THURSDAY, APRIL 17, 1879

THE AUSTRALIAN AND TASMANIAN RACES

The Aborigines of Victoria, with Notes relating to the Habits of the Natives of other Parts of Australia and Tasmania. Compiled from various sources for the Government of Victoria by R. Brough Smyth, F.L.S., F.G.S., &c. 2 vols. (London: Trübner and Co., 1878.)

IN these two bulky volumes we are for the first time presented with a really comprehensive account of the natives of Australia; and by their timely publication under the auspices of the Victorian Government an emphatic reply is given to the charge often brought against the colonists of indifference to the past history, present condition, and ultimate fate of those races. The work, whose title gives a very imperfect idea of its varied contents, may be best described as a complete encyclopædia of Australian folk-lore, as complete, at least, as a judicious utilisation of all available materials could render it. As such, its appearance may fairly be regarded as an "epoch-making" event in the progress of ethnological studies, performing much the same office for the Australian that the writings of Castren, Uslar, and Bleek, and the Schoolcraft series have done for the Finno-Tartar, Caucasian, South-African, and North-American races. In the character and selection of the subject-matter it bears most resemblance to this last-named compilation, while differing widely from it in the method of its treatment, the confusion and discordant elements inseparable from Schoolcraft's erratic plan being here avoided by a clear arrangement of the materials and a uniform system consistently adhered to throughout.

A large portion of the work, it should be mentioned, has been composed by the distinguished geologist, Mr. R. Brough Smyth, at intervals during the sixteen years he has acted as secretary to the Board for the Protection of the Victorian Aborigines. In this capacity he has had exceptional opportunities of obtaining the most reliable information regarding the natives of that colony, who naturally occupy the largest share of attention. But the others are by no means neglected, and the subject is rendered sufficiently complete by several valuable papers on the tribes of New South Wales, Queensland, South and West Australia, supplied by the Rev. W. Ridley, Philip Channey, J. Moore Davis, and other contributors, all speaking from personal knowledge of the facts.

Besides an able introduction of some fifty pages, surveying the whole field and imparting a certain unity to the work, the first volume is devoted to strictly ethnological subjects. Under twenty separate headings the physical and mental qualities of the aborigines, their social habits, daily life, food, diseases, dress, weapons, implements, manufactures, and myths, are treated in detail. The general impression produced by a careful perusal of the vast array of facts here brought together is, that the "black-fellow" is not nearly so black as he has been painted, a statement which is quite as true in the material as it is in the moral sense of the word. Thus the prevailing colour is represented as not black at all, but rather a "chocolate brown," sometimes inclining to black, sometimes of a lighter hue, and it may be remarked that this is supported by the independent testimony of Richard Oberländer, a most accurate observer, who expressly states that "die Haut ist nicht schwarz, sondern von dunkler Kupferfarbe" ("Der Mensch vormals und heute," Leipzig, 1878, p. 41). The hair also, though in some cases jet black, would appear to be more frequently of a "deep brown," and with boys and girls, "in colour brown, not very dark" (i. p. 5). This, combined with its wavy character ("crisp," "waved," *passim*, but never "woolly" or even "frizzly," like the Papûan), will be regarded by many anthropologists as conclusive of the mixed origin of the aborigines. On this interesting point the compiler unfortunately throws very little light, though he adopts the view held by many, that "there are in Australia two distinct races of men, one of which is clearly of the white variety" (i. 328). By "the white variety" he obviously means what is commonly understood by the "Caucasian" type, and the countenance here and elsewhere given to the belief in the presence of a Caucasian element in Australia is one of the weak points of the work. The curious lists of words adduced, though with some reserve and hesitation, in support of a community of speech carries us back to the days when etymology did duty for science. Thus the native terms *kurrin*, *trippin*, *throkkun*, are compared with the English *inquiring*, *dripping*, *throwing*, leaving the impression that there might possibly be some sort of connection between a native verbal ending *in*, *un*, and the quite recent English verbal ending *ing*—recent, at least, in its modern participial and gerundial senses. Of course, those who bring together such fanciful comparisons have no sense at all of the growth of language, but they might have common sense enough to reflect that it is a growth, and consequently that in the case of idioms assumed to have been originally one, the comparisons must be made not between subsequent historical developments, but between primitive organic elements, if any such exist in common. Then when they have exhausted English, Anglo-Saxon, Greek, Mœso-Gothic, Sanskrit, they rush off to Hebrew, Phœnician, and especially Tamulic and Telugu, without reflecting that, however mixed, the Australian tongues can hardly be made up of such utterly discordant elements as Aryan, Semitic, Dravidian, or that if they are Aryan, they cannot be Dravidian, and so on; hence that their etymological method, proving too much, proves nothing, or, in other words, is unscientific. It is much to be regretted that these simple principles are not more generally understood, and that too many otherwise valuable ethnological works should still continue to be disfigured by linguistic discussions which, a generation or so hence, will be looked upon as amusing anachronisms.

The sections devoted to the native weapons, stone implements, canoes, &c., are of great interest to the anthropologist, who will here find more than one long-cherished doctrine rudely shaken. Thus the argument for a common Australoid race, embracing the Australians, natives of the Deccan, and others, based on the supposed identity of the boomerang with the Indian throwing-stick is shown to be utterly worthless. The question of the resemblance between the *wonguim* or true returning boomerang and other similar weapons met with amongst other ancient and modern peoples is discussed at considerable length, and the result thus briefly summed up in the introduction:—"Those who have seen such a wonguim thrown by a native accustomed to its use, need not be told that the statements published from time to time in the scientific journals in Europe are founded on imperfect information, or dictated in an unphilosophical spirit by a too great desire to prove that the Dravidian races of the Indian Peninsula and the ancient Egyptians belong to the Australoid stock, and that the boomerang was known to the Egyptians. . . . . There is nothing to show that anything like the wonguim was known to any other people anywhere at any time, and it is at least doubtful whether any weapon resembling the barngeet [*i.e.*, the war boomerang that does not return] was known to the Egyptians. The wonguim and barngeet are altogether different from the saparu, or sickle-shaped sword, which is represented on Babylonian and Assyrian cylinders as the weapon of Merodach or Bel." Thus the boomerang goes the way of the etymologies, though it is but fair to add that the famous passage quoted at p. 327 of vol. i. from St. Isidore of Seville, descriptive of the Gaulish or Teutonic *cateia*, "Genus Gallici teli ex materia quam maxime lenta; quæ, jactu quidem, non longe, propter gravitatem, evolat, sed ubi pervenit vi nimiâ perfringit. *Quod si ab artifice mittatur rursum reddit ad eum qui misit.* Hujus meminit Vergilius dicens. *Teutonico ritu soliti torquêre cateias.* Unde et eas Hispani *Teutones* vocant" ("Origin." xviii. c. vii.), has not been satisfactorily got over. At the same time it may not be superfluous to remember that Gauls and Teutons were not Dravidians, and that, notwithstanding its return motion, the *cateia* was not necessarily a *wonguim*, for other weapons also can be made to behave in the same way. The author regards the boomerang as of native invention, and adds that it is not known in all parts of the Continent, and has not been found in New Guinea or Tasmania.

In the section devoted to the subject of canoes, another popular error is exploded, for it is here abundantly shown that seaworthy boats made of the bark of the gum-tree, and evidently of native invention, were common in the south and east, and not merely on the north coast, where they might have been introduced by the Papûans from New Guinea, or the Malays from the Eastern Archipelago. On the other hand, the practice of cannibalism, about which doubts have always been entertained, is fully confirmed. "It cannot be denied that cannibalism prevailed at one time throughout the whole of Australia. The natives killed and ate little children, and the bodies of warriors slain in battle were eaten. . . . . It is sad to relate that there are only too many well-authenticated instances of cannibalism," &c. (Introd. xxxvii.). It may be added that some years ago the writer received direct evidence of an undoubted case from a lad named Benedict brought to Europe by Dr. Brady, formerly Roman Catholic Bishop of Perth (West Australia), and who assured him that his own little sister had been "speared, roasted, and eaten" by a hostile tribe near New Norcia.

The current views regarding the extremely low mental capacity of the natives, and even regarding their moral qualities, are in other respects shown to be entirely at variance with the truth. In such a wide area there are, of course, great mental as there are great physical differences. But the author's assertion that the estimate commonly entertained of their intellect is, on the whole far too low, seems to be fully borne out by the evidence here accumulated. Though without permanent dwellings, they make provision for the future, construct permanent works of art, have a common property in some things, respect each other's rights, are skilful hunters, have five different ways of catching fish, and are far less cruel and ferocious than many savage races usually regarded as their superiors. They have a keen sense of justice, though their standard of right and wrong, and their notions of political economy may be different from ours, as is evident from the language addressed to Mr. G. F. Moore, Advocate-General of West Australia, by *Yagan*, Chief of the Upper Swan tribe, in the year 1843: "Why do you white people come in ships to our country and shoot down poor black fellows who do not understand you? You listen to me! The wild black fellows do not understand your laws; every living animal that roams the country, and every edible root that grows in the ground, are common property! A black man claims nothing as his own but his cloak, his weapons, and his name! Children are under no restraint from infancy upwards; a little baby boy, as soon as he is old enough, beats his mother, and she always lets him! When he can carry a spear he throws it at any living thing that crosses his path, and when he becomes a man his chief employment is hunting. He does not understand that animals or plants can belong to one person more than to another. Sometimes a party of natives come down from the hills, tired and hungry, and fall in with strange animals you call sheep; of course, away flies the spear, and presently they have a feast! Then you white men come and shoot the poor black fellows! But for every black man you white fellows shoot I will kill a white man! And the poor hungry women have always been accustomed to dig every edible root, and when they come across a potato garden, of course down goes the wanná (yamstick), and up comes the potato, which is at once put into the bag. Then you white men shoot at poor black fellows. I will take life for life" (ii. p. 228). And so the comedy is played out, until there are no more "black fellows" left on the scene, and when they are gone the white man does them, perhaps, the tardy justice to admit that he never understood them, and that they were not, after all, quite so bad as he had supposed.

At one time the natives were thought to be so stupid that they could not recognise the pictures or other representations even of such familiar objects as kangaroos, emus, or gum-trees. But so far from that being the case, they are here shown to be tolerably expert draughtsmen; and at p. 258, vol. ii. there is given a facsimile of a drawing of some squatters by a native lad, in which the attitudes and expressions are admirably delineated, "clearly indicating the humorous train of thought passing through the mind of the artist, who must have been a close observer and a good mimic."

