis on which it rests, and to break with the past psychological history and tendencies of a speech."

Here it should be observed that the author may not inconsistently deny the necessary development of agglutination into inflection, because he does not regard the latter as a higher type than the former, and because he takes, not the word or root, but the sentence, as the unit and starting-point of all speech. Now the sentence may have been originally cast in an agglutinative form, and if so agglutination would neither imply development in itself nor any necessary further evolution in a new direction. This, at least, we take to be the underlying argument, though it appears nowhere explicitly stated in this way. It is stated, however (p. 131), that by taking the sentence as the unit "there is no longer any difficulty in distinguishing between the several families of speech and assigning to each its character and place."

To all this many will of course reply that to take the sentence as the starting-point is to beg the whole question. It cannot, of course, be denied by the consistent evolutionist that there must have been a time when a single articulate utterance supplemented by tone and gesture, did duty for a whole sentence, and in this sense it may be admitted that the sentence is the starting-point of speech. But whether this incipient state can be regarded as constituting language, properly so called, is quite another matter, and in any case it could not be predicated of such language that it was either agglutinating or polysynthetic, or even isolating in the sense that Chinese or Annamese is isolating. Here we are, in fact, dealing rather with the germs of the plant than with the plant itself.

It will further be urged that if "the Finnic idioms have become so nearly inflectional," progress from agglutination in the direction of inflection is admitted, in which case the fact that "they have never cleared the magic frontier" becomes what the French would call a mere detail, a question of time or other circumstances. The Magyar has already developed an article, and the Dravidian tongues possess what look remarkably like true case-endings, while more than one language of the Caucasus, notably Georgian, Chechenz, and Lesghian, have apparently passed quite over to the inflecting state. The fact that this transition "revolutionises the whole system of thought and language" will not alarm those evolutionists who necessarily hold that revolution is the law of nature and the order of the universe. Only the great issues are worked out *sensim sine sensu*, and not by violent cataclysms and fresh creations, as was formerly supposed by unorthodox interpreters of a book which allows of but one creation and one partial cataclysm. Lastly, the critical analysis of agglutination, and still more of inflection, clearly shows that both are the result of sematological and phonetic decay continued over immense periods of time, during which numbers of concrete terms and notional words of all sorts gradually lost their independence, and thus became transformed to relational particles first loosely tacked on (agglutination), and then completely fused (inflection) with the theme. Thus it is that the passing vagaries of deep thinkers serve but to re-establish on firmer ground the very truths they seem to assail.

On other questions the work is equally suggestive, and there are some trenchant remarks at p. 349 of vol. i. which ought definitely to close the doors of the old school of etymologists. "The etymologist must be thoroughly trained in the principles of scientific philology. He must have mastered both phonology and sematology, and he must be well acquainted with more than one of the languages with which he deals. Then and then only can his labours be fruitful; then and then only will his work be a gain and not a hindrance. False etymologies stand in the way of true ones, and the charlatans who have brought the name of etymology into contempt have

discredited the labours of better men. There is much in etymology which must always defy analysis, there is much which will have to be corrected hereafter, but this will matter little if we have once learnt the lesson that change of sound and meaning can only take place in accordance with fixed and invariable law. Etymology is but a means to an end, and that end is partly the history of the development of thought and civilisation as reflected in the fossil records of speech, partly the discovery and illustration of the laws which govern the shifting and decay of sounds and the modifications of sense."

The whole subject of phonetics is of course treated in a masterly manner, and well illustrated with diagrams and useful tables of Lautverschiebung as applicable to the Semitic, Bantu, Finno-Tataric, and Aryan families. The last, especially, is very full, including the Oscan and Umbrian, the Old Welsh and Gaulish, besides those usually given. It need scarcely be added that this, like all other branches, is brought well up to date, a good instance of which is afforded by the reference to the use already made of the phonograph in the scientific treatment of phonetics. Most readers will here learn, probably for the first time, the curious fact that "all sounds may be reproduced backwards by simply beginning with the last forms indented on the tin-foil: *sociability*, for example, becoming *ytibilaishos*. Diphthongs and double consonants may be reversed with equal clearness and precision, so that *bite*, which the phonograph pronounces *bâ-eet*, becomes *tee-âb*. In this way we have learnt that the *ch* of *cheque* is really a double letter, the reversed pronunciation of the word being *kesht*" (i. 335).

The question of mixed languages, that is, mixed in their structure, claims a good deal of attention, and is handled with considerable reserve. But the important truth is loudly proclaimed that the "physiological races of the modern world are far more mixed than the languages they speak; the physiologist has much more difficulty in distinguishing his races than has the glottologist in distinguishing his families of speech" (i. 366). This is perhaps as far as it is safe to go at present, and is sufficient for practical purposes. It points out that it is in the nature of ethnical groups to mix, and of linguistic groups to keep aloof, thus vindicating for language its rightful position in anthropological studies. It is not always or necessarily a test of race, but it is often an indispensable collateral agent of research, becomes under special circumstances, and with all due precaution, a final court of appeal, and in many cases bears witness to the presence of racial elements which would not otherwise be suspected. Its development also is extremely slow, slower even under certain conditions than that of physical types themselves, as shown, for instance, in the case of the Osmanli, Magyars, and many Finnish and Turkoman tribes, all of whom continue to speak purely agglutinating Finno-Tataric tongues, although through intermixture they have been largely assimilated to the Caucasian ethnical type.

The chapter on Roots (vol. ii.) is accompanied by a table of all known languages, for the classification of which Fr. Müller seems mainly responsible. The appended references to authorities will be found extremely useful, but the classification itself is defective in many respects, and calls for revision in future editions. Sonrhay and Haussa, for instance, ought not to be grouped together, nor have Wakuafi (read Ki-Kwafi) and Masai anything in common with the Nuba and Fulah groups. It is not clear why Berber any more than Egyptian (both Hamitic) should be described as sub-Semitic; but it is still more startling to find Brahui amongst the neo-Sanskritic tongues in company with Siah-Pôsh, which latter would appear to belong rather to the Galcha or pre-Sanskritic of the Eastern Turkestan Highlands, and which is unaccountably excluded altogether from the table. Etruscan, in spite of Corssen, is grouped apart as agglutinating, though there are many good authorities for this view. But Horpa is not a Tibeto-Burman isolating tongue, nor are Lolo and Mautse properly linguistic terms, but rather collective Chinese names of hill-tribes, mostly probably of Caucasian stock and untoned speech. The "Mon-Annam" family has no existence, the Mon or Talain having little to do with the Annam, and nothing at all with Kambojan, which belongs to a totally different connection. The Miztec, Matlalzinca, Totonac, and other Mexican tongues are described as isolating, all being polysynthetic, some, such as the Miztec, in the very highest degree with "bunch-words" of fifteen and even seventeen syllables.

The second volume is largely occupied with some of the principal linguistic families typical of the several orders of speech, followed by concluding chapters on Comparative Mythology and the Origin of Language, all handled in a masterly manner, extremely suggestive even when somewhat heterodox, and accompanied by much incidental matter of great value and interest. The statement (p. 324) that "the characteristics of race were fixed before the invention of speech" is one of those astonishing paradoxes which seem inseparable from original thought, but which remain none the less paradoxes. It is scarcely conceivable that the yellow, black, fair, and other fundamental types of mankind should have become slowly differentiated before man had acquired the faculty of speech, that is, the very faculty by which the human is distinguished from all other species, and that the art was then "invented" in various independent centres. But though it cannot be argued on this ground that "the idioms of mankind have had many independent starting-points" (p. 323), few will probably question the conclusion that linguistic science "can throw no light on the ethnological problem of the original unity or diversity of the human race" (p. 324). Such questions are truly "the task of the ethnologist, not of the student of language" (*ib.*) And even should the hope have to be finally abandoned of ultimately establishing the original unity of human speech, no argument could thence be deduced in favour of the original diversity of the human species. Dispersions of babbling tribes, whether originally one or not, probably took place at various stages in the evolution of human speech, or at times while it was still in process of formation, or when little more than the faculty existed, so that it must needs have afterwards developed into types no longer reducible to one hypothetical primæval type. This hypothetical type becomes daily more shadowy, continually retreating to the background of an inconceivably remote past, according as the astonishing complexity and diversity of articulate speech is revealed to the earnest student of

language. But it seems obvious that this diversity and complexity must have been evolved in the natural course, whether starting from one or many original centres.

At p. 163 a view is taken of the Aryan suffixes which many will be inclined to regard as a retrogressive step rather than an advance in linguistic studies. "We must rid ourselves of the notion that suffixes were ever independent words like our 'if' or 'in'; so far back as our knowledge of Aryan speech extends they possessed no existence apart from the words to which they belonged, and which, again, only existed as words in so far as they possessed these suffixes. Suffixes became flexions through the help of analogy." The point would involve too much technical matter to be here adequately discussed, but it may be remarked that our knowledge of Aryan speech is as of yesterday compared with the many ages it must have taken to reach the highly-inflected state presented by the oldest known members of the family. If in a brief thousand years or thereabouts the Latin ablative *mente* had time to become a Romance adverbial suffix, the verb *habeo* a verbal ending, and the adverb *inde* a pronoun with a genitival force, surely there was ample time in the ten, twenty, or fifty thousand years of the early lifetime of the organic Aryan speech for hundreds of independent words to pass from one part of speech to another, from the noun or verb to the particle, and thence to the relational suffix. And if "suffixes became flections through the help of analogy," being hitherto "meaningless terminations" (*ib.*), it may be asked through the help of what analogy? At all events, the internal vowel change here taken as their pattern does not meet the case, for, if properly considered, all such internal vowel change must itself be regarded as primarily due to the influence of reduplication and flection acting on the body of the word, and gradually becoming absorbed, often leaving no trace of its former presence beyond the very vowel change in question. Such seems undoubtedly to be the history of the strong Teutonic conjugation and of such Teutonic plurals as seem now to be effected by mere internal modification, just as we know that it is the history of such past tenses in Latin as *ēgi, fēci*. Two things it seems impossible to admit—the development or invention of "meaningless terminations," that is, meaningless *ab initio*, and internal vowel change with flectional force, produced, as it were, by spontaneous effort independently of outward influence, the influence either of reduplication or of pre- or postfixes reacting on the theme.

The chapter on Comparative Mythology, as expounded in the light of comparative philology, is thoroughly satisfactory, and will be read with pleasure even by those unfamiliar with the technicalities of the subject. In the last chapter, also, on the Origin of Language and collateral subjects, much excellent advice is given touching spelling reform, the pronunciation of the classical tongues, the application of sound linguistic principles to the teaching of languages, and many other points of a more practical nature.

There is an excellent analytical index supplied by Mr. W. G. Hird, but it does not dispense with the necessity of a full alphabetical index, which is urgently needed in a work overflowing with matter of the most varied description, and which it may be hoped will be supplied in future editions. Some oversights and casual slips in minor points should then also be rectified, and with that view a few of the more important may here be noted. The *ve* in the Italian compound *portandovelo* (ii. 210) is derived from the Latin adverb *ibi*, used pronominally instead of from the pronoun *vobis*. The particle *vi, ve* often, of course, represents *ibi*, as in the sentence *io v'era* (lit. *ego ibi eram*); but it equally represents the pronoun, as in the sentence *io vi dico* (lit. *ego vobis dico*), and obviously in the compound in question. The Nogairs (properly Nogais) are described (ii. 199) as "Russian Cossacks" instead of Tatars. The Nogais are of Tûrki stock, whereas all the Cossacks are of Slav stock, either Great Russians (Don Valley, Cis-Caucasia, &c.), or Little Russians (Ukrania). The Cossacks are often spoken of as Tatars by careless writers, confounding them with the *Cassaks*, who, being Kirghizes, are true Tatars. It seems scarcely accurate to say that in the Greek and Latin sentences τύπτει and *amat* "the subject is not expressed" (ii. 329), seeing that εἰ (for ἔτι) and the *t* of *amat* are pronominal, though so old that they do not distinguish the gender of the subject referred to, and may possibly have originally been *objective* forms. The statement (i. 417) that "in Hindustani the genitive takes the marks of gender according to the words to which it refers," is apt to mislead the unwary, who might conclude from this that the Hindustani noun had cases, whereas there is nothing but a general oblique form followed by postpositions. One of these postpositions (*kā* = of) follows the gender of the noun of reference (*larkē-kā, larkē-kī* according to circumstances), but the noun remains unchanged. There is another reference (p. 423) to a point of Hindustani grammar, which as worded is unintelligible. The place of the definite article is not supplied "by a dative with the suffix *-ko*," for there are no datives, but by the postposition *ko*, which, though usually giving a dative force, often idiomatically emphasises the objective noun and thus does duty as a sort of definite article. The reference to Voltaire (i. 60) should be emended by shifting the places of the words "consonants" and "vowels." No one who has ever heard a native of Northern India speak any of the current neo-Sanskritic tongues will hesitate to transcribe the sonant explosives with the rough breathing (*gha, dha, bha*) by the side of *kha, tha, pha*, though the point is treated as doubtful (i. 281). The *h* in such words as *ghora, bhā,ī, dhōbi* is heard quite as distinctly as it is in the English word *mad-house*. Lastly, such terms as "Turanian" (i. 325), "Alfurian," and even Malayo-Polynesian might well be dispensed with in future editions of a work, which as it stands reflects lasting credit on English scholarship, and which all will accordingly be anxious to see rendered even in small details as perfect as possible.

A. H. KEANE

STATICS

Treatise on Statics. By George Minchin, M.A. Second Edition. (Clarendon Press Series.)

SINCE the publication of Thomson and Tait's "Natural Philosophy," thirteen years ago, an important change in the treatment of the theory of dynamics has been making rapid progress. Previous to that time it was the almost universal practice to follow the French writers and to find a basis for the theory of the equilibrium of forces

independent of any consideration of motion. Force was often defined to be that which caused or tended to cause motion; but the theory of the combination and resolution of forces was founded on certain assumed axioms about the properties of forces without further reference to the effect by which force was described. The proof of the parallelogram of forces was to most beginners such a formidable *pons asinorum* that the broad conception that velocities, accelerations, and forces acting at given points were all fully represented by vectors, and that each could be added just in the same way as the vectors which represented them, was not soon grasped by the mind. Consideration of the fundamental principles of dynamics and of the philosophic position of the first law of motion, which at the same time defines the measure of time and states a law of nature, was avoided, and the theory of the motion of matter became a development of the equations of statics.

Thomson and Tait returned to the order of Newton and abolished artifices from the foundations of the science of dynamics. The influence of Thomson and Tait's "Natural Philosophy" on the volume before us is apparent in the first chapter. The proofs of the parallelogram of forces by Duchayla and Duhammel are conspicuously absent, and the fundamental proposition of statics is deduced quite naturally from consideration of the parallelogram of velocities. When it is once admitted that statics should rest on Newton's laws of motion, the appropriateness of a separate treatise on the subject, to include electrostatics and elasticity, becomes questionable. Why should dynamics be divided and a separate treatise be written on that portion from which it is possible to exclude the idea of mass? A book on the analysis of systems of forces or "wrenches" deals with a natural group of propositions, so does a book on attractions, on electrostatics, or the relations of stresses and strains. But we cannot see that it is natural to group those subjects together with the view, as it would appear, that the student should make himself acquainted with them before mastering the dynamics of a particle. Indeed, however we may admire each chapter of Prof. Minchin's work, we cannot help regretting that he has limited his subject-matter by the title of the volume.

At the end of each chapter is an abundant selection of examples—a very necessary part of an educational work on any department of mathematics. It would have been well that amongst these should have been found a larger proportion of examples demanding a numerical answer; the best students show a liability to failure in rapidly dealing with dynamical questions when concrete numbers take the place of the more familiar symbols.

It is not often that a graduate of Dublin University omits to set forth in its proper place the work of a Dublin professor. Any one would have looked with considerable confidence in Chapter X. of Minchin's "Statics" for some account of Ball's theory of screws as a sequel to Poinsot's central axis, but he would be disappointed. As that theory is very instructive as well as exceedingly elegant, the omission is a loss to the student.

Chapter IX. is devoted to friction, and ends with four articles on the friction of a pivot, based on the assumption that the pressure between pivot and footstep is uniform over the surfaces in contact; and in Art. 134 the equation of the tractory is found by a further condition that the vertical wear shall be constant. As a fact, when a pivot has been at work for some time the vertical wear becomes of necessity constant, and thence may be deduced the normal pressure at any point which will not be constant unless the form of the pivot be the tractory. As an illustration we propose the following to our readers: A conical footstep is to bear a maximum load with a minimum frictional moment; show that it should have a hole in the middle one-third the diameter of the footstep. A similar consideration may be applied to ascertain the distribution of pressure between a horizontal shaft and an ordinary bearing.

The book ends with a chapter on stresses and strains and their relation to each other. The examples appended to this chapter will be found most useful to the student; so far as we know he will not find elsewhere such facilities for testing his skill in this department of dynamics. Although we do not think it desirable that the departments of the science of dynamics should be classified for teaching purposes into statics and kinetics so completely as the present volume implies, we can heartily recommend each several chapter for the subject on which it treats, and we hope that Prof. Minchin will produce a work dealing with kinetics, and that when a fresh edition of both is demanded he will weld them into a single treatise on dynamics.

AUSTRALIAN ORCHIDS

Australian Orchids. By R. O. Fitzgerald, F.L.S. Part V. (Sydney, N.S.W.)