From the facts adduced in the section devoted to the native myths it is evident that they have some notion of a future state, though their ideas of the deity are often somewhat crude, and their conception of the universe decidedly materialistic. Thus we are told that *Bun-jil* created all things, but he made no women. Bun-jil has a wife named *Boi-boi*, a son named *Bin-beal*, and a brother named *Pal-ly-yan*, and though the creator of all things, yet he had help from his son and brother. He always goes about with a large knife, and after making the earth he went all over it, cutting and slashing it into creeks and rivers, mountains and valleys. Such, at least, is the belief of the Boonooreng tribe, Coast of Victoria. But, on the other hand, that of the Barwen tribe differs little from the Christian conception; for their account is that *Baiame* (lit., the *builder*, *shaper*, cf. *Schöpfer*) made earth and water and sky, animals and men. "He makes the rain come down and the grass grow;" he has delivered their fathers from evil demons (cf. the mediæval doctrine of demonology); he welcomes good people to the great *warrambool*, *i.e.*, watercourse and grove, in the sky—the Milky Way—a paradise of peace and plenty; and he destroys the bad" (cf. Revelations, *passim*). Indeed, the parallel is often so striking, that a suspicion sometimes arises whether these myths may not be spurious, mere travesties of the Christian doctrines disseminated by the missionaries amongst the natives, and improved upon by them for the benefit of over-zealous collectors of popular traditions. The doubt is raised in this work, but not always removed. Some, however, are undoubtedly genuine, as, for instance, the account of the River Murray, which was made by a snake. "He travelled from the head of the river to the mouth, and as he went along he formed the valley and the bed of the river." But in doing this he disturbed the crow, which was perched on a tree, be came angry, and cut him into small pieces. The pieces are left where the Hindu myth leaves the turtle that supports the elephant upholding the globe.

The second volume is mainly devoted to the native languages, but also contains a series of appendices consisting of a number of papers on incidental subjects supplied by the contributors already referred to. Of these the "Notes on the System of Consanguinity and Kinship of the Brabrolong Tribe," by A. W. Howitt, and the monograph on "The Crania of the Natives," by Prof. Halford, of the Melbourne University, are specially interesting. The latter, which is a very valuable contribution to anthropological studies, is illustrated by a series of carefully made drawings of five skulls, by Major Shepherd, from four different points of view, and is accompanied by complete tables of measurements on the plan recommended by Prof. Cleland, and for the purpose of "obtaining national distinctions of a most exact description." Amongst these skulls is that of "King Jemmy," of the Mordialloc tribe, which presents some very remarkable peculiarities. It is of an extremely brutal type, in the front view showing a mid-rib running along the top, like the crest of a gorilla, and bounded on either side by a temporal ridge, which, with immense orbits, nasal fossæ, and prognathous upper-jaw, give it a most ape-like appearance. Jemmy, lately deceased, is not stated to have been of an abnormal type; and the side view, in which the brutal aspect disappears, conveys rather the impression of a skull of large capacity.

The philological section, occupying altogether 220 pages, does not consist of a systematic treatise on the native languages, but is made up of a number of papers by more or less competent hands, on a large number of Victorian dialects. Some of these papers, as might be expected, are very sketchy and superficial, but others are extremely valuable, containing, besides vocabularies, many grammatical features, short specimens and sentences accompanied by verbatim and free English translations. Ample materials are here supplied for forming at least a general idea of the nature of these idioms, and often of their mutual relations to each other. It is obvious that while all are strictly agglutinating, and so far of uniform structure, they do not stand on the same level, some being much more highly developed than others. They also agree in the general employment of pronominal suffixes instead of prefixes; but this is such a common feature that no conclusions can be drawn from it as to their mutual affinities, still less, as has been argued, for a possible relationship with the Dravidian linguistic group. Owing to their different stages of development, the grammar of some is far more regular and consistent than that of others, and the Lake Hindmarsh dialect, amongst others, is specially interesting, in its present state clearly showing the growth of true inflexion by the gradual absorption of detached pronominal elements. This will be made evident by comparing together the first and second persons singular, present, and future, of the two verbs *woarta* (to come) and *nyä-ngä* (to see) which are as under:—

Present	woartin yan woartin yar	Present	nyangan nyangar
Future	woartin yuan woartin yuar	Future	nyakinyan nyakinyar

Here we see in the first column the full pronouns *yuan yuar* of the future reduced in the present to *yan* and *yar*, while in the second column they become in both cases fused with the root. It is easy to understand from this example how the fusion might, in course of time, become the universal law, and how the language might pass thence rapidly from the agglutinating to the purely inflecting state.

Amongst the arguments here advanced in support of the view that all the Australian languages flow from a common source is one based on their generally defective numeral system. The dialect spoken near Wickliffe, Western Victoria, has distinct words for 1, 2, 3, 5, and 6; but this seems to be almost a solitary case, and it seems safe to say that as a general rule the native arithmetic is limited to the first two numerals, beyond which reckoning becomes a series of sums in addition, which even then scarcely ever gets beyond 10. A typical instance is the Lake Hindmarsh system, which runs thus: (1) Ke-yap; (2) pullet; (3) pullet ke-yap *i.e.*, 2 + 1); (4) pullet pullet (2 + 2); (5) pullet pullet ke-yap (2 + 2 + 1), &c. It is also interesting to note the very general prevalence of the word for 2—*pullet*, *bullat*, *pulla*, *bulla*, *bolita*, *polail*, &c., occurring in most of the dialects all round the south and east coasts, and reaching far inland, especially in Queensland and New South Wales. This may be accounted for either by supposing that some more advanced tribe at some remote period evolved the idea of *two*, and passed it on to its neighbours, or that it had been evolved before the dispersion. In the first case it would afford no argument for the original unity of the race; in the second we should have to believe that since the dispersion scarcely a single tribe ever got beyond that low stage of development. But this would seem to be altogether incredible, when we reflect on the immense lapse of time intervening since the dispersion, as shown by the vast accumulations of kitchen middens on many parts of the coast, and by the numerous stone implements that are constantly being turned up, some belonging to an age answering to the Neolithic, some even to the Palæolithic period of Europe. "Chips for cutting and scraping, fragments of tomahawks and pieces of black basalt are found on the low silurian ranges near the rivers and creeks in all parts of Victoria; and wherever the soil is dug or ploughed over any considerable area, old tomahawks are turned up, thus showing the immense period of time that the land has been occupied by the native race." Introd. lvii. Some of the kitchen refuse heaps are over an acre in extent, and "there are also some large shell-mounds on the coast, especially near Cape Otway, where the largest is about 300 feet long, 40 or 50 feet wide, and 16 feet high. It must have taken ages for the fish-eating natives of the coast to build up such heaps" (ii. 234). It seems inconceivable that during all these ages they should never have made a single step in advance of the numeral "two," assuming that this had been inherited from the outset. Hence the first hypothesis appearing to be the most reasonable, the argument for racial unity based on the general currency of the word for "two" falls to the ground. All the reasons for the prevalent belief in the original unity of the Australian languages are briefly resumed at pp. 43 and 44 of Introduction. None of them, except that drawn from their common phonetic system is, perhaps, very cogent; but altogether, taken in connection with other circumstances, go a long way towards justifying the general conclusion arrived at by Threlkeld, Grey, Schürmann, Moore, Bulmer, Hartmann, Hagenauer, and nearly all recent Australian philologists.

The work is rendered still more complete by a final section devoted to the Aborigines of Tasmania. Here nearly everything is brought together that is ever likely to be known regarding the physical and mental characteristics, habits, speech, implements, dress, ornaments, &c., of that extinct race. The difficult question of their origin and affinities is fully discussed, and ethnologists will feel specially thankful for the reprint of Dr. Joseph Milligan's valuable paper "On the Dialects and Language of the Aboriginal Tribes of Tasmania and on their Manners and Customs," which appeared originally in the Journals of the Royal Society of Tasmania. The importance of this contribution to Tasmanian ethnology is due to the fact that the compiler "was for many years Medical Superintendent of the Aborigines' Establishment, first at Flinders Island, and afterwards at Oyster Cove, to which the remnant of the race was removed in the year 1848" (ii. p. 480).

Mr. Smyth evidently regards the Tasmanians as belonging to a different stock from the Australians. They "are darker, shorter, more stoutly built, and generally less pleasing in aspect than the people of the continent. Their hair was woolly and crisp, and some bore a likeness to the African negro. Their aspect was different from that of the Australians. In their form, their colour, and their hair they were rather Papuan than Australian" (Introd.," lxix.). This last sentence probably goes very near the truth, and there can be little doubt that the island was peopled "by some members of the dark-skinned populations of the north" (lxxi.). Their woolly [1] or at least frizzly hair is alone conclusive as to the presence of Papûan blood. But there are, on the other hand, scarcely less clear indications of Australian affinities. The compiler himself admits that "they were not all alike," adding that "there is reason to believe that the members of some tribes were scarcely distinguishable from the Australians" (ii. 379). On the whole, the balance of evidence goes to show that they were a mixed race in which the Papûan element was predominant, and in which special features had been developed by long local seclusion.

This race is generally stated to have become extinct with William Lanney and Truganina ("Lalla Rookh"), the former of whom died in March, 1869, the latter in June, 1876, but some half-castes are still living, "and it is nearly certain that the blood will mix with that of the whites and never be lost. But the race, the traditions of the race, and the language are lost for ever" (ii. 384).

It remains to be stated that the work is well printed and richly illustrated throughout. It is also supplied with an index, which might be fuller, and with two maps on a large scale—the Australian Continent and a tribal map of Victoria. The few misprints that occur will doubtless be corrected in future editions, when the curious English sentence at p. 79, vol. ii., beginning with "However I am inclined," might also be re-cast. There seems to be also something wrong with the paradigm given at p. 30, vol. ii. of the verb *to go*, unless it be made up of three different roots (*Yangan*, *blanga*, and *plapa*); but if so, the fact should be stated. As it stands, the arrangement of tenses is about as intelligent as that of the same verb in popular English and French grammars.

A. H. KEANE

[1] "As woolly as that of any native of Guinea" (Cook); "black and woolly" (R. N. Davies); "woolly hair" (Lieut. Breton); "courts, laineux et crépus" (M. F. Péron).

ON THE MAGNETISM OF ARTIFICIAL MAGNETS

Sur le Magnétisme des Aimants Artificiels. Par V. S. M. van der Willigen. (Haarlem: Les Héritiers Loosges, 1878.)

VISITORS to the Loan Collection of Scientific Apparatus at South Kensington in 1876 will remember a remarkable series of permanent steel magnets contributed from the museum of the Teyler Foundation of Haarlem. Most of these were the work of a famed artificer of the name of van Wetteren, who during a period of thirty years has been occupied in the construction of magnets of excellent quality, under the advice and with the co-operation successively of MM. Logeman, Elias, and van Willigen. The last named of these, whose posthumous monograph lies before us, devoted himself for the last four years of his life to important researches in magnetism.

The memoir, published originally in the *Transactions* of the Teyler Museum, commences by explaining the methods adopted in fusing, tempering, and magnetising the bars of steel. A succeeding chapter describes the methods employed in measuring the distribution and amount of their magnetism. Then come three long chapters recounting very minutely the details of the dimensions, weight, strength, &c., of no less than forty-six individual magnets, together with particulars of the successive magnetisations imparted to them. The work concludes with a discussion of results and of the formulæ for empirically representing them, and with a brief obituary notice of the author, by Dr. Figee.

It appears from the observations of the constructor, van Wetteren, that bars of steel of apparently equally good qualities in other respects will not make equally good magnets; a point which the author tells us he was unwilling to recognise until he found all the magnets fabricated from one bar inferior to *all* the magnets fabricated from a bar of what appeared to be equally good steel. English bar steel was found inferior by comparison with that manufactured on purpose by M. Wetteren, but the author confesses his inability to assign any reason for the inferiority. Concerning the details of forging and tempering a judicious silence is maintained. The method of magnetisation which was found most efficacious both for bar and horse-shoe magnets, was to place their extremities upon the poles of a powerful electro-magnet of the form constructed by Ruhmkorff for diamagnetic experiments; and then, while thus magnetised above saturation, to remove them after having applied the appropriate keeper. For magnets weighing so much as half a kilogramme an Elias ring was also applied as an auxiliary in the process of magnetisation. The maximum power was not developed until after two or three such magnetisations, the keeper being momentarily removed between each repetition. Reversal of the poles always produced consequent points. The methods of touch, the best of which the author considered to be Hoffer's method of stroking the horse-shoe magnet with a second horse-shoe of soft iron from the poles toward the equator of the magnet, he finally rejects, *in toto*, as being hurtful to the strength and regularity of distribution of the magnetism.

The most important part of the memoir is that devoted to a discussion of the portative force of magnets. Häcker has given the ratio between the portative force of a horse-shoe magnet and that of a bar-magnet of the same weight and length as two to one. M. van Willigen found the ratio with an actual magnet of Häcker to be as three to one; and with van Wetteren's magnets more than four to one. The empirical formula assigned by Bernoulli to express the relation between the weight of a magnet and its portative force is—

$$p = C R^{\frac{2}{3}},$$

where p is the weight which the magnet will sustain, R its own weight, and C a coefficient dependent on the quality of steel and other undetermined conditions. A magnet was adjudged good by the author's standard for which Bernoulli's coefficient had a value of 20 or 21; though 22·5 was occasionally attained. The empirical formula now assigned by van Willigen for the portative force of supersaturated magnetisation is—

$$P = \alpha K \sqrt{S} . \sqrt[4]{\frac{l}{\sqrt{S}}} ;$$

and for the permanent portative force—

$$p = \beta K \sqrt{S} . \sqrt[4]{\frac{L}{\sqrt{S}}} \cdot \frac{L}{l}$$

where K is the perimeter and S the area of the polar surfaces, l the length of the bar, L the reduced length (or distance between the actual poles or points of maximum free magnetism), and α and β two coefficients depending on temperature, quality of steel, temper, &c. It will be seen that since for magnets of similar form the quantity $K\sqrt{S}$ is proportional to the $R^{\frac{2}{3}}$ of Bernoulli's formula, M. van Willigen has determined that factor of the coefficient which is concerned with the length of the magnet and the position of its poles. It would be interesting, though out of place here, to compare these results with those recently obtained by M. Petrowchevsky in his researches on the distribution of magnetism in magnets.

The author falls into the common error of ascribing to M. Jamin the invention of magnets made of laminæ of steel bound together in bundles. Magnets of this description were employed by Dr. Scoresby in his Arctic explorations at the beginning of the century, and may still be seen in the Whitby Museum, where they are deposited. Similar magnets were in even earlier use by Duhamel and Coulomb; and a magnet almost the counterpart of those of Jamin is described in a memoir on magnets by Geuns published at Venlo, in Holland, in 1768.

SILVANUS P. THOMPSON

OUR BOOK SHELF

Mittheilungen aus dem k. zoologischen Museum zu Dresden, herausgegeben mit Unterstützung der königlichen Sammlungen für Kunst und Wissenschaft. Von Dr. A. B. Meyer. Drittes Heft, mit Tafel XXVI.-XXXV. (Dresden: Baensch, 1878.)

DR. MEYER has now issued the third volume of his "contributions" to science from the well-filled stores of the Dresden Museum—a volume which quite equals its precursors in value and interest. The Director first gives us an account of his new cases for the exhibition of zoological objects, and supplies exact details as to their cost. These particulars may be useful for those engaged on the fittings of several other national museums which are now in process of erection. A contribution from M. Edm. de Selys-Longchamps, which follows, contains a general account of the dragon-flies of New Guinea and the Moluccas, and descriptions of a large number of new species of these insects. We have next an account of the human skeletons and skulls in the Dresden Museum, drawn up by the Director and Herr E. Tungel jointly. The number of skulls in the collection is stated to be 836. We have then an important article by our countryman, Mr. R. Bowdler Sharpe, on the collections of birds belonging to certain groups, made by Dr. Meyer during his expedition to New Guinea and the Moluccas. The groups treated of in this paper are the Accipitres, Dicruridæ, and Campophagidæ, of all of which divisions Dr. Meyer obtained a goodly series of specimens, embracing among the Campophagidæ examples of nine new species.

Dr. Kirsch, the Entomologist of the Dresden Museum, follows Mr. Sharpe with descriptions of some new wasps found in the collection, and the volume is concluded by a second portion of Dr. Meyer's memoir on the Papuan skulls of which he obtained such a splendid series during his Eastern Expedition.

It is quite evident that the present director of the Dresden Museum is not only capable of doing good work himself, but is likewise able to extract good work out of other people—a task often more hard to be accomplished than the former one.

The Countries of the World. By Robert Brown, M.A., Ph.D. Vol. iii. (London: Cassell.)

THIS volume is devoted to Central and South America, and appears to us to present a fairly full and trustworthy and certainly interesting account of the countries of this most attractive region. Dr. Brown has evidently taken the trouble to search most of the authorities likely to help him. The illustrations to this volume are unusually good and appropriate.

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.*]

A Carnivorous Goose

I INCLOSE to you an account of a Golden Eagle, which I have reason to know to be authentic. The possibility of a bird so purely graminivorous as a goose being taught to eat flesh, and acquiring the power of digesting it, is extremely curious. It is well known, however, that cows are largely fed on fish offal in Scandinavia, and I have heard of a Highland cow devouring a salmon which an unwary angler had hid among fern on the banks of a river in Sutherland. ARGYLL

Isola Bella, Cannes, April 7

"March, 1879.—There is in the possession of W. Pike, Esq., at Glendarary, in the Island of Achil, Co. Mayo, a Golden Eagle, now about twenty-five years old, which was taken from the nest and brought up in confinement. This eagle, in the spring of 1877 laid three eggs, which Mr. Pike took away, replacing them with two goose-eggs, upon which the eagle sat, and in due time hatched two goslings. One of these died, and was torn up by the eagle to feed the survivor, who, to the great tribulation of its foster-parent, refused to touch it, together with the other flesh with which the eagle tried to feed it, Mr. Pike providing it with proper food. The eagle, however, in course of time, taught the goose to eat flesh, and (the goose having free exit and ingress to the eagle's cage) always calls it by a sharp bark whenever flesh is given to it, when the goose hastens to the cage and greedily swallows all the flesh, &c., which the eagle, tearing its prey to pieces, gives it.

"I saw them in May, 1878, when, the goose being a year old, had made a nest in the eagle's cage, and laid eleven eggs, and the two birds were sitting side by side on the nest. I hear from Mr. Pike that he did not allow them to hatch out, fearing that it might interfere with their attachment to one another.

"The eagle is very tame and fond of Mr. Pike; he goes into the cage, and it allows him to handle it as he likes, but will not allow any one else near it. It never attempts to get out of the hole made for the goose to go in and out."

Sense of Force and Sense of Temperature

THE sense of force, or of resistance to pressure, and the sense of temperature, have been very commonly confounded under one name, "sense of touch." Indeed, I think they are still imperfectly distinguished in many modern works dealing with the subject of sensation. Nevertheless, there can be no doubt as to these two being sensations altogether distinct. It is even quite probable that they are observed and transmitted by distinct nerve-systems.

An important and interesting question arises as to the kind of information given to us by these two senses; viz., how far it is merely relative, and how far these senses may, by cultivation, be made to give us absolute information.

So far as the sense of force is concerned, it is with most persons chiefly relative. Every one is prepared to say, but generally very roughly, that of two bodies, A and B, A is heavier than B. To test their relative weights we lift first the one and then the other, and decide between them. Sometimes we may go a little farther towards making an absolute estimate by means of the sense of force. I can tell, for example, that a weight is greater than 20 lbs. and less than 30 lbs. by trying to hold it out at arm's length; and most likely with a little practice I could learn to estimate weights to within closer limits than 5 lbs. on each side of 25 lbs. But such testing as this is all that is done in ordinary cases.

There is, however, a very remarkable case in which the sense of force is made absolute to a high degree by practice. It is the case of letter-sorters in the Post Office, who learn to distinguish letters that are over a particular weight with accuracy that is perfectly marvellous. It would be very interesting to try a series of experiments with letters of different weight, some slightly under weight for a particular postage, and some slightly overweighted, and to observe the errors or rather the limits of uncertainty.

The sense of temperature may also be rendered absolute to a certain extent. Several instances might be mentioned, some of which depend, as in the case of testing force by lifting the greatest possible weight in a particular way, on the limit of endurance.

One remarkable case of an absolute determination of temperature by the senses is that of the plumber and tinsmith who are in the habit of holding up the soldering bolt to the face, and judging by feeling whether it is at the proper temperature for a particular piece of work in hand.

Probably there are other cases in the arts in which the sense of temperature is cultivated to a high degree. It is in the hope of getting information on this subject through your readers that I address this note to you. J. T. B.

April 7

Did Flowers Exist During the Carboniferous Epoch?

MR. A. R. WALLACE, in his review of Mr. Allen's, "The Colour Sense" (NATURE, vol. xix. p. 501), has been misled in supposing the fossil insect from the Belgian coal-fields, named *Breyeria borinensis* may be a moth. It was originally described as the hind wing of an orthopterous insect, under the name of *Pachytylopsis borinensis* (*Comptes Rendus*, Soc. Ent. Belg. xviii. p. xli). Subsequently it was transferred to the lepidoptera on bad advice, and re-named *Breyeria borinensis* (same *Comptes Rendus*, p. lx.). Its original location was nearer the truth. I examined the fossil at Brussels in 1877, and have no doubt it belongs to the pseudo-neuroptera, family Ephemeridæ (*vide* my note to this effect in the same *Comptes Rendus* for 1877, xx. p. xxxvi.). The very dense transverse reticulation did not receive sufficient importance when M. de Borre was induced to refer it to the lepidoptera. Thus we remain without any zoological evidence that would tend to prove the existence of flowering plants in the carboniferous age. R. MCLACHLAN

Lewisham, April 4

Water-level Indicators

I OBSERVE in NATURE (vol. xix. p. 518) a description of what is stated to be a new form of water-level indicator which has lately been erected by the India-rubber, Gutta-percha, and Telegraph Works Company, at the Leamington New Waterworks.