THE part of this beautiful and instructive work which has just reached us contains ten plates, illustrations of sixteen species belonging to the genera Prasophyllum, Thelymitra, Sarcochilus, Dendrobium, Pterostylis, Cleisostoma, and Bolbophyllum, all full of analyses, displaying in a very satisfactory manner the forms, disposition, and, in many instances, the development of the reproductive organs; whilst the letterpress is as full as is that of previous parts, of curious and instructive observations on the habits of the species and their modes of fertilisation. Whether, in point of scientific importance, or fulness of illustration, there are few works upon the Orchideæ to compare with this, certainly none at all comparable to it has ever been attempted in a colony. Its only rivals are the magnificent orchideous plates in Blume's "Rumphia," and in his still more beautiful "Orchideæ of the Indian Archipelago." On the other hand, in respect of descriptive matter the works of these two authors widely differ. Blume had to deal with a host of previously unanalysed and unnamed generic and specific forms, which he classified and described in a truly masterly manner, and his works are hence almost purely systematic. The materials for the "Australian Orchids" had been for the most part classified by Brown in the "Prodromus Flora Novæ Hollandiæ," with a skill equal to that subsequently displayed by Blume in respect of the Indian ones, and Mr. Fitzgerald has therefore rightly devoted his descriptive matter chiefly to the "life-history" of the species. As a specimen of this we may quote his observations on *Prasophyllum fimbriatum*:—

"This little flower presents another of the anomalies

frequent in the family. So constantly does the labellum appear to act as a resting-place for insects, that in trying to trace the probable manner in which they fertilise a species, you naturally look upon it as the platform of the operator; but in this case, should a tiny insect alight upon one of the lips which hang trembling from the flowers, it would meet with a projection resembling the column and in the same position usually occupied by it, but without anther or stigma, being in fact nothing more than the hinge from which the fringed lip depends. This baffling is caused by the flowers being inverted, and the dropping of the labellum in front of them. Such modifications as this are useful in checking the natural tendency to assume that a certain part of a flower is designed to act in a certain way simply because through a long series we find it performing that function, and to show us how a slight change may alter all the results. Here the labellum bars access from the ordinary direction; the lower sepal incloses the column from below; the petals and wings of the column intercept access from the sides, and a prolongation of the anther obstructs it from the end; so that a very small space is left open beneath the labellum in what would appear to be the least likely place for an insect to approach, though from the conformation of the column the intervention of insects seems to be a necessity. After a very careful examination, I came to the conclusion that the most probable method in which this interesting little orchid becomes impregnated is by a very minute insect alighting on the under surface of the labellum and following it up into the flower, the lip giving way to its pressure upwards (by being lifted on the hinge) should the visitor be slightly too large. Would not the chances of the reproduction of this species be improved by the removal of the labellum? This, then, is another instance of a part of a flower, generally of importance, becoming of very doubtful advantage, if not actually detrimental."

Hitherto Mr. Fitzgerald's studies have been confined to the orchids of Eastern Australia, but it is most earnestly to be desired that they will be extended to the southern and western species, as indeed the title of his work implies will be the case.

LETTERS TO THE EDITOR

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

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Ice-Crystals

SINCE the publication of the Duke of Argyll's first communication on "Ice-Crystals" (NATURE, vol. xxi. p. 274), I have been expecting that some of the physicists who have noticed similar phenomena would have looked up the *literature* of the subject.

About thirty years ago I made this class of phenomena the subject of a somewhat careful investigation, and published the results of my researches in the *Proc. Am. Assoc. for Adv. of Sci.*, third meeting, March, 1850, vol. iii. pp. 20-34; also in the *Phil. Mag.*, 3rd series, vol. xxxvi. pp. 329-342, May, 1850. The *former article* is illustrated by several engravings representing the appearances presented by the "exudation of ice" from the foot-stalks of the *Pluchea*. I think that my investigations show that the phenomenon in *plants* is purely *physical*, having no connection with the *vitality* of the stems; and that it is due to the *same cause* as the "protrusion of icy columns" from the ground in frosty weather.

In relation to the *explanation* of the phenomena, I have nothing to add to that given in the above-mentioned paper, except in relation to *two points*, viz. (1), that I did not sufficiently *emphasise* the importance of the fact that the water contained in the *capillary* tubes in the upper stratum of earth is cooled many degrees *below* the freezing temperature; and (2) that, consequently, the congelation would necessarily take place *paroxysmally*.

JOHN LE CONTE

Berkeley, California, April 27

Anchor-Ice

MY remarks on anchor-ice, published in NATURE, vol. xxi. p. 538, have called forth several letters to myself, in addition to the articles on this subject by Mr. Allan Macdougall and C. F. C. respectively, which have a place in vol. xxi. p. 612 and vol. xxii. p. 31 of your journal. I am happy to find that C. F. C. agrees generally with my views, but I regret to have to differ from him when he says that "the original (ice) crystals, if not *heavier than water*, are at least as heavy." Were this supposition true, anchor-ice might as readily form in one part of a stream as in another, and would not require the conditions which I believe to be necessary. These minute crystals have never been seen by me "distributed" pretty evenly throughout the body of water at rest, nor even where there was a smooth, slow, steady current, which would be the case if the specific gravity of the crystal and water were alike.

C. F. C. is right in saying that this ice resembles manufactured "water ices"; it is never, as far as I know, transparent. It also looks like salt-water-ice.

Mr. Macdougall tells us of anchor-ice in Georgian Bay. This at first sight would appear to be incompatible or at variance with my belief in the necessity of a "comparatively swifter current" being essential for this formation, but to those who are familiar with the large lakes of America, the apparent contradiction seems not difficult of explanation.

At Great Bear Lake inexplicable currents of several miles an hour, sometimes running against the wind, are found in many of the narrow and shallow channels separating islands from the shore, making agitation sufficient to disturb the equilibrium of the floating ice-crystals and surface cold water. The same condition of things doubtless obtains in the Georgian Bay, which is the most easterly portion of the extensive and irregularly-shaped Lake Huron.

One remark of Mr. Macdougall's, to the effect that "the anchor-ice in the great northern lakes *floats* at a considerable depth under the surface of the water, and that it seemed to be floating at various depths in water fourteen feet deep," is curious. One way of accounting for this peculiarity may be that when the air becomes detached from the bottom, it not improbably brings up with it stones or gravel; soon afterwards a part of the ice gets separated, thus diminishing the floating-power, until the specific gravity of the compound mass exactly equals that of water, in which condition it might, of course, be found "swimming" at any depth below the surface.

Mr. Macdougall asks, "Does the (anchor) ice form by action of the intense cold of the ground (meaning, I presume, the bottom of the lake or stream), favouring the formation of rasee?"

I do not think that as a rule the coldness of the ground has anything to do with this formation, except in so far as this coldness of the ground, *i.e.*, the stony bottom, is caused by contact with the ice-cold water and ice-crystals, as already mentioned. "Intense coldness" of the ground at the bottom of the middle of a stream can scarcely be caused by abstraction of caloric, through its connection with the supposed colder land on shore, which is usually covered and protected by snow from cold in early winter; also, were this the cause, or one of the causes, the part of the river nearest the shore would first show anchor-ice, which is not the case.

At Repulse Bay flooding of some of the rapids of North Pole River took place when the ice was forming. This we know could not be caused by a greater flow of water, as the lakes supplying the river and all the rivulets running into them were already firmly ice-bound.

These overflows were caused by barriers of anchor-ice, which dammed the water up to the height of two or three feet, until the pressure became so great as to force a passage through the soft but tenacious mass, the portion of which that remained unbroken being now, by the running off of the water, brought into contact with the cold air, soon became frozen hard and solid.

J. RAE

4, Addison Gardens, W., May 15

"Sarsens"

I SUPPOSE it is in the order of things that utility should be a prime consideration, but still one cannot but regret the wholesale destruction which is overtaking the picturesque stones which have given its name to the "Valley of Grey Wethers," near Marlborough.

This destruction has been going on for some years, as is witnessed by the cottages in the neighbourhood built of "sarsen," but has of late been vastly increased by the demand for this strong stone for the bridges on the railway now making between Swindon and Marlborough. Nearly all the large blocks have indeed already disappeared.

So far no attack has been made on the fine cromlech of the "Devil's Den," which lies at the foot of the valley. It has had a narrow escape before, for a weather-beaten shepherd told me some years back that he "minded" how when he was a boy the farmer there got all the horses and oxen and tackle he could in the parish and laid on to the capstone, and "they drawed 'un and drawed 'un, but *it warn't to be moved*."

The geological interest in these rugged stones is considerable. They are found, more or less, all over the chalk range, but always as scattered or isolated blocks. The temple at Avebury was constructed of monoliths of this stone, so is most part of Stonehenge. The cromlechs of "Kit's Cotty" and "Wayland Smith's Cave" are formed of it, and its curious mode of weathering is well shown by the "blowing stone" under Uffington Camp. There is hardly a village amongst the chalk hills in which a mass of this rugged stone may not be seen, but nowhere is it found in anything like the abundance which has characterised the "Valley of Grey Wethers."

It is, I believe, the generally-accepted view that these "sarsens" are the indurated remains of a tertiary stratum of sand with which the chalk was once overlaid. Perhaps some of your readers can inform me where these stones can be seen in their native sand. The circumstance of the fracture of some of the "grey wethers" near Marlborough disclosing imbedded in them what look to me like chalk flints possibly points to an earlier origin for them.

A. G. RENSHAW

May 19

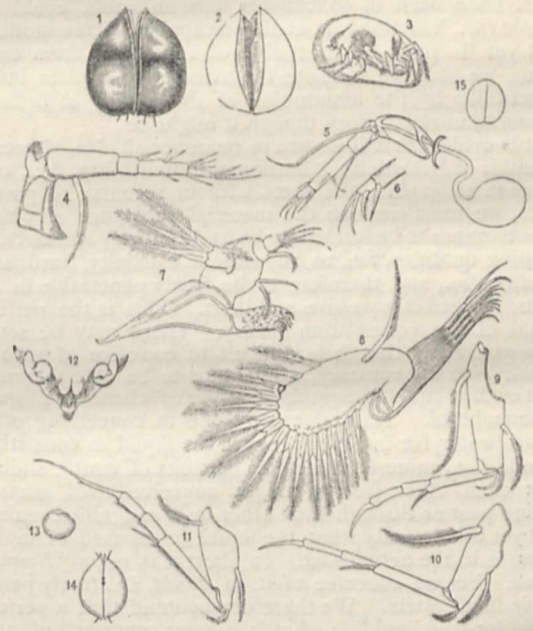
AN ENTOMOSTRACON LIVING IN TREE-TOPS

IT is not to be wondered at that the moist and shady hiding-places between the leaves of the Bromeliads, filled as they are by food of various descriptions, should be occupied by all sorts of animals, and that some of these should have chosen them as their favourite abodes and should have exclusively deposited their eggs in them. And indeed, according to Fritz Müller's friend, Friedenreich, almost all the coleoptera peculiar to the Bromeliads have been for the last thirty years found by him exclusively in such places, and the same is probably true of the larvæ of very many species of insects, and for the tadpoles of the tree-frogs, which undergo their metamorphoses therein.

But for all this it is, as Fritz Müller, writing from Itajahy, November, 1879, says, a very astonishing thing that there should be found living among the aquatic animals in the tops of the woods a little crustacean whose relations one is accustomed to find among the sea-weeds. It is about one millimetre long, and is of the family of the Cytheridæ.

Of the two cosmopolitan genera, each rich in species, Cypris and Cythere, into which the untiring investigator of the salt and fresh waters of Denmark, Otto Friedrich Müller, divided the bivalved crustacea, those of the first (Cypris) live almost entirely in fresh, and those of the second (Cythere) almost entirely in salt, water. Only a very few isolated exceptions to this rule have as yet come to light, and in the Brazils Fritz Müller only knows Cythere as having marine species, while those of Cypris are from fresh water; and never would he have expected to meet with, on the trees of his wood at Itajahy, an old Baltic acquaintance which he erewhile had collected when wading bare-footed with Max Schultze in Greiswalder Bay. At the first glance he did not recognise the Cythere of the Bromeliads as a relation of its recent marine cousins, because it differed a good deal in the shape of its bivalved shell from all known species of Cythere, and even from all known Entomostraca. These generally possess laterally-compressed valves, which are broader than they are long, and are commonly bean-shaped. In the Bromeliad-lodger the length of the valves is a good deal more than the breadth, and, in addition, the ventral surface is flattened, and has a longitudinal furrow, reminding one of a coffee-bean. In consequence of this, when this new form is out of the water, instead of falling on its side as the others would do, it falls upon its back, or upon its ventral surface. This is probably an adaptation to its place of abode. In the sea the species of Cythere climb up on the narrow filaments of the algæ; and in the Bromeliads they must move about on the flat surfaces of adjacent leaves.

While no recent entomostracon was known to Fritz Müller which this new form resembles, he was at once reminded of a species (*Elpe pinguis*) which occurs as one of the oldest fossil Cytheridæ, and which Barrande described from the Silurian strata of Bohemia. This the Bromeliad form very closely resembles, but it is just five times as small. Fritz Müller describes this new form as *Elpidium bromeliarum*, for though it possesses no very marked peculiarities in its feet, still it does not fit into even any of the genera into which the old genus Cythere has been of late subdivided.



Elpidium Bromeliarum, Fr. Müller. 1, dorsal aspect; 2, ventral aspect; 3, side view, right valve removed; 4, anterior antenna; 5, 6, posterior antenna of male and of female; 7, mandible; 8, maxilla; 9, 10, 11, feet, of 1st, 2nd, and 3rd pairs; 12, last body segments; 13 and 14, egg and young, from the parent valves; 15, *Elpe pinguis*, Barr. Magnified 1 to 3 = 10 : 1; 4 to 12 = 71 : 1; and 13 and 14 = 36 : 1.

Everywhere that Fritz Müller has looked for this new form, from the sea-side to some hundred kilometres into the interior, he has found it common in the tree-frequenting Bromeliads of the primæval woods. As it cannot, like some other of the animals inhabiting such places, wander from tree to tree, or even from one plant of Bromelia to another, its distribution must be affected by beetles (Agabus, Laccophilus, Hister, &c.), or some other of the Bromelia investing forms. The young Elpidia, when they leave their mother, are only 0·2 mill. long, and doubtless they cling to some of the flying insects, and so are transported. As, however, the colonisation of the Bromeliads is thus seemingly entirely left to chance, it

is the more astonishing that these little crustacea are found in almost every Bromeliad.

It cannot but sometimes happen that a few specimens must be washed away into other waters, as on the contrary, one may sometimes meet with a stray entrapped Cyclops that has slipped into the Bromeliads. Yet Fritz Müller has hitherto searched in vain for Elpidium in running waters, which produce, among other species, Cypris, Cyclops, Canthocamptus, Chydorus, Alona, Camptocercus, Pasithea, Moina, Ceriodaphnia, Simocephalus, &c. It seems not to flourish outside the Bromeliads.

[Translated from *Kosmos*, February, 1880. *Elpidium* comes somewhat near to *Elpidia*, Theel.—E. P. W.]

ON THE PHYSICAL ASPECTS OF THE VORTEX-ATOM THEORY

IN all attempts to arrive at a satisfactory conception of the ultimate constitution of matter, the grand difficulty has hitherto been to reconcile the proved indestructibility of the atom with its capacity for executing vibrations, as demonstrated by the spectroscope. The ancients, by assuming the atom to be *infinitely hard*, attempted in this way to get over the difficulty of indestructibility (or indivisibility), but thereby debarred all means of conceiving the "*elasticity*" of atoms, or their known powers of taking up vibrations of different periods.

When we consider the immense difficulty that there must have been in conceiving how an atom could be elastic (*i.e.*, how its parts could be capable of free motion) and yet its parts be incapable of separation from each other, we may well excuse the attempt to explain indestructibility by the assumption of the quality of *infinite hardness*, unsatisfactory though it might be.

It is evident that if we are to renounce all idea of occult qualities of "elasticity," hardness, indivisibility, &c., and purpose to explain the facts without recourse to postulates, we must assume the material substance of which our atoms are to be formed, to be itself entirely without any positive qualities, *i.e.*, to be without elasticity, hardness, rigidity, &c., and therefore to be freely penetrable in all parts, or perfectly passive and inert. This is the perfect liquid of the vortex-atom theory. There may be some who would say that it is difficult to conceive of such a liquid. On the contrary, we venture to be able to prove that such a liquid *always is conceived of* whenever a liquid is thought of. Thus, does any one in conceiving of a liquid (water, for instance), regard the liquid as consisting of solid (*i.e.*, more or less rigid) portions of matter sliding over each other [as we might conceive solid masses sliding past or through each other on a magnified scale]; and yet this is truly what the liquid (composed of molecules) is in the actual fact. In short it is not a "*liquid*" at all. Yet we conceive of it as *liquid, i.e.*, freely penetrable in all parts. We therefore contend that a perfect liquid (or true liquid) is what is *always* conceived of, and therefore that there can be no difficulty in regard to the conception of the true liquid that forms the basis of the vortex-atom theory.

In the next place, it is an obvious condition to any consistent conception of matter that matter must possess *extension*,[1] or occupy space, *i.e.*, so that two portions of our liquid cannot occupy the same space at the same time. If, therefore, the liquid fills all space, it must be incompressible. This is, therefore, not an arbitrary postulate.

The next question naturally suggesting itself would be, how are portions of such a liquid to attain the properties that we recognise in atoms? We venture to think it will be conceded as evident that the only *conceivable* way (if it be admitted that the result is attainable at all) is through *motion* [for this is the only conceivable way in which the liquid can be affected]. The further inquiry would therefore be, what would be the *character* of this motion? Now, in order to fulfil the condition that the atom itself can be brought to rest without losing its properties as an atom, it is evident that the motion of the material forming it must take place in such a way that the atom can remain in one spot, or be to our senses at rest, *i.e.*, the material of the atom, although in motion, must not deviate from one spot. We ask if there is any other *conceivable* form of motion than *rotary* motion that would fulfil this condition? Hence the necessity for looking to *rotary* motion as the basis of the properties of the atom. In the next place a portion of material in rotation must rotate about an *axis*. If the ends of this axis were exposed, we should have two points *at rest*, which would forfeit the condition of *motion* being the essential basis of the external qualities of our atom. The question is, therefore, how is a portion of material to be in rotation about an axis, and yet not expose the ends of the axis? The only *conceivable* answer (as we think will be admitted) is that the rotating portion of material must have the form of a closed ring, or complete circuit, so that the axis has no ends. We therefore think it may be said beforehand that conceding that the problem of the atom can be solved at all (or if it be conceded that a fact can exist solely in virtue of the explanation that underlies it) then the problem could only *conceivably* be solved under the fundamental conditions above developed, *i.e.*, under the condition of a portion of material (having no positive properties in itself) *rotating* in the form of a *closed circuit*.

This (as is well known) is what has been found to satisfy the conditions for the atom by the application of mathematical analysis (without, apparently, that object having been in view at all), and in a manner the most remarkable in its completeness. It appears possible, in view of the above considerations, that a profound and competent thinker who had devoted himself to the subject might have arrived, even before the mathematical analysis had been applied, at the *sole conceivable* physical conditions that in principle could satisfy the problem of the atom (admitting the *existence* of the solution); but the mathematical analysis can of course alone make the fact of the solution apparent to us. It is related in the article on "The Atomic Theory of Lucretius" (*North British Review*, March, 1868) that Hobbes had arrived at the fundamental idea that the *rotation* of a portion of material must be the basis to the solution of the problem of the "elasticity" of the atom, without having applied any mathematics.

The difficulty of the mathematical side of the vortex-atom theory is curiously contrasted with the simplicity of the physical side of the theory. If we suppose a cylindrical bar of india-rubber to be rotated about its longitudinal axis, and the bar (still rotating) to be bent round into a ring shape and the ends joined (the rotation of the material of the ring being always continued), then this may serve to illustrate in a simple way the motion of the material forming the vortex-atom. It is here apparent that the material of the india-rubber ring (in our illustrative case) may be in rapid motion while the ring itself preserves a fixed position in space. It would seem to be a pity if a spurious mystery should be allowed to envelope this subject, which is unworthy of it, in view of the simplicity of its physical basis. No one doubts the difficulties that had to be surmounted on the mathematical side of the theory, but there is all the more reason on that account that the extreme simplicity of the physical side of the theory should be duly appreciated, and unnecessary obstacles not be thrown in the way of its adoption. The tendency to invest physical subjects with a halo of the occult [possibly partly attributable to the unfortunate introduction into physical science of the spiritualistic conception of "*force*"—in the sense of an action across space without the intervention of matter] has probably done more to hinder progress than any real difficulties.

[1] The quality of extension may even be regarded as included in the definition of matter.

We shall simply state the facts of the mathematical analysis here, our business being more particularly with the physical side of the theory. First it is shown by incontrovertible mathematical proof that a portion of material having the motion above described possesses all the qualities of a *solid*. It is at the same time "*elastic*," or capable of changes of form when acted on through impact by other atoms—always tending to return to its symmetrical form when removed from constraint. It is, moreover, proved to be competent to execute vibrations of definite periods which it is the function of the spectroscope to measure. The atom thus constituted is demonstrated to be incapable of being divided or severed by the collisions of other similar atoms against it, and *since this is the sole means of acting upon it*, the long-standing riddle of indestructibility is thus simply solved, without the necessity for any postulate of *infinite* hardness. As the degree of hardness merely depends on the velocity of rotation of the material, it follows that the vortex-atom may possess any degree of hardness. Indeed, if we imagine the atom to be magnified up to visible scale, it might be conceived to be harder or more rigid than a ring of steel of the same dimensions, since the hardness of steel is limited by the resistance of the component atoms to displacement.

The centrifugal tendency of the rotating material of the vortex-atom is controlled by the exterior incompressible liquid, and as there is no friction [there being no ultimate solid parts in the rotating liquid to "catch" against the inclosing fluid walls], the rotating portion therefore glides smoothly over the incompressible liquid that surrounds it like a pipe. Indeed, if we leave out of our conceptions the portion of rotating liquid, then the surrounding liquid actually forms a complete pipe in the form of a closed ring. If the liquid in the pipe were to fly out, a temporary void would be formed in it, which is impossible in a liquid that already occupies all space. An idea of the resistance of such a rotating portion of material to bending may be got by attempting to deflect a gyroscope or spinning-top.

In the old idea of *infinitely* hard atoms there were difficulties in forming a satisfactory conception of what took place at the collision of two such atoms or how the rebound could effect itself (consistently with the conservation of energy). The following difficulty may also be mentioned :—Since two such atoms are supposed to be absolutely hard or unyielding, the area of contact at the collision would necessarily be merely a mathematical point. Now the intensity of a given pressure on a surface is inversely as its area ; and accordingly, since the area is here a mathematical point (or infinitely small), the pressure attendant on the collision of the two atoms would require to be *infinitely* great. It may be a fair question how even an *infinitely* hard atom is to withstand the disintegrating influence of an *infinite* pressure.[1]

In the case of the vortex-atoms they yield somewhat at collision (without change of volume, of course), whereby the encounter takes place over a surface (not a point) ; and they rebound in virtue of their elasticity, due to the motion of the material forming them.[2]

There would seem to be a view to a certain extent prevalent that the vortex-atom theory essentially alters the basis of the old-established ideas of solid indestructible atoms surrounded by space in which they can freely move, to which so many have accustomed their conceptions, and worked upon to the successful discovery of new facts, and which ideas, therefore, they might be reluctant to abandon. This step, however, is not required at all. The main purpose of the vortex-atom theory is to explain the "*elasticity*" of atoms, retaining substantially everything else appertaining to the old atomic theories, merely removing the unsatisfactory postulate of *infinite* hardness. For since the perfect liquid (outside the portions of it that form the atoms) opposes no resistance whatever to the passage of the atoms through it, or it is impossible to act on the exterior liquid, it is therefore in this respect as if a void existed outside the atoms. It is desirable, however, to note that the vortex-atom theory involves essentially the *existence* of the liquid outside the atoms, which performs important functions, but since this exterior liquid is proved to be incapable of appealing to our senses in any way, it therefore *in that respect* may be said to play the part of a void. The exterior liquid of the vortex-atom theory corresponds to the void space of the theory of Lucretius. With the above qualification, therefore, it may be allowable, when we are not specially dealing with the problem of the constitution of the atom itself, to leave out of our conceptions the presence of the exterior liquid: that which we call "matter" being the atoms, and not the exterior liquid. In all practical problems of physics, therefore (apart from the problem of the constitution of the atom), we may properly regard the atoms simply as *elastic* indestructible solids moving freely in space. Moreover, since the motion of rotation of the material of the atom is incapable of transference, and cannot appeal to our senses, and this motion does not in any way alter the position of the atom in space [but it is exactly as if the atom *itself* were at rest] ; we can therefore, if we like, leave this rotatory motion out of our conceptions, merely keeping in view the result produced by the rotation, viz., the sharply-defined elastic indestructible solid thereby formed. The function of the modern theory is accordingly not to destroy the atomic theory of the ancients, but rather to support it, by explaining *how* such indestructible bodies can exist, without recourse to the unacceptable postulate of *infinite* hardness. This old theory of the atomic constitution of matter was really too firmly grounded on reason and observation, as that one should suppose that its very foundations could be shaken.

Broadly and generally, therefore, in practical problems of physics, the essential points to recognise are that atoms—or molecules—are elastic indestructible bodies, capable of rebounding from each other without loss of energy, and of executing vibrations of fixed periods. The existence of this *elasticity* is a fact so definitely proved by the spectroscope, which actually measures the *number* of vibrations executed per second by molecules, that it would become a question to *explain* this fact, even if the vortex-atom theory had not been proved to be capable of affording a complete explanation of it. Indeed, not only is the theory *capable* of doing this, but the vibrating capacity possessed by molecules is shown to be a *necessary* consequence of the theory, so that, therefore, the fact might even have been deduced *à priori*. Considering how enormously difficult it appeared to account for this fact at one time, or how impossible it seemed to reconcile the mobility of the parts of a molecule with the inseparability of these parts by the most energetic collisions, and how an explanation of this fact was at one time sought after, it would appear not too much to expect that those who hesitate to accept the explanation given by the vortex-atom theory, should endeavour to define for themselves wherein their grounds of objection lie. For if the explanation of a fact be admitted to be substantially complete, it would be at least unreasonable to look for more. The question might also suggest itself as a fitting one to any impartial inquirer, whether any other solution to the problem of the constitution of the atom is in principle *conceivable*, or whether [as in the case of many other physical problems, the constitution of the ether, for instance] but *one* solution is conceivable (or we have no choice at all). It cannot be said at least that the theory of vortex-atoms, or its physical side, is not *simple*, dealing

[1] The fact of two such infinitely hard atoms being stopped in an infinitely short space at collision [for there is by hypothesis no *gradual* yielding] would by itself entail an infinite pressure *in addition* to the infinite pressure due to touching at a mathematical point.

[2] The rebound of vortex-atoms may be illustrated (as is known) roughly by the rebound of two smoke-rings from each other, or by the rebound of vortex rings in an ordinary (imperfect) liquid.

as it does with the mere *rotation* of a portion of matter.[1] It is so far recognised that simplicity of the means to the end is a general characteristic of nature. No doubt there may be difficulties in the mathematical development of the subject; but if an atom be once proved to be elastic and indestructible, that fact surely goes very far to supply all we want for the practical applications of the theory. Of course there may be some refinements that may present great mathematical difficulties. For instance, Prof. Tait in his work, "Lectures on some Recent Advances in Physical Science," mentions a case where a vortex-ring is supposed to come into collision with another in such a way that the motion is not symmetrical in relation to the axis, and it is cited as an almost insurmountable difficulty to find what exactly takes place (in regard to particular vibrations or rotations developed, possibly). But one might ask, is it necessary to know this for practical problems of physics? We may know broadly that vibration or rotation is developed, and if so (apart from the abstract interest of the question), do we want to know precise quantitative details for practical purposes? It might for example be extremely difficult to determine mathematically the exact deformation or changes of form (vibrations, &c.) that a steel ring underwent when thrown against the hard surface of an anvil; but the practical question is, do we want to be acquainted with this for any ordinary problem that might occur, or in order to appreciate the general principles of impact, for instance? So in the case of vortex-atoms, no doubt many instances might be cited when it would be difficult to ascertain precise results, but the practical question is, Does this prevent our applying the theory to ordinary physical problems,[2] or to dynamical phenomena involving questions of principle? For possibly it may not be necessary to know the exact vibrations developed at a collision (for instance), provided we recognise the fundamental point that energy is conserved, and that the atoms can rebound from each other like perfectly elastic solids. It would be a pity if the mere *difficulty* of arriving at precise mathematical results of a refined character, should be mistaken by some for *mystery*, or it would be a thing to be regretted if there should be any tendency to throw a veil of the "occult" over what in its *physical basis* (at least) is very simple, this procedure only hindering progress and rendering a closed book what might be a most interesting branch of mechanics.

The investigations regarding the perfect liquid have already (as is known) thrown some important light on the important practical question of the resistance of ships. Mr. Froude has especially devoted himself to these inquiries. The old idea that a ship (or more correctly a totally immersed body, such as a fish) encountered a mysterious resistance in addition to the mere friction of the molecules of water on its sides, is now known to have been a pure delusion. If it were not for the fact that the water consisted of molecules or ultimate rigid parts which are caught and put in motion by the rough sides of the ship, there would be demonstrably no resistance at all. Hence the absence of resistance in a true liquid (which is not formed of ultimate rigid parts or molecules). If the molecules or ultimate rigid parts of which an ordinary "liquid" consists, were to be liquefied, a being immersed in it would (if conscious) imagine he was surrounded by empty space.

The late Prof. Clerk Maxwell in a review of the theory of vortex-atoms in the "Encyclopædia Britannica" for 1875, under the word "*Atom*," makes the following remark on the theory:—

"But the greatest recommendation of this theory from a philosophical point of view, is that its success in explaining phenomena does not depend on the ingenuity with which its contrivers 'save appearances' by introducing first one hypothetical force and then another. When the vortex-atom is once set in motion, all its properties are absolutely fixed and determined by the laws of motion of the primitive fluid, which are fully expressed in the fundamental equations. The disciple of Lucretius may cut and carve his solid atoms in the hope of getting them to combine into worlds; the follower of Boscovich may imagine new laws of force to meet the requirements of each new phenomenon; but he who dares to plant his feet in the path opened out by Helmholtz and Thomson has no such resources. His primitive fluid has no other properties than inertia, invariable density, and perfect mobility, and the method by which the motion of this fluid is to be traced is pure mathematical analysis. The difficulties of this method are enormous, but the glory of surmounting them would be unique" [p. 45].

Much misapprehension would seem to exist in regard to the physical side of the theory, especially in Germany,[1] where the mathematical investigations out of which it sprung, had their origin. Some appear to be unable to conceive how motion should take place in a material substance continuously filling space, losing sight of the fact that the liquid outside the atoms plays the part of a void (in so far as it cannot appeal to our senses)—or it is only the atoms that affect our perceptions. Others fail totally to appreciate the simplicity of the physical side of the theory, and seem to think it involves arbitrary postulates, whereas the main peculiarity of the theory is its freedom from positive assumptions, inasmuch as the theory evolves all the properties of matter out of the *motion* of a material substance, which without this motion has no positive qualities at all, and could not appeal to our senses. The fact seems to be overlooked that if we renounce the occult quality of *rigidity* in the atom, we have no other resource than a *liquid* (*i.e.*, a substance without rigidity). Much of the misunderstanding on the subject may no doubt be due to the scarcity of the literature relating to it, and the extreme brevity and absence of detail or attempt to assist the conceptions regarding the physical side of the theory. This want the author himself has much felt, and having been at considerable trouble to render clear his own conceptions as far as he could, he has thought that the result of this analysis might not perhaps be unacceptable in the form of a paper on the *physical aspects* of the theory.[2] For there are no doubt

[1] It would seem to be thought by some that the primary *ring* form of the vortex-atom involves something complicated in it. I venture to think that this is only one of those first impressions, which will disappear on reflecting on the subject. First, many facts strongly indicate that matter possesses a more or less *open* structure (or is highly porous). These ring-molecules would give matter an open structure. It would seem also independently probable that a molecule should have no more material in it than is essential to give it a certain amount of *extension*, or to make it occupy a certain range of space. Why should we suppose that waste or apparent superfluity of material in a molecule that a solid structure throughout would involve? Does not this violate one of the fundamental principles of large scale architecture, where superfluity of material is recognised as one of the worst faults, and mechanical principles are admittedly independent of scale? The *ring* shape for the atom is evidently the simplest elementary form to satisfy the condition for the maximum of *extension* combined with the minimum waste or expenditure of material. In view of these considerations, the ring-shape, the primary form required by the vortex-atom theory, may seem in itself independently probable. Indeed, it seems a remarkable fact that the main conditions inevitably led up to by this theory by a rigid mathematical process, are precisely those that independent observations support, (1) the *indestructibility* of the atom, illustrated by chemistry and numerous facts, (2) the *elasticity* of the atom, proved by the spectroscope, (3) the *open* structure of the atom, in harmony with the transparency of some bodies to light, the free passage of the magnetic disturbance through all bodies, and numerous other facts—not to mention the physical theory of gravity. In short, it would appear that it would be necessary to infer the *existence* of indestructible elastic atoms of open structure, even if the vortex atom theory (which *explains* this fact) had not been invented.

[2] The writer himself has seen from German comments on Prof. Tait's work, that the passage above referred to [German translation] has been regarded by some as if the difficulty there mentioned were of such a nature as to prevent the practical adoption of the theory.

[1] The writer has had personal experience of this, partly through correspondence, and partly through the literature relating to the subject. Quotations from the writings of Prof. Zöllner especially seem to show a want of appreciation of the *physical* points of the theory at their true value and significance.

[2] As regards sources of information as to the vortex-atom theory, the following may be mentioned. Sir William Thomson, "On Vortex-Atoms," *Phil. Mag.*, July, 1867. Prof. Clerk-Maxwell, article "Atom," *Encyc. Brit.* 1875. The theory is dealt with to some extent in a popular manner in

many investigators in the paths of natural science who may find some difficulty in realising the physical basis and real bearings of the theory, and who nevertheless take a rational interest in the solution it is capable of affording to some of the greatest difficulties of molecular physics. The whole structure of physics may be said to rest upon a *molecular* basis, and therefore the importance of a right view of this basis cannot be over-estimated. The old theory of *perfectly rigid* molecules put an immense difficulty in the way of the development of physical results upon such a groundwork. A theory of *elastic* molecules therefore becomes of the utmost importance as a practical working hypothesis, and the accordance with observation of new results predicted from this hypothesis as a basis, will then form additional confirming illustrations of its truth. The removal of any misunderstandings that might be obstacles in the way of the use of the vortex-atom theory as a working hypothesis becomes, therefore, a point of considerable importance. Those more especially who have handled the spectroscope and viewed the exquisite precision of its results, become impressed with the *certainty* of the groundwork upon which their molecular studies are based, and no less imbued with the conviction of the existence of that *explanation* that forms the basis of the facts that are recorded with such unfailing accuracy.

S. TOLVER PRESTON

COMPARATIVE ANATOMY OF MAN[1]

I.