So far as mere form goes, it possibly may be considered new, but hardly so in any other sense, as a water-level indicator, fulfilling the purposes you mention, on a very extended scale, has been in action at the Nottingham Waterworks for many months past. It is not only capable of being made to give smaller indications than one foot, but is actually doing so. This apparatus was designed and constructed in the electrical department of the General Post Office, and has given great satisfaction. I may mention that it was under the consideration of Mr. Preece so far back as the latter end of 1877, and but for his determination to have an instrument perfect in every respect before he turned it out, it might have been at work early in 1878.

Nottingham, April 8 H. ROFE

Eastern Yucatan

Is there any information to be had about Eastern Yucatan? In 1847 the Maya Indians there rose against Mexico and have become independent. The animosity between them and the Mexicans is so great that there is scarcely any possibility of penetrating to the Independent Indians of Eastern Yucatan from the western part of the peninsula, which remains Mexican. But should this not be possible from Belize (British Honduras)? I have heard that the coloured people of the colony trade with the Mayas. Would it be possible then to obtain some information in this way?

As to the interest of a visit to the Maya country by an educated traveller it would bear especially (1) on the condition of the people since they are free from their white masters. How does it compare with the condition of the Mayas of Western Yucatan, who live in a *de facto* serfdom to the large landowners? (2) The antiquities, of which we have a description by Stephens, but certainly would know more. Very likely the Mayas will allow a white man who is not a Spanish-American to travel in their country; they have no special reason to hate anybody except the latter. A. WOEIKOF

Jurschtatskaya, 9, St. Petersburg, March 25

Deltaic Growth

IN reference to the question as to the amount of sediment brought down by Delta Rivers, I had occasion in 1877 to ascertain the amount of sediment carried by the waters of the River Plate, and found it to amount to the $\frac{1}{7752}$nd part by weight. Mr. J. F. Bateman, the well-known hydraulic engineer, in his report on the proposed harbour of Buenos Ayres, fixes the minimum flow of the River Plate at 670,000 cubic feet per second. Assuming its mean volume at 700,000 cubic feet per second (a quantity very much under the mark), it would appear that this river carries seaward some 224,000 tons of sediment every twenty-four hours—or say, in round numbers, 82,000,000 tons every year.

Some portion of this sediment is deposited in the 100 miles of river that intervene between Buenos Ayres and the sea, forming the great banks that render the navigation of the River Plate so troublesome, but a large portion is carried out to sea and deposited beyond the mouth.

I have been informed by captains of steamers trading with Buenos Ayres that the soundings shown on the chart of the coast of Uruguay vary considerably, in many places, from the actual ones now existing, and I have little doubt that a correct re-survey of this coast would show changes as marked as those discovered by Mr. Doyle near Rangoon.

The subject is one of great importance, as the coast of Uruguay is a difficult and dangerous one to make, and from the low character of the coast, the frequency of fogs, and the great uncertainty of the currents, captains have frequently to depend a great deal on the lead to ascertain their position when making this land. During the last few years several fine steamers—French, German, and English—have been lost on this coast near the Castillos, when making the land. GEORGE HIGGIN

3, Great George Street, Westminster, S.W., April 10

Temperature Equilibrium in the Universe in Relation to the Kinetic Theory

MY attention has been called to an ambiguous phrase in my recent paper[1] on the above subject (NATURE, vol. xix. p. 460) which it is necessary to rectify. On page 461 is the sentence "*Let us suppose now the excessive temperature to fall, or, in other words, the total energy to diminish.*" This is meant as a *supposition*, not as a possible case. The imaginary rise and fall of temperature in the universe are given merely for the sake of aiding the conceptions of the actual facts, by affording *imaginary* cases to show what the effects would be if such cases were possible. S. TOLVER PRESTON

London, April 15

Transportation of Seeds

THE penetration of seeds of the so-called "flechilla" grasses into the flesh of Australian sheep is too well known to squatters. On some "runs" these grasses are so abundant that the annual loss of stock is a very serious matter. The ripe seed falls upon the wool, and, owing to the re-curved barbules with which it is armed, easily penetrates to the skin, when, its point being as sharp as a needle, every movement of the animal tends to drive it into the flesh. I have found the internal organs so crowded with seeds that they felt like a bag of needles if squeezed in the hand. ARTHUR NICOLS

[1] "On the Possibility of Explaining the Continuance of Life in the Universe Consistent with the Tendency to Temperature-Equilibrium."

Earthquakes

A SHOCK of earthquake was felt in this neighbourhood on the evening of Tuesday, April 8, at 8·35 (about). We were sitting in the drawing-room of this house, when we heard a sound like the rumbling of a heavy waggon, or distant thunder. It increased in loudness till the room slightly vibrated and the window rattled, as it seemed to pass the house. From the peculiar nature of the sound, and the fact that we are some 50 feet above the road, and 80 or 100 yards from it, I felt certain the disturbance was due to an earthquake and not a passing waggon, but walked to the window to listen, when I heard the sound dying away in the distance. It seemed to come from the south-east, and travel towards the north-west, and to be audible, from first to last, for some seconds, perhaps five or six, because we spoke one to another during the time. I find that the shock was noticed by other people in the neighbourhood, and that in a cottage near Bettws Gormon, a mile or so from here, two glass bottles were thrown down from a high shelf and broken. T. G. BONNEY

Bron Celyn, near Bettws y Coed, North Wales, April 10

WE were visited by an earthquake of some violence this morning at 2 A.M. (Cadiz mean time). The shock was preceded by a profound subterraneous noise like that of a distant carriage, and it extended to Port St. Mary and Port Royal (six miles). The earthquake travelled from south to north approximately; some clocks stopped. AUGUSTO T. ARCIMIS

Cadiz, April 3

OUR ASTRONOMICAL COLUMN

BESSEL'S NEBULA IN PERSEUS.—On November 8, 1832, in zone 527, Bessel observed an object, which he recorded as a nebula, distant about one degree from 20 Persei. It is No. 1,063 of Weisse's second Catalogue, where, though called a nebula, it has 9m. attached. D'Arrest, in his "Resultate aus Beobachtungen der Nebelflecken und Sternhaufen," has two observations, in January, 1856, to the first of which he attaches a note that no nebulosity was visible in Bessel's position, and that possibly a comet was observed; the second observation records a star 9·10m., without trace of nebulosity or diameter, the place of which was found to be within a few seconds of arc from Bessel's position, preceded 24·22s. by a star 9m., 76″ to the north. In "Siderum Nebulosorum," &c., D'Arrest remarks: "Star 9m. quæ Besselio quondam nebulosa apparuit . . . Argelandro in Perlustratione ceu fixa 9·3 magn. apparuit; nobis sæpius inspicientibus nunquam nebulosa visa." This refers to the star in the "Durchmusterung," at 2h. 43m. 56·5s. + 36° 54′·2; Argelander has another star of the same magnitude, 9·3, 10′ south. Are we to infer that Bessel's star was surrounded in 1832 by nebulosity so conspicuous that it was caught at once in his zone observations, which had wholly disappeared in 1856, or, as appears the more probable conclusion, that at the time of his meridian observation a comet happened to be centrally over the star? In this case the observation gives its place for 1832 November 8 at 10h. 10m. 25s. G.M.T.; the catalogued position for 1825·0 is in R.A. 2h. 42m. 5·56s., Decl. + 36° 46′ 46″·7.

This observation of Bessel's might at first sight appear of some interest, considering that the comet of the November meteors (1866 I.) must have been near perihelion about November 1832, but upon further examination it will be found that with the elements of 1866 it is not possible to bring the comet near the observed position of the "nebula," upon any assumption as to the time of its arrival in perihelion.

BRORSEN'S COMET.—Comparing the second of the two observations on April 4, in Major Tupman's letter published in NATURE, vol. xix. p. 527, with Dr. Schulze's elements, only with the perihelion passage assumed March 30·5716 G.M.T., the differences from observation are $\Delta\alpha = -2''\cdot1$ and $\Delta\delta = +1''\cdot3$. This position, therefore, with others obtained by Prof. Strasser and Dr. Tempel, show that when the mean anomaly is so altered as with the other elements of Dr. Schulze's orbit to bring about an exact agreement between the observed and calculated geocentric longitudes, there is still an outstanding difference between the latitudes of from one to two minutes, which indicates that, notwithstanding the apparently careful computation of the perturbations since the comet's last appearance in 1873, the elements determining the position of the plane of the orbit are susceptible of correction. The ephemeris we gave last week will, however, amply suffice for readily finding the comet, and we shall continue it for May in our next.

Mr. Tebbutt, of Windsor, N.S.W., writes that, aided by Dr. Schulze's ephemeris, he found the comet on February 22, and observed it again in the fading twilight on the following evening. It could hardly be seen with a telescope of less than four inches aperture. It had the appearance of an elliptic nebulosity, the major axis of the ellipse extending in the direction of the parallel of declination.

NEW MINOR PLANETS.—Prof. Peters, of Clinton, New York, notifies his discovery of No. 194, on March 22, in R.A. 12h. 11m., Decl. $+9^\circ 31'$, magnitude 10·5. No. 192 was found by M. Palisa at Pola on February 17, and No. 193 by M. Coggia, at Marseilles, on March 1.

GEOGRAPHICAL NOTES

AT the meeting, March 22, of the Russian Geographical Society, Col. Petroussevitch read a very interesting paper on his exploration of the Amu-daria, from Chardjui, in Bokhara, to the delta of the river, and on its former beds. M. Petroussevitch has arrived at the conclusion, based on a thorough levelling of the country, that the turning of the waters of the Amu-daria into the Sara-kamysh depression through one of the former beds, would not meet with great difficulties. This depression being, however, very wide and deep, the waters of the Amu River once arrived there, would form a great lake, and it would be difficult to direct them further to the Caspian. For this last reason it would be better to open a way for the waters of the Amu along one of its former beds which run south-east from the lake Sara-kamysh. All explorations make it very probable that in this way the Amu-daria could easily reach the Caspian. The Russian Trade Society sends, next summer, an expedition for the study of the lower parts of the Amu-daria, of the best direction for a railway to Central Asia, and of the possibility of a canal between the Amu and the Caspian. Several officers of the Russian general staff, with geodesists, a geologist, a botanist, an archæologist, and an artist will be members of this expedition. They will start from the Ural River, passing through Kara-tugay, Tashkent, and Samarkand; further they will go down the Amu to the Uzboi.

UNDER the title of "L'Afrique Centrale en 1522," M. A. J. Wauters, Assistant-Secretary of the Belgian Geographical Society, has drawn up an interesting memoir, in which he has gone with much care into the doctrine of Portuguese geographers respecting the discovery of Central Africa in the sixteenth century. M. Wauters was induced to study the subject by the recent discussions in regard to the geographical data furnished by the great globe in the Lyons Library, and if anything were required to dispose of its claims to originality, this memoir does it most effectually. He traces back the idea of a great central lake, under the name of Saphat or Sachaf, to the days of Martin Hylacomilus and Gerhard Mercator, so that the data on which it was based must have been known previous to the year 1522. M. Wauters's memoir appears in the current number of the *Bulletin* of the Belgian Geographical Society, and is illustrated by a facsimile map.

A LISBON paper gives the text of a letter which Major Serpa Pinto addressed to Sir Theophilus Shepstone from Shoshong, Bamangwato country, on January 2, and which adds some information to that already made public respecting his adventurous journey. He states that he went beyond the Zambesi and purposed proceeding to the east coast through the country of the Choculumbes, when successive obstacles obstructed his passage. Having lost all his resources and being abandoned by his carriers, he found himself in the greatest difficulties, when fortunately he heard of a missionary who had arrived at the Upper Zambesi, and he resolved upon finding him. After a journey of 200 miles he found the missionary, M. F. Coillard, a Frenchman of the Evangelical Mission of Sesuto, Basuto-land, director of the station of Lesibo. His strength being exhausted, Major Pinto was taken seriously ill, but on his recovery succeeded in reaching Shoshong with M. Coillard and accompanied by eight of his followers, the only ones who continued faithful.

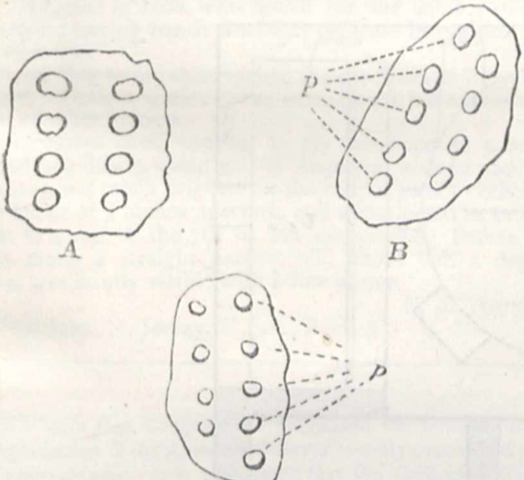
THE Danish Government has appointed Lieut. Jensen to explore all the fjords in Greenland from Holsteinborg to the coast facing Disco. The explorations will bear on the moving ice-fields which send so many icebergs into the Polar Ocean.

MR. IM THURN paid a second visit to the Kaieteur Falls, on the Potaro River, British Guiana, in February and March last, when the river was in full flood. Referring to our remarks on his previous visit, he states that he by no means intended to depreciate the grandeur of the fall. At his last visit he found it "so infinitely more grand, so infinitely more beautiful, that it is painfully hopeless to try to express in words anything of its beauty and grandeur." Mr. im Thurn's brief account contains several interesting notes on the botany and zoology of the region traversed.

THE WOLF FISH

OF late the wolf fish (*Anarrhichas lupus*) has been somewhat plentiful in the Frith of Forth. A specimen which lived in the Edinburgh Aquarium for a little over a week, came into my possession a few days ago, and I have thought that an account of the dental armature of this curious fish may prove interesting to readers of NATURE. The wolf fish is a near relative of the Blennies. In this fish we see the same elongated dorsal fin, and the same anal fin as in the Blennies; but the dental arrangements of the wolf fish are of a much more specific and unusual kind than are seen in the former group. The specimen dissected measured twenty-five inches from the top of the nose to the extremity of the caudal fin. It was therefore by no means a large specimen, since from six to seven feet is not an unusual length for the sea wolf to attain. Its dark grey body was faintly banded with brown, but the head was beautifully and distinctly marbled with black on a grey ground. The aspect of the mouth, provided with its well marked teeth, partakes somewhat of a feline look, and has suggested the name "sea cat," often applied to it on these northern shores, where the fish is frequently eaten, it somewhat resembling the cod in taste. The appearance of the mouth is highly characteristic. In front of both jaws is found an array of sharp incisor teeth. The upper jaw bears five of these pointed teeth, the two lateral teeth being large, and the central three teeth small. The lower jaw possesses six teeth of similar pattern, the two central teeth being larger than the four lateral ones; and when the jaws are closed the lower teeth interlock in an exact manner with the upper. The hold or grip of a wolf fish must therefore be of a tenacious kind. Behind these incisor teeth, both above and below, are seen a few small teeth, destined by the ordinary laws of dental succession in the fish-group to replace the incisors in case of injury or loss. These front teeth are firmly anchylosed to the bones on which they are borne.

More interesting are the palatal teeth, and the corresponding teeth of the lower jaw. To these latter, the name of "molars" or "grinders" is frequently applied. Close to the front of the upper jaw we find a series of three tooth-masses, one central and two lateral, arranged in diverging fashion. The central and largest mass resembles the tuberculate molar of a bear in form, and is composed of four firmly united segments, each segment in turn consisting of two pieces. The lateral teeth of the palate, similarly consist of a double series of firmly united segments, but in each of these lateral pieces the outer row of pieces is composed of sharp-pointed segments, resembling miniature incisors. The accompanying diagram will afford an idea of these curious palatal arrangements:



A is the central piece; B and C are the lateral pieces, the outer teeth of which (*p p*) consist of pointed and incisor-like pieces. It follows from this description that the sea wolf possesses in its mouth an apparatus not merely adapted for tearing its food but for exercising a triturating and bruising action as well.

No less characteristic are the dental arrangements of the lower jaw. In the front of this jaw are four incisor teeth, each fully three-quarters of an inch in length; whilst two smaller incisors exist as already mentioned, one at each side of the larger series. Behind these incisors are the rudiments of succeeding teeth, and these rudimentary teeth gradually merge into the main dental arrangement of the lower jaw, which consists of a prominent row of blunt teeth anchylosed to form a common mass, and partially forming a double row on each side of the jaw. Section of the jaw shows that the teeth are imbedded in a common groove, and that complete and thorough ossification of the various dental pieces renders the whole apparatus compact and solid. The arrangement seen in the mouth of the wolf fish suggests the idea of the high specialisation of this type of fish, as indicated by the development of the dental apparatus. In none of the near neighbours of this fish have we at all a near approach to the perfection of teeth thus exhibited; and in respect of its complexity and differentiation of type, we may well be inclined to lend some countenance to the idea of the independent origin in widely removed fishes of structures seen in still greater perfection in such widely-removed fishes as the Elasmobranchiate Skates, Rays, and Cestracion.

The stomach of the specimen I dissected was greatly distended, and contained fully four ounces of digestive *débris*, consisting chiefly of disintegrated Ophiuroids, spider-crabs, broken shells, shrimps and prawns, along with sand and small gravel. The pyloric aperture was firmly contracted and the collection of matter in the stomach clearly pointed to some obstruction of the digestive canal as the cause of death. It was also instructive to find that close to the vent the rectum was largely distended with broken pieces of shells and fine gravel. These matters, along with those in the stomach, had evidently been intussuscepted before the arrival of the fish in the aquarium and probably caused death by the irritation consequent on their non-removal by digestion. ANDREW WILSON

THE ETNA OBSERVATORY

IT will be within the recollection of some of our readers that in September, 1876, Prof. Tacchini, of Palermo, communicated to the Accademia Gioenia of Catania a letter, "Sulla Convenienza ed utilita di erigere sull' Etna una Stazione astronomico-meteorologica" (*vide* NATURE, vol. xv. p. 262). This letter was published in the *Atti* of the Academy, and afterwards appeared in the form of a quarto pamphlet with ground-plan and elevation of the proposed building. The project was at once taken into consideration both by the Italian Government and by the Municipality of Catania; plans were prepared, money was voted, and it was confidently believed that the observatory would be commenced in July, 1878. Owing, however, to certain delays, this was found to be impracticable, and the commencement was postponed till June, 1879. There is every reason to believe that the building will be erected and the instruments in working order by the end of this year. The cost will be borne by the Government, the Municipality of Catania, and the Province of Catania. Merz, of Munich, has offered to construct a 12-inch lens for the great refractor, at the price of a 10-inch lens, and the enterprise has received encouragement and support from various sources both at home and abroad.

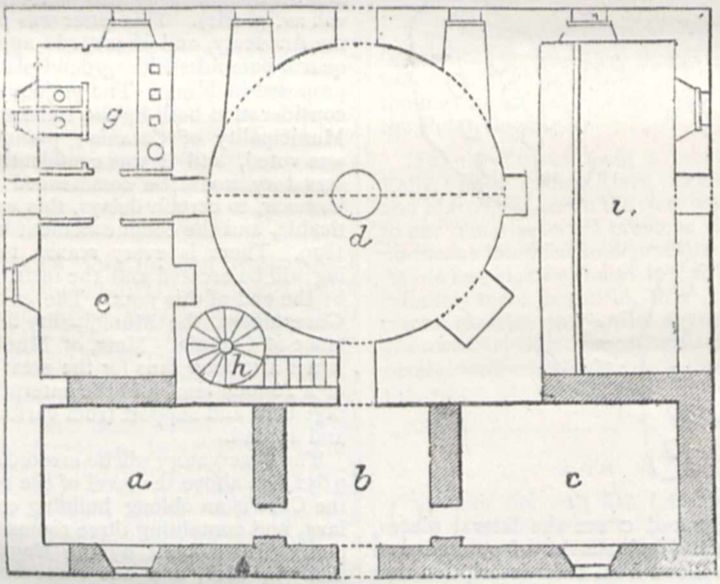
The observatory will be erected at the Casa degl' Inglesi, 9,652 feet above the level of the sea. At the present time the Casa is an oblong building constructed of blocks of lava, and containing three rooms (*vide* the accompanying plan). It was built by the English when they occupied Sicily in 1811, and has since been used by those who ascend the mountain as sleeping quarters. A few years ago it had fallen into decay owing to the accumulation of snow in winter and to other causes, but it was put into complete repair in 1862 on the occasion of the visit of the present King of Italy. The observatory will be the property of the University of Catania, and will indeed be a kind of offshoot of the Bellini Observatory of Catania. It is to be devoted not only to astronomical and spectroscopic observations, but it will also be furnished with a complete set of meteorological and seismological instruments. Between the Etna Observatory and Catania three or four meteorological stations will be established at different elevations, as at Nicolosi, and the Casa del Bosco, and observations will be made at the same hour daily at each of these stations, at Catania, and at the Etna Observatory.

The Merz lens of 12 inches diameter, has a focal distance of $5\frac{1}{2}$ metres. The telescope and clock-work movement are in course of construction by Signor Carignata, the mechanician of the Padua Observatory, who constructed the instruments which were employed by the Italian astronomers who went to India to observe the transit of Venus in 1874. The observatory will only be inhabited during the months of June, July, August, and September, and the large lens will then be transported to Catania, and fitted to a duplicate mounting in the Bellini Observatory. But a number of self-recording instruments will remain in the observatory, and thus results will be registered during the winter months.

Prof. Tacchini, to whom the whole undertaking owes its existence, specially desires that it should be an International Observatory. With this object in view, the large telescope will be fitted with a second tube, the length and aperture of which can be altered at will, so that astronomers from any part of the world can bring with them their objectives and eye-pieces, and can fit them to the telescope of the observatory. Special arrangements will be made for photographing the sun and moon, and for spectroscopic observations.