THE great scope and interest of the subject of anthropology, as well as its most convenient subdivisions, are well illustrated by the prospectus of the teaching at the Anthropological Institute of Paris. There are at present six chairs :—(1) Comparative Anatomy in Relation to Anthropology, by Broca; (2) Biological Anthropology, or the Application of Anatomy and Physiology to Anthropology, by Topinard ; (3) Ethnology, or the Study of the Races of Man, by Dally ; (4) Linguistic Anthropology, by Hovelacque ; (5) Palæontological and Prehistoric Anthropology, by Mortillet ; and (6) Demography, which includes what we commonly call social and vital statistics and Medical Anthropology, by Bertillon. These subjects are publicly taught in a school supplied with all necessary appliances, founded partly by private munificence, but also liberally subsidised by the Municipality of Paris and the Department of the Seine. There is also at Paris a complete course of general anthropology given yearly by M. de Quatrefages in connection with the magnificent museum at the Jardin des Plantes. To these institutions we have nothing comparable in England, and neither at our Universities or elsewhere is any branch of anthropological science systematically taught. The present lectures only embrace a small portion of one of the six subdivisions enumerated above, that of biological anthropology. This science is purely one of observation, and in proportion as the materials upon which our observations are founded are multiplied, so will the value of the observations be increased. These materials are collected in museums, which at present in this country are not so complete as might be desired. The largest public collection is that of the College of Surgeons, containing about 1,200 crania of different races ; the largest private collection is that of Dr. Barnard Davis, of Shelton in Staffordshire, considerably exceeding that of the College both in number and variety of specimens. Happily these are about to be united, and, under the care of the Council of the College, will be made accessible to all who wish to pursue the study of anatomical anthropology. Besides the Barnard Davis collection, only a small portion of which has as yet been received, one of the most important additions to the museum since the last course of lectures is a series of skulls collected in the Fiji Islands in 1876 by Baron Anatole von Hügel, forming part of a donation made by Mr. Erasmus Wilson. They consist of sixteen crania of the *Kai Colos*, or mountaineers of the interior of the western portion of Viti Levu, and five crania from the eastern coast and small islands adjacent. The inhabitants of the Fiji group are generally described by ethnologists as a mixed race, compounded of Melanesians and of brown Polynesians, as the islands are situated on the confines of the territories inhabited mainly by these two races, and the few crania hitherto accessible have favoured this view. Those, however, of the Kai Colos brought home by Baron von Hügel, and which probably represent the most primitive native population of the islands, show all the characters of the purest Melanesian type, without the slightest trace of Polynesian mixture. Their purity is shown by their wonderful similarity, and by their very peculiar and strongly-marked characters, discernible with equal facility in both sexes and at all ages. They are large, the average capacity of eight adult males being 1,482 cubic centimetres; and with muscular ridges and impressions strongly developed. In proportion to their length, they are the narrowest crania known, having an average latitudinal index of only 66·3. Not one has the index so high as 70·0, and in one it descends as low as 61·9, which is below that of any other normal skull in the collection. The height in all very considerably exceeds the breadth, the average altitudinal index being 74·1. They thus belong to the most strongly marked *hypsistenocephalic* type. The zygomatic arches are very wide compared with the cranium. The brow ridges are strongly marked, though less so than in the Australians. The orbits are low and quadrangular, the nasal bones short, though rather prominent, and the nasal aperture wide (index 57·1), the jaws prognathous, though not to an extreme degree, and the teeth large. The skeleton of the face thus conforms with what is generally found in the Melanesians or Oceanic negroes, but the features are on a larger scale and more strongly pronounced than in the inhabitants of many of the New Hebridean and Papuan islands. The skull of the Tongans and Samoans, living on islands scarcely 300 miles from the Fijis, presents the greatest possible contrast to that just described. It is short and round (latitudinal index 82·6), the orbits are round, the nasal bones long and flat, and the aperture narrow (index 44·3), and the jaws are not prognathous. It is well known that for a long time the Tongans have been in the habit of visiting the Fijis, especially the smaller islands to the east of the group, and that there is in the inhabitants of that region a considerable infusion of Tongan blood. Five skulls of natives of the small island of Vanua Balavu, where this influence is supposed to prevail, show a distinct deviation in every character from that of the Kai Colos, and these deviations are, without exception, in the direction of the Tongan or Polynesian type. The average latitudinal index is raised to 71·9; the nasal index is 50·0, the orbits intermediate in form, and the prognathism much reduced. No skulls have as yet been examined from the second large island, Vanua Levu, and the numbers of those just described are, perhaps, not sufficient to draw any great conclusions from, but, as far as they go, they tend to show that, so far from the Fijians generally being a mixed race, the mass of those that inhabit the interior of the large islands are remarkably pure, and of the Melanesian or Papuan type in its most characteristic, almost exaggerated, form, but that the natives of the coast districts and outlying islands to the east show certain tendencies towards the brown Polynesian type, and as these are the people with whom European visitors to the Fijis have mostly come

an article on "The Atomic Theory of Lucretius," *North British Review*, March, 1868, also by Prof. Tait, in his work "Lectures on Some Recent Advances in Physical Science."

[1] Abstract Report of Prof. Flower's lectures at the Royal College of Surgeons, March 1 to March 19, on the Comparative Anatomy of Man.

into contact, an undue impression has been created as to the extent of the mingling of the races. At all events, little countenance is given by these facts to the view, which rests chiefly in the interpretation of some ancient legends, that at a former time the Tongan influence was much greater in the Fiji Islands than it is at present.

Races of America.—Two extreme views have been held as to the unity or diversity of the races of man inhabiting the American continent. It has been said on the one hand that "when you have seen one Indian you have seen all," and on the other, that as much difference can be found in the native Americans, as among the inhabitants of the Old World. Both statements are exaggerations, the truth lying between the two. A source of difficulty in studying the cranial conformation of the Americans lies in the wide-spread practice of deforming the head artificially in infancy. This habit prevailed extensively but not uniformly throughout all the western parts of the continent, from Vancouver's Island down to the southern parts of Peru. It also occurred, though less generally, in the southern part of what is now the United States, and in the West India Islands. It was forbidden to the Peruvians in 1585 by the synod of Lima, and again with severe penalties in 1752. In British Columbia it has only recently fallen into disuse. The custom is, or perhaps we may almost say was, not confined to America. Hippocrates and various other writers of his age, speak of the *Macrocephali*, people who dwelt on the eastern shores of the Black Sea, who purposely altered the form of their children's heads. Skulls thus deformed have been found in ancient tombs in the Caucasus (especially near Tiflis) in the Crimea, and, though less numerously, at various places, along the course of the Danube, and extending as far as the south of France. These have been assigned to Avars, Huns, or Tartars, but more probably belong to the Cimmerians, who originally inhabited the region where they are now found most abundantly, and spread westward over Europe some centuries before the Christian era. The custom, though in a modified degree, is scarcely yet extinct in the south of France. Cranial deformation, though usually only of the simple occipital form, is also practised in many parts of Asia and Polynesia, though quite unknown in Africa or Australia.

Many attempts have been made to classify the various kinds of cranial deformation, but as they pass insensibly into one another, it is not very easy to do so. They may, however, for convenience of description be grouped thus: 1. Simple occipital flattening, often probably undesigned, being occasioned by the pressure of the board or hard pillow upon which the child is laid; this is very common among the ancient Peruvians and also among some Mongol tribes and Polynesians. 2. Simple frontal flattening, also common in Peru, though less so than some of the following forms; also among the Caribs and in the island of Mallicollo, in the new Hebrides. 3. Fronto-occipital flattening, with lateral (compensatory) expansion, usually unsymmetrical. This, which may be depressed or elevated according to the point at which the greatest occipital pressure is applied, is the commonest form among the Indians of British Columbia and Vancouver's Island, and is also met with in Peru. The head is compressed between pads of birch bark and moss from birth to the age of twelve months. During subsequent growth it recovers somewhat from the extremely flattened form that it usually presents at that age. 4. Elongation by lateral as well as frontal and occipital pressure. In this form the head is symmetrical, and the sides compressed. It is produced by bandages passing round the forehead, vertex, and occiput, and is variously modified, according to the mode in which these are disposed. The Aymara Indians of the neighbourhood of Lake Titicaca, in Peru, some of the tribes in Vancouver's Island, and the *Macrocephali* of the shores of the Euxine, present examples of this form.

As far as can be ascertained by observations upon the North American Indians, no impairment of the intellect is produced by these strange alterations of the form of the cranium, and consequently of the brain. The families of the chiefs, in which alone it is practised in many tribes, maintain their ascendancy over the lower orders and slaves with undeformed heads. Foville, however, appears to have traced numerous cerebral lesions among the peasant population of France to the custom of tightly bandaging the heads of infants.

No motive can be alleged for this singular and wide-spread practice, except blind obedience to custom or fashion, precisely as in many analogous cases of barbarous distortions or mutilations of parts of the body, the origin of which is lost in the depths of antiquity. Without looking as far off as China, very few men or women in England can boast of feet which are not quite as much altered by artificial compression in youth from the form given by nature as are the heads of the Chinook Indians. The far more injurious constriction of the waist, so commonly practised by women of nations which occupy the highest rank of civilisation yet attained by mankind, is only another example of the same strange propensity to tamper with a form which good sense as well as good taste ought to teach was the most perfect that could be designed.

The natural history of the population of the great American continent, as it existed before the changes wrought by the European conquest, which followed the adventurous voyage of Columbus, offers an interesting but difficult problem to the anthropologist. Do all the various tribes (1,700 are enumerated by Keane, and these must be but a small portion of those formerly existing), extending from the Polar Sea to Cape Horn, through such various climates, and inhabiting regions so diverse in their physical characters, belong, as many writers have averred, to one primary division of the human species, or are they capable of being divided into groups, having as strongly-pronounced distinctive characters as are to be found among the inhabitants of the old world, as has been stated by others? Again, if we find difficulty in dividing them into well-marked groups, do we find such uniformity of characters as to lead to the belief that they are all of common origin, or have we reason to think that they are the result of the mingling together in various proportions in different districts of two or more distinct sources of population? Furthermore, inquiry will naturally be directed to their relation with other people. Whether we consider them as one or as several people, we shall have to ask with which of the races of other parts of the world are they most nearly allied.

The views till lately held as to the peopling of America, though perhaps under various modifications and disguises, may be grouped under two heads:—(1) That the inhabitants of that continent were a distinct auctothonous or indigenous people, created in the country in which they were found, and therefore not related to those of any other land. This is the theory of the polygenistic school, but is probably not held by many scientific men of the present day. 2. The monogenists mostly believed that they are descended from an Asiatic people, who in comparatively recent times passed into America by way of Behrings Straits, and thence spread gradually over the whole continent, as far as Cape Horn, and that their nearest allies must therefore be looked for in the north-eastern regions of Asia. It has also been thought by those who have held the same general views, that at all events a partial peopling of the American continent may have occurred from Southern Asia, by way of the Polynesian Islands, or from North Africa, across the Atlantic. The discovery of the great antiquity of the human race in America, as well as in the Old World, has led to an

important modification of these theories. The proof of a very considerable antiquity rests upon the high and independent state of civilisation, which had been attained by the Mexicans and Peruvians at the time of the Spanish conquest, and the evidence that that civilisation had been preceded by several other stages of culture, following in succession through a great stretch of time, but the antiquity of the quasi-historical period thus brought out, is entirely thrown into the shade by the evidence now accumulating from various parts of the United States, Central America, and the Pampas, that man existed in those countries, and existed under much the same conditions of life, using precisely similar weapons and tools, as in Europe, during the pleistocene or quaternary geological period, and, perhaps, even further back in time. As in Europe his works are found associated with the remains of *Elephas primigenius*, and other extinct mammals, so in America are they found in contemporary deposits with those of *Elephas columbi*. If the inductions commonly made from these discoveries be accepted, and the fact admitted that men lived both in Europe and America before the surface of the earth had assumed its present geographical conformation, the data from which the problem of the peopling of America is to be solved are altogether changed. Recent palæontological investigations, especially those carried on with such great success in the neighbourhood of the Rocky Mountains, show that an immense number of forms of terrestrial animals that were formerly supposed to be peculiar to the Old World are abundant in the New; indeed many, such as the horses, rhinoceroses, camels, &c., are more numerous in species and varieties in the latter, and therefore the means of land communication between the two must have been very different to what it is now. Taking all circumstances into consideration, it is quite as likely that Asiatic man may have been derived from America, as the reverse, or both may have had their source in a common centre, in some region of the earth now covered with sea.

However this may be, the population of America has been for an immense period practically isolated from the rest of the world, except at the extreme north. Such visits as those of the early Norsemen to the coasts of Greenland, Labrador, and Nova Scotia, or the possible accidental stranding of a canoe containing survivors of a voyage across the Pacific or the Atlantic, can have had no appreciable effect upon the characteristics of the people.

The evidence derived from the study of the physical characters of the Americans shows that there is, considering the vast extent of the country they inhabit, and the great differences of climate and other surrounding conditions, a remarkable similarity in essential characters, with, at the same time much diversity in detail, and in other characters which perhaps are not of such primary importance as has often been thought. The construction of the numerous American languages, of which as many as 1,200 have been distinguished, is said to point to unity of origin, as, though widely different in many respects, they are all, or nearly all, constructed on the same general grammatical principle, that called *polysynthesis*, which differs from that of the languages of any of the Old World nations. In mental characteristics all the different American tribes have much that is in common, and the very different stages of culture to which they had attained at the time of the conquest, as that of the Incas and Aztecs, as contrasted with that of the hunting and fishing tribes, which has been quoted as evidence of diversity of race, were not greater than those between different nations of Europe, as Gauls and Germans, and Greeks and Romans in the time of Julius Cæsar; yet all these were Aryans, and in treating the Americans as one race, it is not intended that they are more closely allied than the different Aryan people of Europe and Asia.

The physical or anatomical characters of the American native people, taken as a whole (leaving out for the present the Eskimo), may be thus described:—In stature there is considerable variation. Among them are the tallest known people on the earth, the Tehuelches or Patagonians, who, though not the fabled giants of the early voyagers, appear, by all trustworthy accounts, to attain an average (for the men) of from 5 feet 10 inches to 6 feet, which exceeds that of any other race. Some of the North American Indians are also very tall, 381 Iroquois carefully measured during the late war giving a mean height of 5 feet 8·3 inches. On the other hand, the Fuegians, and especially the Peruvians, are small, the latter not averaging more than 5 feet 3 inches. There is, however, no pigmy race on the American continent, like the Bushmen, Negritos, and Lapps of the old world.

The hair, always a character of primary importance in zoological anthropology, is remarkably uniform. Its prevailing, if not universal, colour is black, or intensely dark brown. The pale and auburn colour of the hair of Peruvian mummies is probably due to accidental bleaching, and the fair hair, said occasionally to be met with in existing tribes, may be the result of European admixture. It is always straight and lank, though sometimes coarse and sometimes silky in texture, a variation dependant upon the thickness of the individual hairs. In transverse section it approaches the circular form, perhaps more nearly than in any other race, though in this and other characters it resembles that of the Asiatic Mongolian people. On the scalp the hair grows abundantly and often to a great length; in many North American Indians it has been known to trail upon the ground when standing upright. Not less characteristic is the rarity or absence of hair on the face and other parts of the body. The skin is smooth and soft, and of various shades of brown, though cinnamon (commonly called *copper* colour) is the most characteristic. Some Californian Indians and the now extinct Charruas of Uruguay were said to be nearly black; and some scattered tribes, both in North and South America, are described as being nearly as fair as Southern Europeans. The shade of the colour appears to have no relation to the external conditions, such as heat, moisture, &c. Though the features of various tribes, and of particular individuals in each tribe, show considerable diversity, a characteristic type prevails throughout the great majority of the whole people from north to south. The forehead is usually retreating; the face wide in the malar region, narrowing towards the chin; the brows prominent, overshadowing rather small, sleepy, half-closed eyes; the nose long from above downwards, and narrow; the dorsum, as seen in profile, usually arched, rather sunk at the root, then projecting somewhat horizontally, and making a tolerably sharp bend down to the tip, which is not produced down below the septum; though this form is very frequently met with among all tribes, there is some diversity, and the profile is sometimes simply arched and sometimes straight, but a broad flat nose is very rarely met with; the mouth is wide and prominent, the lips rather thin; the chin well formed, narrow, but prominent; the whole face below the eyes long and large, the malar bones projecting laterally, and the lower jaw large.

(*To be continued.*)

VARIATIONS FROM MARIOTTE'S LAW

THE universal application of the law enunciated by Mariotte and Boyle, that the "volume of an aëriform body is inversely as the pressure to which it is exposed," was brought into question at an early date after the publication of the famous experiments on which the principle was based. Oersted and Schwendsen established in 1826 for easily liquefiable gases that the elasticity does not keep pace with the pressure. At about the same

time Despretz showed that notable variations took place in the case of air above a pressure of fifteen atmospheres. Arago and Dulong, intrusted by the French Academy with the verification of these observations, carried out a carefully conducted series of experiments on the compressibility of air extending up to twenty-seven atmospheres, but came, however, to the conclusion that Mariotte's law was correct. This opinion was strengthened by Pouillet's researches in so far as it related to the then so-called permanent gases, while confirmatory evidence was brought in favour of Oersted and Schwendsen's experiments on easily liquefiable gases. This view of the correctness of the law for a certain group of gases was held by the scientific world until 1845, when Regnault, by a brilliant series of experiments of the most exact kind, showed that air, nitrogen, and carbonic acid experienced a constant decrease of elasticity when submitted to pressures rising to thirty atmospheres, while under the same conditions a regular increase of elasticity in the case of hydrogen occurred. A few years later Natterer of Vienna published some remarkable experiments on the compressibility of gases, making use for the first time of enormous pressures, reaching in several cases nearly 2,800 atmospheres. While Natterer's methods of measurement were by no means exact, the results of his experiments showed beyond doubt that for pressures above eighty atmospheres oxygen, nitrogen, and carbonic oxide possessed the same peculiar property manifested ordinarily by hydrogen, viz., the volume of the compressed gas being greater than that demanded by Mariotte's law. The verification of Natterer's

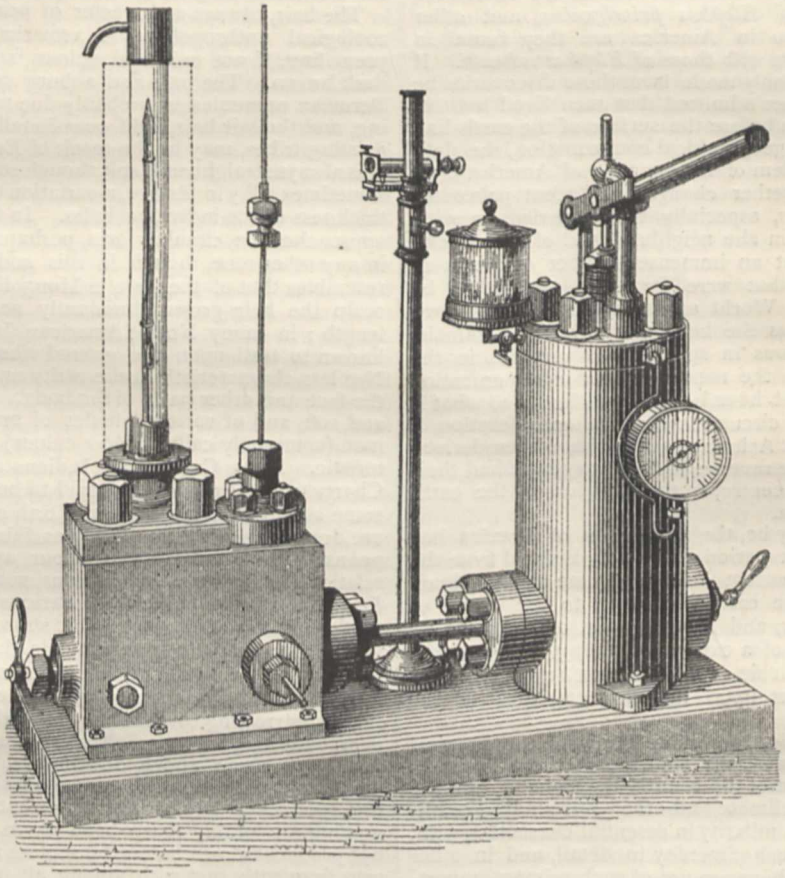


Fig. 1.

results was undertaken in 1870 by Cailletet, whose name has been so prominent of late years by his success in liquefying the so-called permanent gases. By making use of one of Desgoffe's manometers he experimented on air and hydrogen up to 600 atmospheres, and obtained figures comparing very closely with those published by Natterer.