The observatory will contain the large telescope covered by the usual dome in the centre; on each side there will be rooms for the other instruments, and below, sleeping quarters, a dining-room, and kitchen for the use of travellers. The following plan, for which, together with many of the above facts, we are indebted to Prof. Tacchini, will show the general arrangement of the observatory.

In his report on the subject Prof. Tacchini commences by pointing out that since the year 1868 the study of the physical constitution of the sun has made very rapid progress. In these studies the spectroscope has played a very important part. But the spectroscopic observations are often hindered, and their exactitude is disturbed by atmospheric causes, and these disturbances are mainly due to the lower layers of the atmosphere. Hence an observatory at a considerable elevation would greatly facilitate such observations. The isolated Mount Etna affords an admirable locality for such an observatory. The blueness of the sky is intense, the stars shine with an extraordinary brightness, Venus casts shadows, spectroscopic lines which cannot be seen at the Palermo Observatory are perfectly distinct when viewed from an elevation of 10,000 feet. "Ora il mio desiderio," says Tacchini, "sarebbe quello di andare sull' Etna per verificare la tanto decantata purezza del cielo e il suo colore speciale, osservare l'aureola del sole, studiarne lo spettro se sarà possibile e fare anche qualche tentativo di fotografia. . . . ." He then mentions some of the observations made by Young with a 9-inch refractor at an elevation of 2,800 metres, and describes his own observations made on Etna with a Dollond refractor of 99 mm. aperture,



a, b, c, the three rooms of the already existing Casa Inglesi; *d*, circular chamber, 8 metres in diameter, with a massive pillar in the centre, upon which the great refractor will be placed; *e*, a room for guides who accompany those who ascend the mountain; *g*, kitchen and offices; *i*, stable for mules; *h*, staircase. On the upper floor, *a, b, c*, will be bed-rooms; *e, g, i*, instrument-rooms; and *d*, the circular chamber for the refractor, extending through both floors, and surmounted by a movable dome of iron.

and a spectroscope of great dispersive power constructed by Tauber. "La cromosfera era magnifica e dettagliata abbastanza tenendo conto della piccolezza del magnesio e dello 1474, ciò che non vidi a Palermo collo stesso cannocchiale." Then having made the suggestions which are in part carried out, and which have entirely been adopted, he concludes by a fervid peroration which we heartily endorse:—"Io ritornerò dunque all' Etna, lo spero, e in migliore stagione, e sin d'ora mi figuro coll' immaginazione, la vista della nuova specola, che mi ricorderà l'epoca fortunata e la circonstanza solenne, che qui mi tiene ora unito a voi, e il nome del grande Bellini, che prima ancora di dare alle scene il suo capo lavoro, la Norma, volle in omaggio alla scienza degli astri, suonare all' osservatorio di Palermo la celeste melodia della preghiera alla casta Diva."

While we feel perfectly convinced that important results will accrue to more than one science from the establishment of the new observatory, we must not shut our eyes to the fact that many difficulties will have to be encountered. The observatory on Vesuvius stands upon a projecting spur of rock, and lava-streams of any ordinary magnitude breaking out on this side of the cone would divide, and leave the observatory as on a rocky island. But the Etna Observatory will stand near the upper termination of the Piano del Lago, the plain out of which the great cone of Etna rises. A great eruption, leading to the breaking down of the cone and flow of lava in this direction, could not fail to overwhelm the Observatory. Fortunately the lava usually finds vent by a *bocca del fuoco* on the sides of the mountain below the great cone. The building must be of very great strength; it will be subject to violent shocks of earthquake, to fierce storms of wind, and to the accumulation of great masses of snow upon its dome and roof. Those who have read the history of the mountain know with what tremendous power it scatters its terrors abroad; how hours of loud bellowings and detonations are followed by days of violent earthquake, and weeks during which many square miles of country are inundated by millions of cubic yards of molten lava. That the new Observatory may flourish, unassailed by the fearful forces of the imprisoned Cyclops, will be the wish of all our readers.

G. F. RODWELL

NOTE ON THE SPECTRUM OF BRORSEN'S COMET

ON April 1 and 2 I succeeded in determining the position of the green band in the spectrum of Brorsen's comet. The spectrum was so faint that the other bands could not be measured. The instrument was the 9½-inch equatorial of our astronomical laboratory, armed with a one-prism spectroscope. The observations were made by bringing an occulting bar, movable by a micrometer screw, into such a position that the well-defined lower (less refrangible) edge of the band in the comet spectrum should be just visible as a thin line, the rest of the band being hidden by the bar. After the pointing the flame of a Bunsen burner was brought in front of the slit, and the position of the band in the comet-spectrum was thus fixed.

It was found by four independent pointings (which all agreed within about the interval of the *b*-lines) that the central band of the spectrum of the comet coincided precisely (within the limits of perception) with the green band in the flame of the hydrocarbon.

The interest of the observation lies entirely in the fact that it seems irreconcileable with the result obtained by Mr. Huggins in 1868, who found for the same comet a spectrum having bands distinctly different in position and appearance.

According to my observation, the spectrum of Brorsen's comet no longer stands out as exceptional, but agrees with that of other comets.

The comet itself appears in my telescope as a small round nebulosity, about 40″ in diameter, without definite nucleus, but much brighter in the centre, easily visible in the finder of 3 inches aperture, and about equal in brightness to a star of the 7th or 8th magnitude. Before the new moon a straight narrow tail, about half a degree long, was faintly visible with a low power.

C. A. YOUNG

Princeton, N. Jersey, U.S.A., April 5

NOTES

WE learn that Congress has sanctioned the scheme for the reorganisation of the American Surveys recently commented upon in these columns. It is understood that the Geological Survey will be placed under the control of Mr. Clarence King, who has so long had charge of the Geological Exploration of the 40th Parallel. But no details have yet reached us.

IN the Paris Academy of Sciences, M. Alphonse Milne-Edwards has been elected a member in place of the late M. Gervais, in the Section of Anatomy and Physiology; M. Abich a correspondent in the Section of Mineralogy, in place of M. Damour; and Mr. Lawes a correspondent in the Section of Rural Economy, in place of the late Marquis de Vibraye.

THE following are the probable arrangements for the Friday evening meetings at the Royal Institution after Easter:—April 25. Francis Galton, F.R.S.: "Generic Images." May 2. Prof. John G. McKendrick, M.D.: "The Physiological Action of Anæsthetics." May 9. Sir John Lubbock, Bart., M.P., F.R.S.: "The Habits of Ants." May 16. Prof. A. Cornu: "Étude Optique de l'Élasticité" (in French). May 23. W. H. Preece, M.R.I.: "Multiple Telegraphy, or Duplex and Quadruplex Telegraphy." May 30. Grant Allen: "The Colour-Sense in Insects; its Development and Reaction." June 6. Prof. Dewar, F.R.S. June 13. Frederick J. Bramwell, F.R.S.: "The *Thunderer* Gun Explosion."

A CATALOGUE of the library of the Museum of Practical Geology and Geological Survey has been lately published, compiled by Messrs. H. White and T. W. Newton, which cannot fail to be of use beyond the walls of the library of which it is a record. The arrangement is alphabetical, the author's name and important groups of works, as "Geological Surveys" and "Statistics," being printed in black thick type, secondary titles and subdivisions in italics. The pages are clear and easily read and the titles full and accurate. The price, considering that there are over 600 pages, and that only 270 copies appear to have been printed, is somewhat less than that which is generally fixed on the publications of this Department. When the Geological Survey was instituted in 1843, its first Director, Sir Henry De la Beche, C.B., commenced the formation of a museum illustrative not only of the palæontology of the country, but of the economic application of geology to the arts and manufactures. These collections were exhibited in a small building in Craig's Court, and wishing still further to foster geological study, Sir Henry presented to the Survey the whole of his scientific library. This was added to from time to time, until in 1851 these collections were removed to the Museum of Practical Geology, which was built for their reception, and to provide accommodation for the Royal School of Mines, which was then instituted, and to a certain extent associated with the Survey. Since this time, partly by the annual grant from Parliament, partly from the gifts of the various scientific societies of the world, and partly by the bequest of the late Sir Roderick Murchison's library, it now numbers no less than 28,000 works, on the special subjects taught in the School of Mines, geology, mining, chemistry, biology, &c., and it is specially rich in foreign transactions, and the works of reference useful to a mining engineer.

LORD DUFFERIN, who had accepted the presidency of the Birmingham and Midland Institute, having been compelled to relinquish that office on his appointment to the Embassy at St. Petersburg, Prof. Max Müller was communicated with by the Council, and has signified his acceptance of the post.

THE publication of weather warnings in Switzerland will begin on May 1 in Zurich, and on June 15 in Geneva. A telegraphic despatch, containing a description of the weather in Europe, with weather warnings, will be sent from the observatory every day, by telegraph, to any person who will pay quarterly 4*l*. 8*s*., and a shorter bulletin containing only a weather prognostic, will cost 1*l*. for three months.

SWISS papers are much alarmed by a case of infection by birds. Two brothers, merchants at Uster, in the canton of Zurich, who have a large collection of various birds and monkeys, lately received some tropical birds which were sent in a cage from Buda-Pesth. Immediately after the arrival of the birds the two brothers, the wife of one of them, and a shop-girl became sick. A third brother, who is a surgeon, understood the cause of the illness and ordered all suspicious birds to be killed, fifty or sixty in number, the cages to be destroyed, and a strong sanitary cordon around the house to be established. A tinker who had done some repairs to the cages also became sick and died in hospital, as well as an innkeeper and his wife, at whose inn the birds stayed for some days. The number of sick already has reached eight, and their state is very bad. The illness is described as a black typhus.

THE third fascicule of the "Pflanzenleben der Schweiz," by M. Christ, has just appeared, and contains a very fine map which illustrates the subdivisions of the Swiss flora.

A COMMITTEE has been appointed by the Paris Society of Photography to collect funds in order to erect a statue to Nicephore Niepce, who was born at Chalons-sur-Saone in 1765. The subscriptions are to be sent in Paris to M. Pector, 9, rue d'Albe, or M. Koziell, 20, rue Louis-le-grand.

MR. CLIFTON WARD's papers on the physical history of the English lake-district have been reprinted in a separate form from the *Geological Magazine*.

M. MARIE DAVY, the director of Montsouris Meteorological Observatory, has set up a registering Thomson electrometer. The indications are recorded by photography in accordance with the system which has been established at Kew by the British Association. A comparison of readings taken by these two establishments will render essential services to the progress of meteorology. M. Descroix, the observer in charge of this instrument, was assailed before the Meteorological Society by a French *savant* who has invented another electrometer, in which the registration is taken with a pencil and mechanical force. But the discussion proved that such instruments are useless without knowing whether their indications are worth being recorded, as many objections can be raised against their use and have been published by competent electricians.