So much for the data on this subject up to within a recent period. While the general truth of the results chronicled by Natterer and Cailletet was accepted by the physical world, it was still regarded as of prime importance to carry out the experiments under the influence of pressures with regard to the measurements of which there could be absolutely no doubt. The only practicable method of attaining this end was evidently to make use of enormously high columns of mercury. In 1875 Dr. Andrews attempted the solution of the problem in this manner, but was forced to succumb before the mechanical difficulties attendant upon its execution. The French physicist M. E. H. Amagat, who has devoted his attention for a number of years past to the phenomena of compressibility, appears to have been more successful in overcoming the manifold obstacles in the way of accomplishing the task, and furnishes [1] an interesting account of what is certainly one of the most remarkable *tours de force* of modern experimental physics. It consisted in making exact measurements of the changes in volume of gases when submitted to the pressure of a column of mercury of over *one-fifth of a mile* in height. In order to give a correct idea of the conditions under which Amagat's important results have been obtained, we will describe briefly the three essential elements of the experiments: the locality, the column of mercury, and the apparatus for receiving the pressures, communicating them to the gases operated upon, and measuring the

[1] *Annales de Chimie et de Physique* [5], xix. 345. Mars, 1880.

changes in volume. The latter (Figs. 1 and 2) consisted of a massive block of cast iron containing two cavities; one (C) for the reception of the extremity of the column of mercury, the second (D) for the reception of the graduated tube (M) inclosing the gas to be experimented upon. A narrow passage connects the two with each other and (F) with the reservoir of a powerful pump, while conical screw-taps (P′, P″) manipulated from the outside permit the openings into the cavity beneath the column of mercury or into the reservoir of the pump to be closed at will. The manometer (M) containing the gas to be compressed is of glass tubing, having an internal diameter of 1 millimetre and an external diameter of 10 millimetres, and is graduated for a distance of 50 centimetres. It is inserted hermetically into a massive bolt (B), which enters into the second cavity (D) of the apparatus. The free portion of the manometer is inclosed by a roomy glass tube, through which flowing water maintains a constant temperature, and that in turn by a copper cylinder, to guard against accidents. Mention can only be made

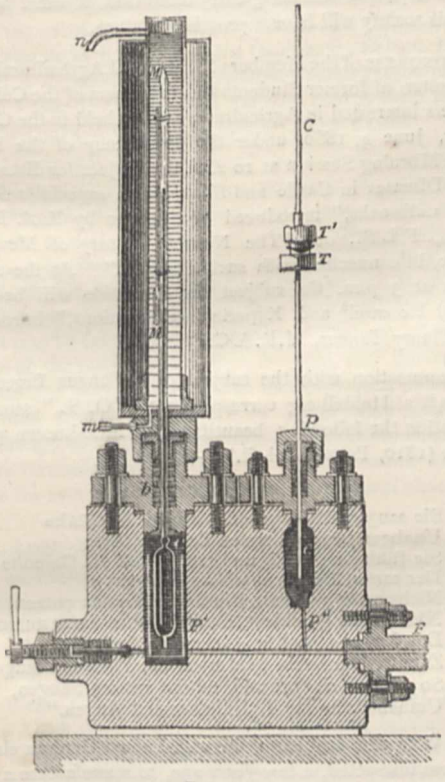


FIG. 2.

here of the ingenious devices for closing hermetically all the joints. The second important feature, the tube (C) for containing the column of mercury, is formed of pieces of steel tubing—internal diameter 2 millimetres, external 5 millimetres—united by specially prepared joints, which, while closing hermetically, are still easily attached or detached. The place chosen for the most noteworthy experiments was the coal-mine of Verpilleux, in the neighbourhood of St. Étienne. This pit reaches a depth of 327 metres, and a constant temperature prevails at the bottom.

The experiments made here were confined to nitrogen gas. The chief features of an experiment are as follows:—A vessel containing warm, dry mercury is placed in the large cavity (D) of the apparatus. The manometer containing dry pure nitrogen and terminating in a capillary point is then introduced beneath the mercury, the point is broken off, and the bolt inclosing the manometer is screwed into its place. Sections of the steel tubing (C) are then screwed on, one above the other. After the addition of each section mercury is forced into the apparatus by the pump, and mounts to the top of the tube; the height of the column of mercury is measured, the volume of the compressed gas is read off by means of a cathetometer, and thus the series of observations proceeds slowly until the mouth of the pit is reached. As can easily be imagined, such experiments in the shaft of a coal-pit are by no means easy or pleasant to perform. We can here allude only to the numerous elaborate precautions taken by M. Amagat to insure accuracy in measurement and reduce all possible causes of error to a minimum. The divergences in corresponding series of observations never exceeded one-tenth of 1 per cent.

Coming now to the results of the experiments made on the compressibility of nitrogen at Verpilleux, we notice, firstly, that the compressibility increases slowly until it reaches a maximum at about 65 atmospheres; secondly, that it decreases equally slowly until it reaches a normal figure at about 91 atmospheres; and thirdly, that after passing this point it decreases rapidly until at 430 atmospheres the volume of compressed gas is five-fourths of what it would be if Mariotte's law were true. In the following table the first column contains the pressures in atmospheres of the column of mercury, the second those deduced according to Mariotte's law from the corresponding volumes of compressed nitrogen, and the third the differences between the two:—

Pressures observed.	Pressures calculated.	Differences.
27·289	27·289	0·000
46·496	46·580	+ 0·084
62·034	62·251	+ 0·217
73·001	73·181	+ 0·188
80·580	80·728	+ 0·140
90·975	90·978	+ 0·003
109·171	108·665	− 0·506
126·896	125·388	− 1·508
168·810	162·835	− 5·975
208·635	196·224	− 12·411
251·127	229·271	− 21·855
290·934	256·669	− 34·275
332·039	282·544	− 49·495
373·302	306·055	− 67·247
430·773	335·707	− 95·066

After having established the above table of the changes in the compressibility of nitrogen, M. Amagat was in a position to study the analogous phenomena in the case of other gases with much greater ease. For this purpose it was simply necessary to replace the tube for the column of mercury in the apparatus just described by a manometer filled with nitrogen, the counterpart of that used for the gas under examination. By means of these modifications of his original apparatus M. Amagat has prepared very accurate tables for the changes in compressibility up to 400 atmospheres of air, oxygen, hydrogen, carbonic oxide, ethylene, and marsh gas. In M. Amagat's graphic delineation of the variations from Mariotte's law in the cases of the seven gases mentioned, the abscissæ correspond to the pressures in metres of mercury, while the ordinates correspond to the difference between the products of the pressures into the volumes and unity, *i.e.*, to the variations from Mariotte's law. They all start from a common point— a pressure of 24 metres. The curves of nitrogen and hydrogen are however continued to a minimal measure in accordance with Regnault's data. The minimum ordinate of the ethylene curve, which is 425, could not easily be given.

In glancing over the curves we see that the most conspicuous variations occur in the case of those gases most nearly approached to the conditions of liquefaction. The variations in the curve of oxygen are much more

marked than in that of nitrogen, while the curve of air lies between the two. Further, hydrogen is the only gas not exhibiting a minimum of the product of pressure and volume. As hydrogen is, so to say, the most perfect gas known, it would seem probable that on being forced to assume a state of tenuity allied to that of hydrogen, *i.e.*, by being exposed to elevated temperatures, the other gases experimented upon would yield curves resembling more and more that of hydrogen, until finally temperatures would be attained at which the convexity of the curves would totally disappear. The results chronicled by M. Amagat, taken in connection with those ascertained by other investigators in experimenting upon gases compressible at ordinary temperatures, would fairly allow the establishment of a law that when a gas on being compressed gives constantly increasing numbers for the product of the pressure by the volume—which according to Mariotte's law should remain unity—it is at a temperature above its critical point; or, to use Dr. Andrews' apt description, without actual liquefaction it can pass by means of pressure alone through all the intermediate stadia between the gaseous and the liquid states.

M. Amagat's interesting researches will, it is to be hoped, be followed by similar experiments executed under a wider range of temperature on the various gases; the results of which will, without doubt, throw much valuable light on the phenomena and conditions of liquefaction. Apart from their purely scientific interest, the tabulated records of his observations furnish to the engineer data of the greatest value, enabling him to construct manometers combining exactness and delicacy for the indication of high pressures, which hitherto have been measured with but a certain degree of approximation to the truth. T. H. N.

NOTES

Dr. M. Treub has been appointed director of the Botanical Gardens at Buitenzorg, Java.

We are glad to learn that the collections from Socotra, which Prof. Bayley Balfour was compelled to send by sea from Brindisi, have arrived safely at Kew Gardens.

At Dorpat a monument is about to be erected to the memory of the celebrated naturalist, Karl Ernst von Baer, who died at Dorpat on November 28, 1876. The funds will be supplied by the Dorpat University and the Imperial Academy of Sciences at St. Petersburg. The eminent sculptor, Herr Franz von Villebois, has made two excellent sketches for the monument.

At a recent meeting of the Court of Common Council, at which the Lord Mayor presided, it was resolved that the freedom of the City of London in a suitable gold casket be presented to Sir Henry Bessemer, F.R.S., M.I.C.E., in recognition of his valuable discoveries, which have so largely benefited the iron industries of this country, and of his scientific attainments, which are well known and appreciated throughout the world.

On August 5, as we have already announced, the exhibition of anthropological and prehistoric objects found in Germany will be opened at Berlin. At the same time the general meeting of the German Anthropological Society will take place. No less than 114 archæological, eight palæontological, and sixteen craniological museums will send objects to this exhibition. The objects found in the Loess strata will be particularly interesting, and besides these we may point to the objects found in caves and in moors.

The British Medical Association will be well received at Cambridge in August, not only by the University but in the town; the Town Council have granted the Guildhall free of cost. The president of the Physiological Section, Dr. Rutherford, will give his address on Wednesday, August 11, at 2 o'clock, and there will follow a discussion on the subject, "Is Urea formed in the Liver?" to be opened by Prof. Gamgee, of Manchester; on August 12 Prof. W. Preyer, of Jena, will open a discussion on "Sleep and Hypnotism." Drs. Gaskell (Cambridge) and Stirling (Aberdeen) are the secretaries of this Section.

Prof. Milne, of Tokei, Japan, who has made a trial of almost every seismoscope in existence, and has devoted all his leisure to seismometry for several years, has exerted himself successfully to interest the Japanese officials in establishing a suitable system of earthquake observation, as well as the Europeans in Japan, who have lately formed a society for the purpose of systematically studying seismic phenomena. Mr. Milne has obtained the assistance of the Government in having immediate telegraphic communication concerning earthquakes, and he aims at getting from telegraph operators throughout the country information concerning earth-currents during earthquakes. If we consider the importance of studying the matter systematically in a country where small earthquakes occur every few days, and where the people are all greatly interested, it must be evident that this society will have a promising future.

A Congress of the Members of the Royal Agricultural College, Cirencester, of former Students and Professors of the College, and of others interested in Agriculture, will be held in the College on Friday, June 4, 1880, under the Presidency of the Principal. At the Morning Session at 10 a.m. the subject for discussion will be—"Diseases in Cattle and Sheep, with especial reference to recent outbreaks," introduced by a paper by Prof. Buckman, F.G.S., F.L.S., on "The Natural History of Meadow and Pasture, in connection with such Diseases." At the afternoon session at 3 p.m. the subject for discussion will be—"Agricultural Research and Experimental Stations," introduced by Prof. Henry Tanner, M.R.A.C., F.C.S.

In connection with the subject of "Fungus Inoculation of Insects," a Heidelberg correspondent, "O. S.," sends us for publication the following beautiful and little-known poem, by Goethe (1810, Poems, vol. ii.):—

Der Fliegentod

"Sie saugt mit Gier verräth'risches Getränke
Unabgesetzt, vom ersten Zug verführt;
Sie fühlt sich wohl, und längst sind die Gelenke
Der zarten Beinchen schon paralysirt;
Nicht mehr gewandt, die Flügelchen zu putzen,
Nicht mehr geschickt, das Köpfchen aufzustutzen—
Das Leben so sich im Genuss verliert.
Zum Stehen kaum wird noch das Füsschen taugen;
So schlürft sie fort und, mitten unterm Saugen,
Umnebelt ihr der Tod die tausend Augen."

Dr. Werner Siemens, the well-known German electrician, had been instructed, a few years ago, to manufacture a series of standard weights on behalf of the Egyptian Government, which wished to adopt the German system; but as the Egyptian Government did not fulfil its financial obligations Dr. Siemens kept the set of weights in his workshop, where they were used for various purposes. On the occasion of the visit of the weights and measures inspector these weights were discovered, and Dr. Siemens summoned before the police. The case has been tried with some solemnity, and Dr. Siemens fined 2 marks.

A remarkable phenomenon was observed at Kattenau, near Trakehnen (Germany), and in the surrounding district, on March 22. About half an hour before sunrise an enormous number of luminous bodies rose from the horizon and passed in a horizontal direction from east to west. Some of them seemed of the size of a walnut, others resembled the sparks flying from a chimney. They moved through space like a string of beads, and shone with a remarkably brilliant light. The belt containing them appeared about 3 metres in length and ⅔ metre in breadth.

THE Mitchell Library of Glasgow, which was opened in 1877, has already attained considerable dimensions, and under the careful organisation of the principal librarian, Mr. Barrett, promises to be of great service as a consulting library. It now possesses 16,828 works, or 27,982 volumes, a large proportion of which are scientific. Of the volumes issued in 1879 19½ per cent. belonged to the division of "Arts, Sciences, and Natural History"—rather a curious division, by the by. This percentage was excelled only by History, Biography and Travel, and "Miscellaneous."

THE eminent physicist, Dr. Rudolf Clausius, of Bonn, has been elected a member of the Roman Academy "dei Lincei."

THE Secretary of State for Foreign Affairs of the Republic of San Domingo has issued a circular to the Ministers of England, America, France, Italy, Spain, Holland, and Denmark, soliciting their co-operation in the erection of a monument to Christopher Columbus in the city of San Domingo.

THE Lisbon Academy has decided to ask the consent of the Government to transfer the bones of Vasco da Gama from Vidigueira Alemtejo to the church of the Jeronimites, Belem. It is proposed that a deputation of the Academy should accompany the remains of Vasco da Gama, and a war ship convey them from Bareira, on the banks of the Tagus, to the Lisbon Arsenal.

ADMIRAL MOUCHEZ, the Director of the Paris Observatory, has published a pamphlet on the work executed in this establishment during the year 1879. A new decree quoted by M. Mouchez arranges that the several *employés* of the Observatory, when not too old, can be admitted to follow the course of lectures given at the School of Astronomy recently created, and are fit to be appointed astronomers if successful in their examinations. The establishment is to be enlarged in the vicinity of Boulevard Arago, the admission of the public to be more frequent, and the magnetical observations to be resumed. The meteorological observations have been continued, and are to be in some respects enlarged, although no change is contemplated in the organisation of the Bureau Centrale and the Service d'Avertissements, which will continue for ever independent of the astronomical observatories.

THE *Sydney Morning Herald* records the death of Mr. Edward Smith Hill on March 17, sixty-one years of age. He was a native of Sydney, and after retiring from business devoted his time to scientific investigations for the last eighteen years. He made a voyage to the South Sea Islands, and wrote some valuable papers and pamphlets on their flora. He wrote for the New South Wales Government a report on the flora of Lord Howe Island, and the condition of its European inhabitants. Among his contributions to Sydney journals was a series of articles describing the fishes found in the harbours and rivers of New South Wales and along the coast.

THE work of examining the 5,000 *employés* of the Pennsylvania Railroad Company as to their power of distinguishing colours and forms was begun in Jersey City on April 1. Acuteness of vision was tested by means of printed cards placed at a distance of twenty feet; also by means of small openings in a screen illuminated on the further side. Many who successfully passed these ordeals failed signally in the colour tests. Three skeins of woollen yarn were used, one being light green, the second rose, and the third red. Each of these was placed on a table in front of the person examined, at a distance of three feet, and, with the vision of either eye obstructed by a spectacle frame, the man was requested to name the colours, also to pick out a similar shade to one or other of the three specified from different skeins of woollen yarn numbered from 1 to 36. One young man correctly designated the test skein as red, but on being told to select a similar shade from the skeins before him, he picked three shades of blue, two of yellow, and one of red. He could distinguish no difference; and the same thing happened to half-a-dozen others who followed him. The skeins in the row were then divided into three sets with twelve numbers in each. Some men proved able to distinguish all the shades of green, but failed lamentably in picking out the different shades of red. The officers of the road were greatly impressed, it is said, by the results obtained.

ON April 1 a "Society for Zoology" was formed at Berlin, with a view of furthering zoological science and zoological research in all its branches. The president is Dr. Eduard Kaiser (27, Friedrich Strasse), who will furnish all particulars to intending members.

AT Paris a Society "contre l'abus du tabac" has been formed, which intends to combat the excessive indulgence in smoking which has of late become the fashion in almost the whole of Europe. The Society offers various prizes for treatises on the human health and the dangers it is subject to from excessive use of tobacco.

THE *Times* Geneva correspondent writes, under date May 12, that a few days before, during a violent thunderstorm, a tall poplar on the Cour de Rive, a street in the upper part of Geneva, was struck by lightning. Directly after the occurrence Prof. Colladon made a minute examination of the tree. The Professor states that it is not true, as has been commonly supposed, that the gashes (*plaies*) found in the trunk of a tree which has been struck by lightning are the parts with which the lightning first came into contact. The parts first struck are the highest branches, especially those most exposed to the rain. Thence it runs down the smaller branches—affecting almost the whole of them—to the larger ones, until it reaches the trunk. These larger branches, and above all the trunk, being much worse conductors than the small branches, the passage through them of the electricity produces heat and "repulsive effects," whereby the bark and sometimes the wood are torn in pieces, the bits being thrown a considerable distance, occasionally more than 50 metres. It not infrequently happens that the upper branches and their leaves are destroyed—this is generally the case with oaks, which are often struck—but the leaves and young shoots of poplars and many other trees are such excellent conductors that they do not appear when struck to suffer any notable injury. This finds full confirmation in the condition of the poplar on the Cour de Rive. In this instance the principal and highest branch of the tree on its south-western side was the first with which the lightning came in contact. Its leaves and twigs, neither withered nor tarnished, were torn into minute fragments and scattered about on the ground. This was the effect, not of the lightning, but of the concussion of air, exactly as if there had been an explosion of dynamite or gunpowder; and the windows of two houses close by were broken in the same manner and by the same cause. The presence of water near the root of a tree is often the determining cause of its attraction for the electric fluid; and the Professor found, 5 metres from the poplar, on its north side, a leaden water-pipe, and close to it a drain filled with waste water from a laundry. The principal fissure in the tree was also on the north side; and half-way between it and the water-pipe a plank lying on the ground had been pierced by a concentrated jet of the electricity as it flashed towards the pipe by the shortest route. Large trees, especially tall poplars, placed near a house, may serve as very efficient lightning conductors, but always on the indispensable condition that there is no well or running water on the opposite side of the house, for in that case the lightning, if it struck the tree, might pass through the building on its way to the water. In erecting lightning conductors it is desirable that their lower extremities should terminate in a stream, a well, or a piece of

damp ground. The plant most sensible to electricity is the vine. When a stroke of lightning falls in a vineyard the leaves affected are turned red-brown or deep green, a circumstance which shows, in the opinion of Prof. Colladon, that the electricity descends in a sheet or shower, and not in a single point, the number of vines touched—sometimes several hundred—by a single *coup* proving that the lightning has covered a wide area.

THE oldest librarian of the Royal Library at Berlin, Dr. Buschmann, died recently at the advanced age of seventy-five years.

A NEW "Illustrirte Naturgeschichte der Thiere," by Philipp Leopold Martin, with numerous illustrations by F. Specht, R. Friese, R. Kretschmer, A. Göring, and L. Martin, jun., will soon be published in two volumes (or fifty parts), by F. A. Brockhaus, of Leipzig. The first volume will contain the chapters on mammals and birds; the second the remaining vertebrates and the whole of the invertebrates.

THE Archæological Society of Athens has purchased about half the village which stands upon the ruins of the Temple of Eleusis. The Society intends building new dwelling-houses in another part, and to begin with excavations as soon as the present inmates of the village have moved.

THE astronomer, Herr Rudolf Falb, well known through his theory of earthquakes, has returned from his South American exploring tour, which extended over a period of more than two years. In his researches he was led in the direction of ethnography and linguistics, and believes that he has made interesting discoveries regarding "the original language of the human race."

IN the vicinity of Milan pile-dwellings have been discovered in a peat-moor, and the foundations of a Roman theatre in the city itself.

"DIE deutsche Arbeit in fremden Erdtheilen" is the title of an interesting lecture recently delivered by Dr. Karl von Scherzer at the Leipzig Gemeinnützige Gesellschaft. It is published by Rossberg, of Leipzig.

THE new Indian Section of the South Kensington Museum, formed from the late India Museum, was opened to the public on Monday.

IT has been resolved to establish a Museum of Science and Art in Aberdeen.

AN experimental department has been established at the Conservatoire des Arts et Métiers in the large hall, where the engines are set in operation every Sunday and Thursday from eleven to six o'clock. Advantage has been taken of the motive power to put in operation a number of Gramme and Alliance machines. After having been exhibited during a fortnight, the instruments will be replaced by others, and so on indefinitely.

DR. JAMES GEIKIE, F.R.S., has been elected President of the Perthshire Society of Natural History, in succession to the late Sir Thomas Moncrieffe. From his address at the annual meeting of the Society we are pleased to see that the local museum to be established by this enterprising Society is making good progress, and promises very soon to be a *fait accompli*. Dr. Geikie gave expression to some wholesome truths as to the functions of such a local museum, the great purpose of which ought to be to fully illustrate the natural history, geology, and antiquities of the surrounding region. This, we are glad to think, is what the Perth Museum promises to be, and it ought, therefore, to prove one of the best local museums in the kingdom, seeing that all in all, from a scientific point of view, Perth is probably the most comprehensive and representative county, as it is among the largest, in our islands.

IN a gravel pit near the town of Posen a mammoth-skull has been discovered, but unfortunately in pieces. Most of the pieces, however, are well preserved—the facial bones alone weigh 28 lbs.

AN earthquake, accompanied by a loud subterraneous noise, is reported from Ilanz, in the Swiss canton of Graubünden. It occurred on April 27 at 3.30 a.m. A smart earthquake shock, coinciding with that at Villeneuve, and accompanied by subterranean noises, was felt at Jarasp and Ardez, in the Engadine, on the 7th inst.

THE centenary of the birth of Gotthilf Heinrich von Schubert, the celebrated naturalist, was celebrated at Hohenstein on April 26. A monument of Schubert was unveiled, and some 500*l*. have been collected for the foundation of a preparatory school for little children, under the name of Schubert-Stift.

A NEW French Society of Agriculture, "The National Society for the Encouragement of Agriculture," held its first meeting on May 15 at the Hôtel Continental, Paris, M. Fouche de Careilles, Senateur, in the chair. The President of the Republic and the most prominent members of the French Government are said to take interest in the new society.

AN ostrich, long on exhibition at Rome, having been suffocated by thrusting its neck between the bars, there were found in its stomach four large stones, eleven smaller ones, seven nails, a a necktie pin, an envelope, thirteen copper coins, fourteen beads, one French franc, two small keys, a piece of a handkerchief, a silver medal of the Pope, and the cross of an Italian order.

A REMARKABLE discovery has recently been made near Hirschberg, in the Riesengebirge (Silesia). In a locality called Weltende, at the entry into the narrow rocky mountain ravine through which the Bober flows, a large heap of bones of diluvial mammals was found, such as pieces of reindeer horns and bones of *Elephas primigenius*, prehistoric ox, &c. The discovery is important, because it proves the former occurrence of the large mammals of the diluvial period even in this elevated valley of the Sudeten mountain-chain.

DR. BECLARD has introduced at Paris, in the buildings where the old Rollin College has been so long established, a new mode of demonstration for physiological experiments on living animals. A circular barrier has been erected round a space where a movable table is arranged on rails. The animal being placed on the table, it is easy to understand that the experiments can be witnessed by each pupil consecutively.

NEAR Bautzen (Saxony) an ancient burial-ground has been discovered. Up to the present not less than 400 antique objects, such as urns, well-preserved "tear-vases," sixteen bronze and iron rings, a head ornament, needles, and buttons were found.

THE additions to the Zoological Society's Gardens during the past week include a Pig-tailed Monkey (*Macacus nemestrinus*) from Sumatra, presented by Mr. J. M. Donovan; a Bennett's Gazelle (*Gazella bennetti*) from India, presented by Mr. Harvey Chevallier; four Rose-coloured Pastors (*Pastor roseus*) from Smyrna, presented by Mr. M. S. Bayliss, C.M.Z.S.; six Paradise Whydah Birds (*Vidua principalis*), two Yellow-backed Whydah Birds (*Coliopasser macrurus*), a White-winged Whydah Bird (*Urobrachya albonotata*), twelve Red-beaked Weaver Birds (*Quelea sanguirostris*) from West Africa, presented by Mr. J. Colman, C.M.Z.S.; a Goffin's Cockatoo (*Cacatua goffini*) from Queensland, presented by Mr. W. T. Green; three Young Lions (*Felis leo*) from Africa, a Grey-cheeked Monkey (*Cercocebus albigena*) from West Africa, a Red-throated Amazon (*Chrysotis collaria*) from Jamaica, deposited; two Common Bluebirds (*Sialia wilsonii*), two Yellow-legged Herring Gulls (*Larus cachinnans*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN

THE TRANSIT OF MERCURY, MAY 5-6, 1878.—An Appendix to the "Washington Observations, 1876," is devoted to reports on telescopic observations of this transit and discussions of them. There are individual reports from Professors Asaph Hall, Harkness, Eastman, and Holden, and from Dr. Henry Draper and Mr. H. M. Paul. Probably no other phenomenon of the kind has been watched by so large a number of observers, 109 names appearing in the general record. They were, with very few exceptions, stationed at different points in United States territory. The observations have been calculated by Prof. Eastman and Mr. Paul: the former, attaching greater weight to a certain number made by more experienced observers, finds for the Washington geocentric times those given in the second column below; Mr. Paul deduces for the most probable values those given in the third column (the time of first external contact depending on only two or three observations being omitted; the other contacts depend on 57, 52, and 8 observations respectively):—

	Eastman.	Paul.
	h. m. s.	h. m. s.
First external contact ...	22 4 42·0 ...	———
First internal ,, ...	22 7 42·1 ...	22·7 40·61 ± 0·46
Second internal ,, ...	5 35 27·8 ...	5·35 28·83 ± 0·48
Second external ,, ...	5 38 25·7 ...	5·38 29·52 ± 1·18

If the first series of times are compared with the figures in the *American Ephemeris*, which depend upon the earlier theory of Mercury of Leverrier, the errors of prediction are respectively + 77s., + 84s., + 110s., and + 119s. These differences are greatly diminished if the times are compared with those resulting from Leverrier's later theory involved in the tables in the Paris *Annales*, vol. v., as used in the *Nautical Almanac*, more especially if the solar semi-diameter employed is diminished by 2″·0, so as to make the results more strictly comparable with those of the *American Ephemeris*: we have then for the errors of computation, + 2s., + 9s., + 25s., + 34s. The superiority of the later theory is thus evident, and it will be remembered that this theory involves the increased motion of the perihelion of mercury, which induced Leverrier to suspect the existence of one or more planetary bodies, or of matter in some form between Mercury and the Sun.

We may add that if the positions of the planet in the *Nautical Almanac* are combined with the semi-diameters of sun and planet inferred by Leverrier from the transits, the computed times of the internal contacts exhibit differences of + 19·8s. and + 16·4s., the first agreeing closely with the corresponding one deduced from observations in Europe.

THE SECOND COMET OF 1880 (SCHAEBERLE, APRIL 6).—On the evening of May 8 this comet passed nearly over a star of the eighth magnitude, No. 6815-6 of Oeltzen's Argelander (= 901 of Fedorenko), and Major Tupman, R.M.A., availed himself of this somewhat unusual opportunity for fixing the place of a comet with great precision. By twenty comparisons, ten before and ten after the conjunction in declination, it was found that at 10h. 16m. 17s. Greenwich mean time, the comet followed the star 2·8os. and was 2″·2 south of it.

The following ephemeris, for Greenwich midnight, is derived from elements which represent the observations pretty accurately up to May 8:—

	Right Ascension.	Declination.	Log. distance from the Earth.	Log. distance from the Sun.
	h. m. s.	° ′		
May 20 ...	6 22 53 ...	+56 43·7 ...	0·38965 ...	0·27695
22 ...	6 23 57 ...	55 49·4		
24 ...	6 25 3 ...	54 56·6 ...	0·39725 ...	0·27379
26 ...	6 26 10 ...	54 5·2		
28 ...	6 27 17 ...	53 15·1 ...	0·40432 ...	0·27090
30 ...	6 28 24 ...	52 26·4		
June 1 ...	6 29 32 ...	+51 38·8 ...	0·41084 ...	0·26829

It appears not improbable that this comet may be observed until towards the end of the year, arriving at its least distance from the earth early in November, and at the same time attaining its greatest intensity of light. It will be lost from proximity to the sun's place for several weeks about the perihelion passage, which is likely to occur about July 1, becoming visible again at the beginning of August in the morning sky. The orbit upon which the above places are calculated gives for the position on August 5 at 12h. G.M.T., right ascension 6h. 58·7m., declination + 31° 52′. The intensity of light on May 8 was about one-third less than is assigned for the first week in November.

PROF. C. A. F. PETERS.—We regret to have to record the death of Prof. Christian August Friedrich Peters, formerly of the Russian Central Observatory at Pulkowa, subsequently Professor of Astronomy in the University of Königsberg, and Director of the Royal Observatory at Kiel, and for upwards of twenty-five years editor of the *Astronomische Nachrichten*. After a long illness he died on the 8th of the present month, in his seventy-fourth year. We reserve a notice of Prof. Peters' principal astronomical work until next week.

GEOGRAPHICAL NOTES

BEFORE starting on his journey from Lake Nyanza to Lake Tanganyika, which we have previously referred to, Mr. J. Stewart, of Livingstonia, spent some time in examining the country on the west of the upper portion of the former lake. He started from Kaningina, and crossed the mountain of the same name at an elevation of about 5,000 feet. After a visit to Chipatula's village he entered Mombera's territory in the Kasitu Valley, and shortly reached the junction of the Kasitu with the Rikuru, which comes from the west through a wild and mountainous country. The valley of the Rikuru north of the junction is called Ntanta, and is exceedingly fertile; the elevation is about 3,700 feet, and the climate is cool and pleasant. Here Mr. Stewart noticed an important change in the geological formation, the granite and quartz giving place to soft shale and clay schists; and he is of opinion that the Kasitu forms the geological boundary, and that it runs in the trough of some great fault or nonconformity in the formation. Ten miles further north regularly stratified beds of hard, dark grey sandstone were met with. The Rikuru Valley, which Mr. Stewart thought would have taken him gradually down to the lake-level, is at its north end blocked by hills forming the lake coast, and the river flows through winding precipitous valleys, falling 2,000 feet in the last fifteen miles. The water enters the gorge clear and sparkling, and leaves it heavily laden with bluish clay silt, which is visible far into the lake. Mr. Stewart reached the lake at the mouth of this river in S. lat. 10° 45′ 15″. Marching northwards, he visited Mount Waller, which he examined thoroughly, and then, after keeping inland for four days, arrived at the Kambwe lagoon, his starting-point for Lake Tanganyika. The country from Mount Waller to this place is very poor, consisting of swamp and hard clay plain, broken here and there by dry gravel ridges, and occupied chiefly by large game.

THE International African Association have just issued the third part of their periodical publication, which contains extracts from the reports of their travellers in East Africa. M. Cambier gives an account of recent earthquakes on Lake Tanganyika and some details of the work at the station at Karema, the position of which he has fixed as in S. lat. 6° 47′ 50″. M. Popelin narrates the particulars of his journey from Tabora to Karema, and some of the plans for the future. There are also other letters from them, as well as from Mr. Carter and M. van den Heuvel and a medical report by Dr. Dutrieux. M. Burdo, the leader of the third expedition, announces his arrival at Mpwapwa on February 18, and sends a report on the route followed from Saadani. His caravan consists of 108 persons and fourteen asses.

THE German branch of the International African Society intends establishing the first German station at the southern extremity of Lake Tanganyika. The expedition, in which Capt. Schöller, the well-known zoologist, Herr Boehm, and Dr. Kaiser take part, has already left Berlin. Dr. Nachtigal made several communications on the subject at the last meeting of the Berlin Geographical Society.

NEWS has been received concerning the expedition of Dr. Mook and Herr von Holzhausen to the Pettit and Atbara rivers. The travellers left Kassala on January 9, and reached Tomat on the 16th, after crossing the Pettit and the Atbara. Tomat is the winter camp of the Sheikh of Dabanya bedouins. Here they were detained for eight days. Then they proceeded along the left bank of the Atbara as far as the mouth of the Bacher Salam River, but were then compelled to return on account of the absolute uncertainty of the country, and the indisposition of Herr von Holzhausen. The country near the Bacher Salam is completely deserted on account of hordes of Abyssinian brigands.

The travellers were robbed, and owe their lives simply to forced night-marches, gun in hand. They reached Kassala on February 12. Dr. Mook gives a sad account of the deplorable condition of the Soudan, where, as it seems, complete anarchy prevails.

THE United States Government is fitting out an expedition at San Francisco to search for the Arctic exploring vessel *Jeannette*, which has now been some months out. The revenue cutter *Corwin* has been selected for the duty, and she will start with one year's provisions. Her instructions are to search for two missing whalers also. The *Jeannette* went by what is called the eastern passage by Behring's Straits, and Capt. Markham, formerly of Her Majesty's ship *Alert*, of Polar fame, suggested that every year during the *Jeannette's* absence a vessel like the *Corwin* should be sent into the Arctic regions to save her or to learn, as the case may be, of her progress.

AN Austrian expedition, under the guidance of Dr. Otto Benndorf, Professor of Classical Archæology at the Vienna University, is about to start for Olympia. Besides Dr. Benndorf, Prof. E. Petersen (Prague), Dr. W. Gurlitt (Graz), some other member of the Vienna University, and an architect, will take part in the expedition. Dr. Wilhelm Klein, who has already started for Greece, will meet the expedition at Olympia. Another authority in archæology, Prof. Ernst Curtius, has also started for Olympia.

THE Dutch ship *Willem Barends* is being equipped for a third North Polar Expedition.

HERR ROBERT VON SCHLAGINTWEIT, the well-known traveller, has arrived at New York, whence he will proceed to Washington. He then intends to go on a scientific tour to the West of North America.

THE first sheet of a large prehistoric map of Bavaria, by Prof. H. Ohlenschlager, has recently been published. It comprises the district where, in the present day, Munich, Rosenheim, and Kempten are situated. The whole map will consist of fifteen sheets.