THE French artists are preparing for an Exhibition of Fine Arts, to be held as usual in the Palais de l'Industrie from the beginning of May. When this exhibition is over a scientific exhibition will be organised by M. Nicolle, the successful organiser of the Exposition Maritime et Coloniale held in the same building in 1877. M. Jules Simon, M. du Moncel, and others are taking an active part in the preparations. The chief peculiarity will be the execution of all the scientific experiments capable of being made before an audience and on an unusual scale. The organiser will try to fill the lacuna, which was so much complained of in the last Champ de Mars exhibition.

A CORRESPONDENT of the *Hiogo News* mentions that in the city of Kioto there are to be seen many semi-foreign buildings which are the Shogakko, or elementary schools. Of these there are 64 in the city, and 445 in the whole *fu*. Kioto is divided into two large districts, called Kami and Shimo Kiyo, which are subdivided respectively into 33 and 32 *ku*. Each *ku* is obliged to establish and maintain one of these schools, except in the case of poor *ku*, when two are allowed to unite and form one school district. Besides the usual Japanese course of studies, the pupils are taught the elements of foreign mathematics, history, geography, and philosophy, and they are also trained in gymnastic exercises. Education is compulsory, only those (who are of age) being exempted who are necessary to the support of their parents.

WE learn that the organisation of the captive balloon has been altered by M. Giffard. The aëronautical and scientific staff has been constituted by him into a private company. He has placed at their disposal the funds required for the working of the balloon, and placed the enterprise in their own hands on their own responsibility and care. This arrangement has been agreed to by the public authorities, and will leave a handsome surplus on behalf of the men who spend their lives in the aëronautical career, as a large part of the profits, exclusive of a handsome weekly pay, is to be divided by equal part amongst them. A few important alterations have been made in the car, and ring, and netting. The net ascending power will be enlarged by a ton. A kind of india-rubber gas-meter, containing 100 cubic metres, has been constructed, in order to render inflation instantaneous between two ascents.

THE Académie des Ascensions Météorologiques opened its Museum in Paris on April 3. More than 600 persons visited the gallery. It is to remain open every Thursday, and any day admission may be obtained by letter to the General Secretary, 50, rue Rodier. The number of exhibitors exceeds 120. Amongst the collection of aëronautical medals we note some commemorating ascents made in England in the end of the last century. A registering barometer for ascents to 5,000 metres is exhibited by MM. Richard frères; it was purchased by the government for the Meudon aëronautical establishment. M. Egasse exhibits an apparatus for filling balloons with hydrogen extracted by the action of zinc and chlorhydric acid. The result of the reaction is employed in large quantities for destroying miasmatic influence in barracks and other similar establishments. A new paddle has been constructed for ascending and descending without gas or ballast when the balloon has been placed on equilibrium with surrounding air, a new guide rope for diminishing the velocity by friction when the balloon is travelling at sea, a safety-car for these perilous occasions, differential valves, &c. Lectures will be delivered and ascensions executed by the members of the institution.

THE *Cologne Gazette* reports, under date the 9th inst., a slight shock of earthquake at Buir and Elsdorf. The shock is stated to have been noticed at five minutes past midnight. It had a rolling noise and took an east-south-easterly direction.

THE *Tiflis Messenger* says that a strong earthquake was felt on March 27 in Persia, at the Gulf of Miama.

A GENERAL exhibition of the various systems and apparatus used for electric lighting is to be held in the Royal Albert Hall in May. An inaugural lecture, at which the Prince of Wales has promised to be present, will be delivered in the evening of Wednesday, May 7, by Mr. W. H. Preece.

AS an agitation prevails in France against the laws proposed by M. Ferry for prohibiting the members of unauthorised bodies from taking any part in public instruction, it is very likely that Government will retain the exclusive right of conferring degrees, but the proposed restrictions will be rejected by Parliament.

THE following details (published by Herr Landauer in the *Reports* of the Berlin Chemical Society) regarding the behaviour of safranine when spectroscopically examined, may interest the readers of our recent article on "Absorption Spectra" (vol. xix. p. 495). It is well known that the salts of safranine show the remarkable reaction that the red colour of their solution turns into violet, indigo-blue, bluish green, and finally emerald green, upon addition of concentrated acids, particularly of sulphuric acid. The change of colour takes place in the opposite direction if safranine is dissolved in strong acids and water is gradually added to the solution. If these solutions are examined with the spectroscope, then it appears that each of the colours mentioned shows a separate spectrum. The green solution absorbs the violet, blue, and red rays, the bluish-green one behaves in the same way, but lets a part of the red rays pass; the blue solution absorbs only the yellow rays, and the more the colour of the solution turns violet and red through the addition of water, the more the absorption passes over to the green part of the spectrum. Herr Landauer attempted to determine the cause of these changes of colour in the liquid, and the corresponding alteration of the spectrum. Finding it difficult, however, to isolate the various chemical compounds formed in the liquid, it was only possible to try an explanation from the chemical behaviour of the liquid itself. Finally he arrived at the conclusion that of the two possibilities, formation of different acid salts, or of different hydrates of the same salt, the latter is the more probable one. The change of colour takes place also when the solution is evaporated, and reappears in the opposite direction when water is again added. The sulphate is the most characteristic salt of all; blotting-paper impregnated with a solution of this salt, and dried by heating until it has become green, soon becomes blue by attracting moisture from the atmosphere, and a drop of water thrown upon it instantly gives a red stain with a blue margin. Herr Landauer supposes that there exist three different hydrates (or two hydrates besides an anhydrous salt), which are red, blue, and green respectively, the violet and bluish-green tints resulting from mixtures of these. Herr Vogel's maxim, therefore, that the rule "each body has its own spectrum" can be admitted only with restrictions, may be still further restricted, inasmuch as it may be asserted that absorption spectra only indicate the component parts of a compound so long as the colour of a given substance is characteristic of its chemical composition.

WE notice an interesting discussion which arose at the last meeting of the Russian Society of Hygiene. M. Malarevsky, pointing out the yearly increasing myopy of scholars, proposed to print books with white letters on a black field, and proved the superiority of this system by experiments he has made with fifty scholars, as well as by experiments on the facility of discernment of black drawings on a white field and of white drawings on a black field, these last always being better seen from a greater distance than the former.

WE have received a very full Catalogue of Official Reports upon Geological Surveys of the United States and Territories and of British North America, by Mr. F. Prime, assistant-geologist of Pennsylvania. It seems to be an enlarged continuation of the Catalogue by Prof. O. C. Marsh, published in the *American Journal* for 1867. The present list covers 50 pp.

AT the last session of the U.S. Congress an appropriation of 250,000 dols. was made for the construction of a fire-proof building for the reception of such collections belonging to the National Museum as cannot be at present accommodated in the Smithsonian Building; and as the plans have already been prepared, it is understood that the work will be begun without delay. The design contemplates a building 301 feet square, with certain projecting corners, the whole covering a space of about 97,000 square feet. Although not quite equal to the area of the Government Building at the Centennial, it is capable of containing a much larger mass of material. The general plan is that of a pavilion, of one story, with brick walls and iron roof, the floor to be of concrete. The corner buildings or projections constitute offices connected with the administration of the Museum, to include a library room, a small lecture-room, and others. It is expected that the entire edifice will be completed and ready for occupation by April 1, 1880.

THE whale whose bones have been so long exposed in the court-yard of the Jardin des Plantes at Paris, is to be demolished in compliance with a report from M. Quatrefages, who shows that the original number of vertebræ has been enlarged, and a series of important alterations have been successively made.

THE publishing office of *Science News*, hitherto published at Salem, Mass., will shortly be removed to New York.

MANY of our readers might like to know of Dr. Karl Möbius' address on March 5 last, on his assumption of the rectorship of the University of Kiel. Its subject is the passage from Goethe—"Leben ist die schönste Erfindung der Natur, und der Tod ist ihr Kunstgriff viel Leben zu haben."

THE Second Annual Report of the Board of Trustees of the Western Pennsylvania Institution for the Instruction of the Deaf and Dumb is one of great interest, and we are sure would be perused with pleasure and profit by all who are interested in the important subject. The Institution seems to be conducted on thoroughly scientific principles, and its success seems very marked. The Report is published by Stevenson, Foster, and Co., Pittsburgh.

WE have received a cheap edition of "The Caves of South Devon and their Teachings," by Mr. J. E. Howard, F.R.S., in which he endeavours to combat the long chronology assigned to the human race by Mr. Pengelly and others. Hardwicke and Bogue are the publishers.

THE *North British Daily Mail* of March 29 contains reports of recent meetings of the Geological and Natural History Societies of Glasgow. In the former Mr. Young gave a descriptive notice of an interesting specimen of *Elephas primigenius* discovered about four years ago when sinking a pit-shaft on Mainbill Farm, near Baillieston, east of Glasgow. In the latter Mr. Harvie-Brown read a paper on the Mammalia of the Outer Hebrides.

"NEW Views in Astronomy, illustrated by Working Models and Diagrams, and Demonstrated by Inductive Philosophy," is the title of a quarto pamphlet by Mr. John Harris, published by Wertheimer, Lea, and Co., of Finsbury Circus.

THE additions to the Zoological Society's Gardens during the past week include a Yak (*Bison grunniens*) from Bhootan, presented by the Hon. Ashley Eden, K.C.S.I.; a Japanese Goat Antelope (*Capricornis crispus*) from Japan, presented by Mr. H. Pryer, C.M.Z.S.; a Rhesus Monkey (*Macacus erythræus*) from India, presented by Mr. J. Roberts; a Grivet Monkey (*Cercopithecus griseo-viridis*) from West Africa, presented by Mr. W. B. Greenfield; a Common Seal (*Phoca vitulina*), British Isles, presented by Capt. Chas. Rawle; a Red-throated Diver (*Colymbus septentrionalis*), British Isles, presented by Mr. J. S. Thompson; a Masked Parrakeet (*Pyrrhulopsis personata*) from Fiji, an Entellus Monkey (*Semnopithecus entellus*), from India, deposited.

THE RESULTS OF RECENT RESEARCHES IN ANIMAL ELECTRICITY[1]

I.—INTRODUCTORY OBSERVATIONS

The State of the Subject Ten Years Ago

UNTIL the year 1867 certain theoretical conceptions based upon the classical investigations of du Bois-Reymond prevailed in the whole department of animal electricity. It may indeed be said that du Bois-Reymond created this branch of modern physiology, for it was he who first struck out the modern method of research and gave the lead to recent investigation. To his individual labours we owe not only the establishment and the orderly arrangement of many facts which had been left ill-defined by his predecessors, but also the actual discovery of a still greater number of fundamental value. These fundamental facts, briefly summarised, were the following:—

1. Muscular fibres and nerve-fibres when cut across exhibit a current directed within them from the transverse to the longitudinal surface, the electromotive force of which may equal one-twelfth of a Daniell's cell.

2. The negative potential of the transverse section also belongs, though in a less degree, to the natural terminations of the fibres of muscle ("natural transverse section"); but in this case it may be wanting, or even be changed to a positive potential. This diminution, absence, or reversal, of the common condition, to which the term "parelectronomic state" is applied, would seem to be favoured by the continued action of cold.