NO. 4 of Band xxiii. of the *Mittheilungen* of the Vienna Geographical Society contains the first part of an account of a botanical excursion to the Kasbeck (Caucasus) in the summer of 1871, by Peter Muromtzoff. At the monthly meeting of the Society, on April 27, a letter was read from Dr. Oskar Lenz from Tarudent, describing his passage of the Moroccan Atlas, in which he gives some interesting observations on the mountains and the people. Another letter was from Lieut. Kreitner, who accompanied Count Széchenyi in his attempt to penetrate Tibet through China. Lieut Kreitner states that he plotted carefully the whole route of the party and took many observations, while his companion, Herr von Loczy, took as careful note of the geological features of the region traversed.

L'Exploration for May 13 has the second of a series of articles on Central Japan, Yeddo being the subject of the present instalment; there is also a translation of Lieut. Bove's project of Antarctic exploration, the main points of which we have already given; the number also contains reports of the geographical societies of Quebec and the Argentine Republic, and numerous notes and news, the sources of which, we regret to see, are seldom acknowledged, their value thereby being much decreased. Under the editorship of M. Tournafond this journal is improving, though we think there is still much to be done ere it can be regarded as occupying a first place among geographical journals.

DR. HOLUB, the well-known African traveller, has opened an interesting exhibition at Vienna, which contains thousands of objects brought by him from the South African tribes. They are arranged in various groups, and are classified as zoological, botanical, mineralogical, archæological, ethnographical, and commercial objects.

THE PARALLEL ROADS OF LOCHABER—THE PROBLEM AND ITS VARIOUS SOLUTIONS[1]

AT a recent meeting of the Inverness Scientific Society and Field Club, and again at Fort William, in the immediate neighbourhood of the phenomena, a lecture was given on the above subject by Mr. William Jolly, H.M. Inspector of Schools, who has, for more than ten years, devoted great attention to the subject, and will shortly publish the results of his investigations.

Mr. Jolly thought the subject peculiarly appropriate for their Society, both on account of its intrinsic interest and the eminent men who had written of it, and the proximity of the Club to the locality exhibiting these singular and attractive phenomena. His aim was to state the problem, to explain the solutions offered, give its bibliography, criticise the theories, and develop more fully the one he adopted. He first described the locality of the roads in Glen Roy, Glen Spean, Glen Gluoy, and Glen Laggan, all at the south end of the Great Glen; and their unique and striking aspect, such as to draw the attention of the primitive Celts. They had received several names, being known in Gaelic as *Na Casan*, literally the feet, hence footpaths, of which Parallel *Roads* was a literal translation. Campbell of Islay's rendering, "The Bends," the Rev. Mr. McGregor, of Inverness, the Gaelic scholar, thought fanciful, and without foundation. They were also variously called "lines," "shelves," &c. The highest recognised is in Glen Gluoy at 1,172 feet, another existing there at 964; the three chief in Glen Roy stand at 1,148, 1,067, and 855; the lowest sweeping round into Glen Spean at the same level. A possible road, discovered by Darwin in 1838, in Glen Laggan, above the Loch Laggan Locks, is 1,300 feet high. Their breadth varies from 40 to 70 feet, giving an average of 60. They slope towards the valley at an angle of from 5 deg. to 30 deg., the hill face being inclined from 25 deg. to 40 deg.

Mr. Jolly then, by means of a printed diagram, which enhanced the clearness of the exposition, explained the Conditions of the problem, all of which must be satisfied by any theory claiming to be the true solution. These conditions were the following:—

I.—THE CONDITIONS OF THE PROBLEM

I.—*The Peculiar Form and Character of the Roads*

1. Their general horizontality and parallelism.
2. Their general equality of width (*a*) in the course of the same line, and (*b*) in relation to each other.
3. Their general continuity.
4. Their stair-like form, as of parallel layers laid successively on each other on the hill-side.
5. Their sloping towards the valley.
6. Their being proportionately narrower where they are steeper.
7. Their general absence where solid rock protrudes, and where the slope is exceptionally flat.
8. The *débris* of the hill above and below the Roads sloping more or less at the angle of repose.

II.—*Their Composition*

9. The absence of rounded, water-worn stones along them, and the general greater or less angularity of these.
10. Their consisting of the same *débris* as the rest of the hill-face, and not of transported matter.
11. The absence of cliffs, caves, and rock-notching, or any deep erosion, along their course.

III.—*Their Distribution*

12. Their sudden endings in all cases, without greater accumulations of *débris* or other indications of the cause of the same.
13. The symmetrical disappearance of the same lines at points opposite each other, in the same and *contiguous* valleys.
14. The outward extension of the roads, according to their lesser altitude.
15. Their occasional disappearance for considerable distances.
16. Their different altitudes in different glens, and the absence of the same lines in neighbouring glens.
17. Their being confined to Glen Roy and neighbourhood.

IV.—*Their Relations*

18. The existence of cols in connection with and slightly lower than each of the main roads.
19. The existence of other lines of a different character, above and below the roads. (Dwelt much on by Chambers.)
20. The existence of much terraced *débris*, below the roads, in the bottoms of the valleys containing them.
21. The relation of the roads to the glaciation of the district and its remains.

II.—THE SOLUTIONS OF THE PROBLEM

Mr. Jolly then expounded, by means of another diagram, the various theories proposed to satisfy these Conditions, and account for the Roads, naming the writers advocating them, with their

[1] By William Jolly, F.R.S.E., H.M. Inspector of Schools, Inverness.

dates, and the various works which they had written. All these are given here in the following table:—

	Theories.	Writers.		Works.
By man —Human.	Fingal	Old inhabitants.		
	Hunting roads of kings ...	Old inhabitants.		
	Aqueducts for irrigation ...	Pennant	1769	Pennant's "Tour," 1771.
		Playfair	1816	Proc. Roy. Soc. Edin., 1816
By a flood —Diluvial.	... ...	Sir Geo. S. Mackenzie	1848	Edin. Phil. Jour., Jan., 1848.
		Prof. Rogers	1861	Lect. Roy. Inst., Lond., March, 1861.
By the sea —Marine.	... ...	Darwin	1839	London Phil. Trans., 1839.
		Lyell (visited 1825) ...	1841	"Elements of Geology."
		Chambers	1848	"Ancient Sea Margins."
		Rev. R. Boog Watson	1866	Geol. Soc. Lond. Jour., February, 1866.
		Prof. Nicol	1869	Geol. Soc. Lond. Jour., August, 1869.
		Campbell of Islay ...	1877	"Parallel Roads of Glen-Roy," printed privately.
By a lake—Lacustrine.	Nature of dam doubtful ...	Macculloch	1817	Trans. Geol. Soc. Lond., 1st series, vol. iv.
		Lubbock	1868	Geol. Soc. Lond. Jour., May, 1868.
		Babbage	1868	Geol. Soc. Lond. Jour., August, 1868.
		Rev. T. Brown ...	1876	Proc. Roy. Soc. Edin., vol. viii., March, 1876.
		Dakyns	1879	Geol. Mag., Dec., 1879.
	Dam of *débris* —detrital dam.	Dick-Lauder	1823	Trans. Roy. Soc. Edin., vol. ix.
		Milne-Home	1847	Proc. Roy. Soc. Edin., 1847.
		Do.	1876	Trans. Roy. Soc., vol. xxvii., 1876.
		Do.	1877	Trans. Roy. Soc., vol. xxviii., part 1, 1877.
		Agassiz (visited 1840)	1842	Geol. Soc. Lond. Jour., vol. iii. 1842; "Atlantic Monthly," June, 1864 (Both by Agassiz).
		Buckland (do.)	1842	
		James Thompson ...	1848	Edin. New Phil. Jour., vol. xlv.
		Jamieson	1863	Geol. Soc. Lond., vol. xix., January, 1863.
		Darwin	1863	In private letters, &c.
		Lyell	1863	"Antiquity of Man."
		Archibald Geikie ...	1865	"Scenery and Geology of Scotland."
	Dam of ice—glacial dam..	Jolly	1873	Trans. Geol. Soc. Edin., April, 1873.
		James Geikie	1873	"The Great Ice Age."
		Sir Henry James ...	1874	"Parallel Roads of Lochaber," Ord. Sur. Off.
		Tyndal	1876	Roy. Inst., June, 1876; "Pop. Science Review," October, 1876.
		Prestwich	1879	Roy. Soc. Lond.; NATURE, May 29, 1879, in abstract; Lond. Phil. Trans., 1880, in full.

III.—The Solutions Examined

After referring to the Traditional theories of Fingal and the Hunting Roads, adopted by Pennant in his remarkable "Tour," published in 1771, he told how Playfair had seen similar appearances exhibited by irrigation works at Brieg, in the Valais, which suggested to him his curious solution.

The Diluvial theory held that they were caused by an immense flood from the Atlantic, through a sinking of the West Coast, rushing impetuously along these valleys. There was no use seriously criticising this theory, though adopted in 1861 by Prof. Rogers, of Glasgow.

The Marine theory had had many able supporters, from its first suggestion by Darwin, in 1839, to Campbell of Islay, so recently as 1877. The greatest exponent of this theory was Robert Chambers, in his "Ancient Sea Margins," published in 1848. He held that these lines were nothing but sea beaches, similar to those found so plentifully all over the country. He contended that other lines in these same glens were of the same kind; but these had been shown by Mr. Jolly, in 1873, to be entirely different in character, outline, and composition, and were probably moraines. Mr. Jolly then traversed the Conditions of the problem laid down on the diagram above, and showed how this theory violated, or failed satisfactorily to account for, Nos. 1, 4, 5, 7, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 21, each of which may be tested by the reader.

The Lacustrine theory would be found not open to the same objections. The great difficulty here was the nature of the dam, or barrier, that confined the waters of the lakes, of which the famous Roads were the successive shores or beaches. This theory was propounded, in 1817, by the far-seeing Macculloch, the eminent geologist, and early delineator of Highland scenery and geology; but he, along with others, had not condescended on the kind of barrier required. Two styles of dam had been contended for, the one of detritus, the other of ice. The Detrital dam, first suggested by Dick-Lauder in 1823, had been adopted by Milne-Home, who accompanied Robert Chambers to the region in 1847, and had written of it then, and twice since, with an amount of observation and detail that were of great and permanent value. These writers held that the lakes were contained by huge banks of *débris*, deposited by the sea and other causes, similar to that existing abundantly in many parts of the country. There was no doubt whatever that a large number of lakes, past and present, had been dammed back by such a barrier in many places; but if the roads were so formed, why were not such remarkable lines (whose character was unique) found elsewhere? Mr. Jolly here examined this theory in detail, in connection with the requisite Conditions, and held that it failed to satisfy many of them. How were these barriers so conveniently deposited at the required points, when the Great Glen, and the other valleys were, according to Milne-Home, filled with similar detritus? In the other lakes adduced by him, the outlets were *over the débris*, gradually wearing it away, while here they existed at the upper ends, flowing over hard rock. The roads ended abruptly on the hill face, with no remains of the asserted barriers, heaped up *at their extremities*, as might be expected, and was almost universal. How were the requisite great accumulations so effectively removed, reaching, as these must have done, to above 1,300 feet? The successive roads were on the same hill-face; so that the damming *débris* must have been wholly removed between the lines at their lower ends, before the new beaches were laid down. Mr. Jolly entered into other difficulties attending this theory, and finally concluded against it.

IV.—The Glacial Theory, as adopted

The Glacial theory was started by Agassiz, the great Swiss, who had been accustomed to the work of glaciers, after a visit paid to Lochaber in company with Buckland, in 1840. It has had the greatest number of adherents, Darwin and Lyell having also given up the Marine theory for it. Its chief exponent was Jamieson of Ellon, in an admirable paper published in 1863. Mr. Jolly, by means of a large survey map, variously coloured, entered into a careful explanation of the glaciation of the region. He held that the roads were produced by lakes dammed back by glacial ice, filling the lower parts of the valleys up to the ends of the roads, and gradually retreating with the ameliorating climate, *at the last stage of the second portion* of the Glacial epoch, immediately before the final disappearance of local glaciers from Scotland. The abundant rolled *débris* at the bottom of these valleys was laid down by former glaciers, and by the sea during the great depression in the *middle* of the Glacial period. He described the peculiar configuration of the Ben Nevis Range, with its parallel system of valleys opening out, on the south, to the close, deep Glen Nevis and its eastern continuation, and, on the north, to the broad Glen Spean and broader Glen More. The peculiarity of Glen Spean was that it would receive not only the abundant ice from the glens opening directly on it on the south, but also the greater part of the ice accumulated in Glen Nevis and its continuation, by the two outlets of Loch Treig and Glen Nevis itself. By this means, and by its special relation to the highest mountains in Scotland, it would receive an unusual supply of ice, equalled by no other valley in the country. This was proved not only by its geographical conformation, but by the superabundant glacial remains in the district, of which Mr. Jolly gave full details. During the first period of greater glaciation, the ice from Loch Treig, after entering Glen Spean, turned east down Loch Laggan, and west down the Spean; while Glen Roy itself was filled with an ice-stream from the same valley, which *moved out at its head, down the Spey*, as shown convincingly by the ice-markings there; and the Great Glen and its side valleys were also swathed in ice. As the climate improved at the *close* of the ice period, the glaciers gradually shrank backwards to their sources in the high Nevis glens, which, from their altitude and neighbourhood to the vapour-feeding Atlantic, would be the last in the country to preserve local glaciers. At that time, from its peculiar relations to these glens, Glen Spean would be filled from its head to the sea with a great ice-stream, resting on the *débris* already deposited by the sea, &c., and moving slowly downwards. This stream, entering the south end of Glen Roy, dammed back a lake there, fed by its tributary torrents, which has left its traces in the roads. As the ice gradually shrank in successive steps, the water subsided and the lake extended, as shown by these

lines. Mr. Jolly here pointed out the position of the successive contractions of the ice required to dam the lake, and described the abundant evidences of this last stage of the glaciers there, in scratchings, carried blocks, boulder clay, &c., and in the splendid horse-shoe moraines of the Treig glacier, lying intact across and along Glen Spean. He held that the lowest road extended up Loch Treig only a short distance, suddenly ceasing there, and not round the whole lake—an additional remarkable proof in favour of a glacier then filling that basin down to the ends of the roads, where a dam was necessary. Similar remarks were made regarding the Glen Gluoy and Glen Laggan parallels.

By means of coloured additions laid over the map, the state of the ice at this period, necessary to fulfil the requisite conditions, was graphically exhibited. Mr. Jolly concluded with an appeal to the Society to study the fascinating problem on the ground itself, so as to help to a final settlement of the much-debated question. Inverness had already done honourable work in connection with it, for the height of the lowest road had been first determined by an Inverness man, Mr. Wm. Paterson, sent there for the purpose in 1847 by Mr. Joseph Mitchell, at the request of Mr. Robert Chambers.

Mr. Horne, of the Geological Survey, Banff, and others, afterwards spoke on the subject, and a cordial vote of thanks was awarded to Mr. Jolly.

The reader may consult with advantage, for the better understanding of the subject, the admirable maps of the district of the Ordnance Survey, both the six- and one-inch, in which the Roads and the related phenomena are accurately and fully laid down; or the special Ordnance selected map of the locality, appended to the paper of Sir Henry James, mentioned above.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The authorities of both Girton and Newnham Colleges have supported the general memorial of 8,500 persons in favour of the admission of women to academical degrees and examinations, by informing the Senate in detail of their past proceedings, the number of their students who have been examined informally, none of whom have failed to attain Tripos standards; and both colleges believe that they will be able to offer sufficient guarantees of stability and good administration, so that the University can admit their students to full academical privileges.

Newnham College has now been fully constituted, with Prof. Cayley as president. Prof. Adams has ably aided the Women's Educational Association during the last seven years as president, and now retires, on the amalgamation of Newnham Hall with it, retaining his place on the Council.

Mr. R. C. Rowe, of Trinity College, is appointed an Examiner in the next Mathematical Tripos, and Mr. A. G. Greenhill Additional Examiner.

Dr. Alexander Dickson has been appointed Regius Professor of Botany in the University of Edinburgh and Keeper of the Royal Botanic Garden of that city in succession to Dr. Balfour, who resigned some time ago.

The new representative Council of Education in France has been completed by the appointment of a number of official members. M. Berthelot has been nominated President by the Ministry. A number of sections and special commissions have been established, amongst which we must direct attention to the Commission for Reforming Secondary Instruction. One of the principal features of the intended reform is to divide secondary instruction into three different courses, so that any pupil leaving the school after having gone through the elementary course might have a general knowledge of the principal subjects which are to be investigated more fully in the other two courses.

The University of the City of Pesth celebrated its hundredth anniversary in presence of the Emperor on the 13th inst.

SCIENTIFIC SERIALS

Annalen der Physik und Chemie, No. 4.—On the propagation of electricity through current water in tubes, and allied phenomena, by E. Dorn.—Thermic theory of the galvanic current, by J. L. Hoorweg.—On the cause of excitation of electricity in contact of heterogeneous metals, by F. Exner.—On diffusion of salts in aqueous solution, by J. H. Long.—On the relation between propagation of light and the density of bodies, by H. A. Lorenz.—On Stokes's law, by O. Lubarsch.—On after images of motion, by G. Zehfuss.—Supplementary note to the paper on currents of the Gramme machine, by O. E. Meyer and F. Auerbach.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, April 29.—"Measurement of the Actinism of the Sun's Rays and of Daylight." By Dr. R. Angus Smith, F.R.S.

When examining the air of towns and the effect of smoke and fogs, I have often wished for a very simple chemical method of measuring the total light absorbed by these gases, vapours, and floating solids. I do not undervalue the work of others, but I think I have obtained a process promising good results with great simplicity, although I daresay it introduces its own class of difficulties.

1. The fundamental fact is that when iodide of potassium in solution is treated with nitric acid, so small in quantity as to cause no change of colour in dull diffused light, a change takes place when the same mixture is brought into clear light; iodine is set free and the solution becomes yellow.

2. The amount of iodine freed can be titrated with great exactness by the use of hyposulphite, as is well known.

In these two facts lies the whole process: the first is the new part, the second makes the first quantitative, and its use is of course part of the novelty.

3. It is known that strong acid liberates iodine. Weak acid does so after a long time, but the process is hastened by light.

4. Heat even to the boiling point does not act so well as light (experiments being made in sealed tubes to prevent loss of iodine, and with a considerable volume of air).

5. Heat assists the action of light.

6. A solution may be exposed day after day so as to give the accumulated effect of sunlight, in a measurable condition at the end of the time.

7. The solution of iodide of potassium as hitherto obtained is subject to change. An old solution, that is, one nearly a month old, was found more sensitive than a new one in all cases tried.

8. The result of No. 7 is, that a certain allowance may require to be made for this, in those cases where the periods of observation with one solution are long.

9. The amount of allowance to be made for temperature is not made out. It is not certain that any is required in the cases when weak acid is used. The weather has not allowed any combined action of great light and heat, but with heat and light in the rays from an electric light with a parabolic reflector, the action was very rapid.

10. Specimens of experiments (prospective at first). It was found convenient to use a solution of 2 grms. of iodide of potassium, afterwards changed to 1 grm., in 100 of water, and to use half of this for an experiment, *i.e.*, 50 cub. centims. of the solution, which may be called A.

A nitric acid solution having an acidity equal to 1 per cent. of sulphuric anhydride was made; this may be called B. Only very small portions of B were added to A.

Examples in which the decomposition was measured by a solution of hyposulphite of sodium, which may be called solution C = 0·1 grm. per litre of iodine (or as convenient). I shall extract experiments made with B solution 0·8 cub. centim., because it is an intermediate one (·2, ·4, ·8, 1·6, and 3·2 have hitherto been the favourites).

1880.		B sol.		Measure by C solution (hyposulphite).
Mar. 3	Sunshine and cloud alternately	0·8	After 2½ hours	8·1. First colour in 20′.
,, 4	Sunshine	0·8	—	First colour in 30′.
,, 5	Dull all day	0·8	,, 4 ,,	0·9.
,, 8	Sunshine	0·8	,, 2½ ,,	7·5. Colour in 20.
,, 9	A little sunshine ...	0·8	,, 2½ ,,	4·8.
,, 10	Foggy, with a gleam of sunshine	0·8	,, 6 ,,	1·5.
,, 11	Bright	0.8	,, 2½ ,,	7·2.
,, 12	Dull and wet	0·8	,, 3 ,,	0 6.
,, 13	Dark and dull	0·8	,, 2½ ,,	Faint trace.
,, 15	Changeable	0·8	,, 2½ ,,	1·8.
,, 16	Changeable	0·8	,, 2½ ,,	1·6.
,, 18	Sun through haze ...	0·8	,, 2½ ,,	5·8.
,, 19	Bright	0·8	,, 2½ ,,	11·5.
,, 20	Fog till 11.30	0·8	,, 2½ ,,	3·2.
April 1	Sun and showers ...	0·8	,, 2½ ,,	1·6.

(*a*) 2½ hours' exposure to not very bright clouds; (*b*) in dark:—

(*a*) Temp. 12° C. in light. Sulphuric acid used, same acidity.	C sol. required.	(*b*) Temp. 20° C. in dark. Sulphuric acid.	C sol. required.
0·4	0·5	0·4	0
0·8	3·9	0·8	0
1·6	4·9	1·6	0
3·2	6·1	3·2	0

11. There seems, therefore, no reason to doubt that this is a true photometric process, with special capacities to be developed in time. I may add that I did obtain better results at the window of my house than at the laboratory at the same time, the latter being nearer the centre of the town; thus the process has done the duty it was intended for, although only once tried for this special purpose. I am looking to it as an agent specially for the examination of climate, but of course it may have many uses. This process does not aim at delicacy, but at accumulation of effect. I have not spoken of a standard; the results are only comparative, but the process may be made to supply its own standard.

12. Since writing the above it appears that by using sulphuric acid some of the fears at first entertained may be avoided, as is shown by the following extract:—

B sol.	C sol. required after 2½ hours' exposure of A to light.	C. sol. required after 50 hours' exposure of A to darkness.
0·2	7·6	0·3
0·5	15·1	0·6
1·0	23·4	0·6
2·0	30·4	0·7
4·0	43·6	0·7
6·0	53·8	1·3

The temperature of the solutions exposed to light = 13° C., kept in darkness = 22° C. The iodine volatilised by heat was found so little that it might be neglected here.

The strength of solutions and the kind of acid to be used may vary. Similar results may be got by using bromide of potassium, but it is less delicate. The surface exposed and other questions require attention.

Mathematical Society, May 13.—C. W. Merrifield, F.R.S., president, in the chair.—The following communications were made:—On Cremonian congruences, by Dr. Hirst, F.R.S.; on some statical and kinematical theorems, by Prof. Minchin; on a class of analytical problems, by Prof. Cayley, F.R.S.

Linnean Society, May 6.—H. T. Stainton, F.R.S., in the chair.—Three Foreign Members were elected.—Mr. T. Christy read a letter from Mr. Blacklaw, of St. Paulo, Brazil, intimating that his experiments to rear the Liberian coffee-plant had all failed, though different seasons, altitudes, and other conditions, without and indoors, had been tried.—The abstract of a paper by Prof. G. Dickie, notes on algæ from the Amazon, was read by the Secretary. This collection was made by Prof. J. W. H. Trail, and consists of 288 species, whereof 190 are diatoms, 31 desmids, and 67 other algæ, 9 of the latter being new forms.—Prof. P. M. Duncan orally communicated the substance of a paper on an unusual form of the genus *Hemipholis*, Agass. This was dredged by Dr. Wallich off the Algulhas Bank, S.W. of the Cape of Good Hope. Its zoological position may be doubtful, for the classification of the Ophiuroidea is at present full of anomalies; but the specimen itself nevertheless possesses unusual interest from the nature of the so-called dental or chewing apparatus. These peculiar dental structures and other points were elucidated by the author.—Mr. G. T. Bettany gave some remarks on the vocabulary of botanical terms in use in the description of flowering plants. The author advocated making a distinction between terms used in elementary descriptions in educational works and those used in the terse and complete floras. Under evolution there was much chance of botanical progress if terms were simplified and made such as children could comprehend; but almost every book aiming at comprehensiveness became obscure. Thinking it necessary to give every possible variety of terms and to add to them, it repelled, instead of aiding in the wide diffusion of knowledge. For these and other reasons the author strongly objected to the now too frequent use of tri- and polysyllabic terms.—Prof. Ray Lankester read a paper on the tusks of the fossil walrus found in the red crag of Suffolk. He withdraws the generic name of *Trichecodon*, instituted by him in 1865, and refers a series of later-discovered large tusks in the Ipswich Museum, as also his formerly-described specimens, to the living genus *Trichechus*, but specifically distinguished in this case as *T. Huxleyi*. He is inclined to think there is insufficient ground for the generic subdivisions *Alachtherium* and *Trichecodon*, as used by Van Beneden, and moreover signifies his opinion that there is yet no good evidence in support of the association of the Suffolk and Antwerp tusks.—A short communication, on an irregular species of *Amblypneustes*, by Mr. Chas. Stewart, was taken as read.

Zoological Society, May 4.—Prof. W. H. Flower, F.R.S., president, in the chair.—Mr. Sclater exhibited a specimen of the Ibis (*Geronticus comatus*), lately obtained at Biledjik, on the Euphrates, by Mr. Danford, and made some remarks on its previously-known distribution.—Dr. A. Günther read a note correcting the statement made by him at the meeting of the Society on January 20 last respecting the occurrence of *Holocanthus tricolor* on the British coast. Further particulars received by Dr. Günther had led him to decide that this fish could not be considered as having been caught on the British coast.—Mr. W. A. Forbes read a note on the cause of death of a leopard in the Society's menagerie.—Mr. Dobson exhibited and made remarks on some bones of the Dodo which had been transmitted from Mauritius in 1847-50 by Dr. F. Reid to Sir James Macgregor, and having been deposited at Fort Pitt, Chatham, were afterwards removed to Netley Museum.—Mr. F. Jeffrey Bell exhibited the immature specimen of *Echinolampas*, referred to by him in his communication on *Palæolampas*, pointing out its more differentiated characters, and suggested the possibility of its being an example of *E. oviformis*.—Prof. Flower called the attention of the meeting to the fact that a young specimen of the Lesser Fin Whale (*Balænoptera rostrata*), fifteen feet long, which had been taken off the coast of Cornwall, was now being exhibited in London.—A communication was read from Prof. J. O. Westwood, containing an account of the species of Saw-flies composing the Australian genus *Perga* of Leach.—A communication was read from Dr. W. J. Hoffman on a supposed instance of hybridisation between a cat and a lynx.—Mr. W. A. Forbes read the second and third parts of his series of papers on the anatomy of Passerine birds. These communications related to the syrinx and other points in the anatomy of the *Eurylæmidæ*, and to the structure of *Philepitta*, and its position among the Passeres.—A communication was read from Mr. F. Day, in which he gave the description of a new Entomostracon from Afghanistan.—Mr. Oldfield Thomas read a paper on a collection of mammals brought from Ecuador by Mr. Clarence Buckley. Among these was a new species of *Bassaricyon*, proposed to be called *B. alleni*.—Mr. A. G. Butler read a paper containing descriptions of a collection of Lepidoptera made by Major Howland Roberts at Rokeran, near Kandahar, on the River Urgundab.—Mr. G. French Angas read a paper containing further additions to the marine molluscan fauna of South Australia, with descriptions of six new species.—A second paper by Mr. Angas contained the descriptions of three species of marine shells from Port Darwin, Torres Straits, discovered by Mr. W. J. Bednall, and of a new *Helix* from Kangaroo Island, South Australia.

Geological Society, April 28.—Robert Etheridge, F.R.S., president, in the chair.—Rev. James Oliver Bevan, M.A., Arnold Hague, Augustus Constable Maybury, Henry Peter Meaden, William Peregrine Propert, and Francis Randell were elected Fellows of the Society.—The following communications were read:—Description of parts of the skeleton of an anomodont reptile (*Platypodosaurus robustus*, Ow.) from the trias of Graaff Reinet, South Africa, by Prof. Owen, C.B., F.R.S. The author referred to certain triassic reptiles from South Africa, already described by him, as showing certain resemblances to implacental mammals. Another still more interesting indication of such resemblances is furnished by some remains from Graaff Reinet received from Mr. E. J. Dunn. These consist of some thoracic vertebræ with portions of ribs, a sternal bone, a scapula, and a right humerus, found imbedded in one mass of rock, and of a femur and phalanges, and a pelvis in another mass. The author described these bones in detail. The vertebræ were said to agree most nearly with those of *Dicynodon* and *Oudenodon*. The supposed sternal bone is of a rounded hexagonal form, and is regarded by the author as the anterior bone of the sternum proper, which is usually unossified in recent lizards, but well ossified in *Ornithorhynchus*. In the scapula, also, the author pointed out resemblances to that bone in *Ornithorhynchus*. The humerus in its general proportions, and

especially in the great development of its ridges, was also shown to resemble the same bone in the Monotremes. The ungual phalanges were described as broad and obtuse, probably constructed to bear claws adapted for digging, as in *Echidna*; the femur also resembles that of the last-named animal. The author remarked upon these approximations to the monotrematous mammalia, in allusion to which he proposed the name of *Platypodosaurus robustus* for this animal, the humerus of which was 10½ inches long and nearly 6 inches broad at the distal end. He also alluded to the interesting problems opened up by the study of these South-African reptiles in connection with their possible relationships to the low implacental mammalia of New Guinea, Australia, and Tasmania.—Note on the occurrence of a new species of *Iguanodon* in the Kimmeridge clay at Cumnor Hurst, three miles west of Oxford, by Prof. J. Prestwich, F.R.S. The pit in which the occurrence of *Iguanodon* was discovered was worked in Kimmeridge clay at the foot of an outlying mass of Lower Greensand forming an isolated hill. The Portland beds, which occur at Shotover, are here wanting. The bones were found in a thin sandy seam intercalated in the clay, and traversing the hill at least fifteen feet below the greensand. The skeleton was probably almost entire; but, as attention was not directed to it until nearly all the clay had been removed, many bones were lost and others injured. Several vertebræ of *Ichthyosaurus* were found in the same seam, and the characteristic *Gryphæa virgula* occurred in profusion. The clay above and below contained fossils of Kimmeridge types. The author stated his opinion that land probably lay to the south-west of the Oxford district.—On *Iguanodon prestwichii*, a new species from the Kimmeridge clay, by J. W. Hulke, F.R.S. In this paper the author described in detail the remains of *Iguanodon* found at Cumnor Hurst in the Kimmeridge clay, as described in the preceding paper. They illustrated nearly every part of the skeleton of an immature individual, adding greatly to our knowledge of the variation of the vertebræ in the several regions of the vertebral column, and of the structure of the head and hind limbs. In the latter both the tibia and the fibula articulate (as in embryo birds) with the *os calcis*, which bone is now first identified in *Iguanodon*. The sacral vertebræ were only four in number, and the species further differed from the Wealden *Iguanodon mantelli* in the simpler character of the serration of the teeth, of which the lamellæ are not mammillated, and in having the vertebræ of the trunk and sacrum not so compressed. The author named the species *Iguanodon prestwichii*.

Institution of Civil Engineers, May 11.—Mr. W. H. Barlow, F.R.S., president, in the chair.—On the manufacture and testing of Portland cement, by Major-General H. Y. D. Scott, F.R.S., and Mr. Gilbert R. Redgrave.—On Portland cement concrete, and some of its applications, by Mr. E. A. Bernays.—On Portland cement: its nature, tests, and uses, by Mr. John Grant.

Anthropological Institute, May 11.—A. L. Lewis in the chair.—The following papers were read:—Notes on prehistoric discoveries in Central Russia, by C. H. E. Carmichael, M.A.—Notes on the occurrence of stone implements of the surface-period in South Russia, by W. D. Gooch.—Notes on the Western Regions, by A. Wylie.—On jade implements in Switzerland, by Hodder M. Westropp.—Flint implements from the Valley of the Banu, by W. J. Knowles.

PARIS

Academy of Sciences, May 10.—M. Edm. Becquerel in the chair.—The following papers were read:—On the transcendants which play a fundamental part in the theory of planetary perturbations, by M. Tisserand.—On a proposition of the theory of elliptic functions, by M. Hermite.—On a rain of dust observed from April 21 to 25, 1880, in the departments of Basses-Alpes, Isère, and Ain, by M. Daubrée. This dust gave a reddish tinge to snow on the mountains at Barcelonnette, up to 2,800 and 3,000 m. (snow further up remaining white). Its chief mineralogical characters were: effervescence with acids, mixture of hydrated peroxide of iron, presence of spangles of mica, residue of fusible acids, principally feldspathic. The dust is thought to be of terrestrial origin, but not volcanic, nor Saharan. (Somewhat similar showers fell in France in October, 1846, and May, 1863.) The same phenomenon seems (from another note) to have been experienced at Autun (Saône-et-Loire) on April 15, *i.e.*, ten days before.—On the crystalline form of magnesium, by M. Des Cloizeaux. Having examined the fine magnesium crystals lately obtained by M. Dumas, he finds that among the rhombohedric metals magnesium is that which, after zinc, presents the most acute primitive rhombohedron. The crystals in question are very malleable and sectile; no cleavage was observed.—On a Cicadella (*Hysteropterum apterum*) which attacks the vines in the department of the Gironde, by M. Blanchard.—On the law of reciprocity in the theory of numbers, by Prof. Sylvester.—On the new siphon established over the Canal Saint Martin, and on the works of sanitation of the Bercy quarter, by M. Levy. The sewers of Bercy (which formerly discharged into the Seine) are in some parts lower than the collector designed for them, and had to cross the Canal Saint Martin to reach this. An ingenious system of siphons and trompes was devised to meet the difficulty.—On linear functions, by M. Pellet.—Experimental researches on the decomposition of some explosives; analysis of products, by MM. Sarran and Vieille. This related to decomposition of explosives under a pressure near the atmospheric. In this case all the explosives liberate bioxide of nitrogen and carbonic oxide. It is important, then, in mining operations to avoid with all care failure of detonation.—On the determination of algebraic integrals of algebraic differentials, by M. Zeuthen.—On simultaneous linear equations and on a class of non-plane curves, by M. Picard.—On a class of functions of two independent variables, by M. Picard.—On the theory of phenomena of interference where rotatory polarisation intervenes, by M. Gouy. He takes a point of view of interference phenomena different from that of Fresnel, and superior in simplicity.—On the equipotential lines of a plane formed of two halves unequally conductive, by M. Guébhard.—On the mutual actions of magnetic needles plunged in liquids, by M. Obalski. Two magnetic needles are hung opposite each other (and a little beyond the range of attraction) by two unlike poles from very fine threads over water in a vessel, which water can be raised gradually over them (by means of a connected tube of caoutchouc). When immersion begins, the needles draw near each other by their immersed parts, and when the immersion has reached the third or fourth of the needles' length, they go together. This is probably due to the separating force of gravity being weakened by immersion.—Analysis by the graphic method of movements produced by excitations of the brain, by MM. François Franck and Pitres. To the detached tendon of a limb-muscle they attached the transmitting myograph; an electro-magnetic signal (of M. Deprez) registered the time on the drum, and another signal the excitation. The character of movements caused by various electrical excitations is described. As to retardation of the movement on the instant of cortical excitation, this is found constant for a given muscular group in the same animal, whatever the form or intensity of the electric excitant. A notable part of it is due to physiological resistance of the grey cortical substance. Beyond a certain intensity of stimulation movements are produced on the same side of the body as the part of brain stimulated, as well as on the opposite, and the retardation for these movements is greater. The retardation is greater for hind than for fore limbs.—On a rain of dust at Autun, by M. De Jussieu (see above).—M. De Lesseps presented specimens of silver ore from California, and gave some information about Mr. Mackay's mines at Virginia City, the galleries of which have been pushed about 1,000 metres, a depth hardly exceeded in Europe (Bohemia). Descent is by means of hydraulic motors.

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ERRATA.—Vol. xxi. p. 202, col. 2, line 5 from bottom, for "Lethö" read "Pethö"; p. 220, col. 2, line 22 from bottom, for "Lethö" read "Pethö."