3. If a certain portion of a nerve-fibre be traversed by a galvanic current, the remaining portions, or the extra-polar regions, become the seat of an electromotive force which has the same direction as the traversing current, and which is strongest in the vicinity of the poles (electrotonus). This influence extends only so far as the structural integrity of the fibre is complete.

4. Muscles and nerves with artificial transverse sections exhibit during the period of stimulation a diminution ("negative variation") of their proper current. In uncut muscle the negative value of the diminution or variation becomes algebraically added to whatever current may be already present in the natural termination of the muscle.

Upon these facts du Bois-Reymond had based the following theory:—

1. Muscle- and nerve-fibres contain electromotive molecules suspended in an indifferent conductor, which present positive surfaces to the longitudinal surface or section, and negative surfaces to the transverse surface or section.

2. At the natural terminations of the muscular fibres are arranged particles of a peculiar kind, the presence of which is

[1] A lecture delivered on February 2, 1878, before the Medical Society of Zurich, by Dr. L. Hermann, Professor of Physiology in the University of Zurich, and published in the "Vierteljahrsschrift d. naturf. Ges. in Zurich," 1878. All the papers referred to in this lecture which have no author's name attached are papers of the author himself.

more or less marked, and which present positive instead of negative surfaces towards the ends of the fibres. Cold, according to the theory, favours the development of this "parelectronomic layer."

3. The electrical molecules of a nerve, under the influence of a current which traverses it, assume a new arrangement which consists in their turning negative surfaces towards the positive pole and positive surfaces towards the negative pole. If we conceive these molecules as electrically dipolar in the state of rest, they would be arranged in inseparable pairs, the positive pole of each member of a pair being turned to the positive pole of the other, the negative surfaces of the molecules being all turned to the transverse sections; and the action of the current would consist in an arrangement of all the molecules in the form of a pile. As this rearrangement of the molecules extends in a less degree beyond the portion of nerve traversed by the current, electrotonic forces are developed.

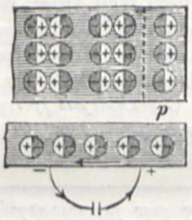


FIG. 1.

In Fig. 1 the upper diagram represents the normal, the lower the electrotonic, arrangement of molecules; above *p* are seen the parelectronomic molecules of the natural termination of the fibres.

4. During stimulation either the electromotive forces of the molecules diminish, or the latter assume a new arrangement, in which they appear less active externally; but the parelectronomic molecules take no share in these changes.

The promulgation of this molecular theory aroused many expectations. It appeared probable that the essence of the condition of activity and of its conduction in muscle and nerve was connected with the electrical properties of certain particles, rotation, oscillation or some other change in one particle leading to similar changes in neighbouring particles. Moreover, it appeared conceivable that even the contraction of muscle might be explicable by the actions of attraction and repulsion among the same particles.

Although speculation upon the origin of these electro-motive forces in muscle and nerve had hardly taken shape, and although the founder of the molecular theory observed a praiseworthy reserve in regard to all such speculation, yet up to the year 1867 it was pretty generally, if tacitly, assumed that the chemical processes occurring in muscles and nerves at rest were essential to the maintenance of the electromotive molecules in constant activity. In a similar way it was taken for granted that excitation depended ultimately upon certain movements of the electromotive molecules which were, of course, associated in some manner or other with increased consumption of oxygen and increased oxidation.

Researches which called forth New Views

Researches which I made upon the exchanges of the gases and other constituents of muscle [1] furnished me with results which differed materially from the then prevailing conceptions of the functional processes occurring in these organs. I found that muscles contain no oxygen capable of being yielded to a vacuum, and nevertheless that they are capable of prolonged exertion in a medium entirely free from oxygen; hence I concluded that the chemical process which underlies muscular work is not a process of oxidation, but a process of decomposition, in which, by the saturation of stronger affinities through the passage of atoms into more stable atomic combinations, energy is set free, just as in the alcoholic fermentation of sugar.[2]

Amongst the products of this decomposition in muscle there occurs carbonic acid. A comparison of the quantities of carbonic acid set free during muscular exertion, and during muscular rigor, showed that in both cases the carbonic acid must spring from the same source, and thus, with the help of an analogous result to which J. Ranke had arrived in the case of lactic acid, a complete analogy between the chemical processes of *contraction* and of *rigor*, was found to hold good. Both processes are processes of decomposition, and as products of the decomposition are known carbonic acid, lactic acid, and in the case of rigor an albuminous coagulum discovered by Brücke and Kühne, which may perhaps in the future be ascertained to be a transitory phenomenon even in the case of contraction. The absorption of oxygen by muscle has nothing to do with this process of decomposition; the former is related to a synthetical process of restitution in which certain of the products of decomposition are perhaps again utilised. In this way was explained the independence (in point of time) between the absorption of oxygen and the production of carbonic acid by muscle.

According to this conception there occurs, during the condition of rest, a perpetual but slow decomposition and a slow process of restitution; the latter is dependent upon a supply of blood containing oxygen. If the supply be intercepted, then the whole store of decomposable matter within the muscle becomes exhausted, and the muscle passes into rigor. During contraction the process of decomposition is suddenly quickened, and the process of restitution can barely keep pace with it: when the latter lags behind the former *fatigue* results.

The analogy between contraction and rigor had attracted attention long before, although, excepting the shortening of muscle, no other feature common to the two processes was known. Rigor had been designated as the last contraction of dying muscle. The new conception reversed the comparison, inasmuch as it assimilated contraction to a momentaneous and transitory rigor; and, since then, the physical analogies between contraction and rigor have been discovered to be more and more numerous. It has been found that in rigor as well as in contraction the volume of the muscle diminishes somewhat, and that in both processes heat is developed; while, to complete the relationship, it has been lately observed that certain evident transitional stages occur between the two.[1] Thus stimuli of excessive intensity, when applied to muscle, lead to a condition in which the state of contraction never perfectly disappears, but leaves behind it a residue of shortening. Fatigue and the process of death favour this condition of persistent, rigor-like contraction (Schiff's "Idiomuscular Contraction"), and a similar condition is induced by many muscular poisons, as veratria, delphinia, digitalin, emetin, caffein, &c.

While pursuing the analogies between the conditions of contraction and rigor I came upon a view of the nature of animal electricity which differed essentially from that which was then in existence.[2]

Fundamental Conceptions of the New Theory

The most important and at that time the most certainly ascertained fact was this, that a transversely divided muscular fibre exhibits, until it has become completely rigid, a negative potential in the plane of the section, and that this difference of potential diminishes or disappears during the state of functional activity. Having regard to the chemical and physical analogy between the processes of activity and of rigor; and considering the fact that when an artificial cross-section is made there is from the very first a portion of matter within the fibre which is passing into rigor, I explained this phenomenon on the assumption that the process of rigor, like the process of contraction, so modifies the protoplasm that it takes on a lower potential than the unchanged inactive protoplasm.

If this be so then an artifical cross-section must preserve a lower potential so long as the fibre has not become rigid throughout its entire extent, and on stimulation of the portion yet alive a diminution of the electrical difference must result.

II.—The Electrical Currents of Organs at Rest

The Absence of Currents in Muscles which are at Rest and Uninjured

In order to sustain the new theory of animal electricity (which, in opposition to the "Pre-existence Theory" of du Bois-Reymond I have designated the "Alteration Theory"), it

[1] Untersuchungen über den Stoffwechsel der Muskeln ausgehend vom Gaswechsel derselben. Berlin, 1867.

[2] Similar views have been more recently expressed, and with a somewhat more general application, by J. Liebig, in the "Sitzungsber. der bayr. Acad.," 1869, ii. 4; and by Pflüger, "Arch. f. d. ges. Physiol.," x. p. 251, 1875. I myself had extended this view to the chemical processes in nerves and glands.

[1] "Arch. f. d. ges. Physiol.," xiii. p. 371, 1876; xvi. p. 252, 1878.

[2] "Untersuchungen zur Physiologie der Muskeln und Nerven," 2 u. 3 Heft. Berlin: 1867, 1868.

was in the first place necessary to determine whether absolutely uninjured muscles are the seat of a muscular current.

Muscles cut out of the body possess almost invariably imperceptible injuries of a mechanical or chemical nature. In the first researches of du Bois-Reymond the muscles were regularly moistened with saturated solutions of common salt, and thereby, to a certain extent, corroded. Hence he was led to ascribe to the natural terminations of muscular fibres the negative potential which is exhibited by artificial transverse sections. This source of error was indeed discovered by du Bois-Reymond himself; but, after he had removed it, there yet remained other electrical phenomena apparently dependent upon the terminations of the fibres, differing, however, entirely from that just mentioned and obeying no strict rule in respect of direction of current. For these phenomena the hypothesis of the parelectronomic layer was introduced.

The more, however, all injuries are avoided in the preparation of muscles about to be used for such observations, the nearer is the approach to complete absence of currents. Chief among the injuries in the case of the frog is that produced by contact with the caustic secretion of the external skin.[1] The gastrocnemius is a muscle which may very readily be defended from such contact during its preparation, and it then exhibits merely weak currents of indefinite direction, such as are found in all circuits containing moist conductors.[2] The muscles of the thigh are, without exception, so connected with one another or with neighbouring parts (skin, bones, &c.) that they cannot be prepared without sustaining *mechanical* injuries in the course of the necessary manipulation.[3]

The statement that cold favours the development of a currentless condition, or of opposing currents, in muscle is not confirmed. The gastrocnemii of freshly-caught frogs do not differ electrically from those of frogs kept for a long time previously in an ice-cellar.[4] It is perhaps as well to observe that muscles which have been actually frozen suffer injury in the subsequent process of thawing, and are therefore to be avoided in these researches.

The most promising method of testing perfectly uninjured muscles appeared to be to examine them in the unskinned animal. Du Bois-Reymond,[5] who was the first to hit upon this method of observation, encountered an unexpected difficulty in the cutaneous currents which almost all animals possess. If it is first attempted to abolish the cutaneous currents by cauterising the skin with salt solutions, the solution rapidly penetrates the skin and attacks the underlying muscles; this is observed to occur by the gradual development of the same current as is induced when the naked muscle is moistened by caustic agents. That the muscles have already been attacked by the time the muscular current is developed[6] may be directly shown by employing silver-nitrate as the cauterising solution, when its action upon the tissues subjacent to the skin is manifested by rendering them opalescent.[7] If the skin is cauterised in places beneath which there are no aponeurotic muscular surfaces, no muscular current can be discovered, or at the most only such weak and irregular currents as count for nothing in the case of a circuit formed of moist conductors; not even the action of caustics, nor abrasion renders the skin absolutely currentless.[8]

Fishes possess no cutaneous current; in their case it suffices to connect any two points on the surface of the skin with the galvanometer in order to ascertain the absence of a muscular current.[9] These animals, like the frogs used in these experiments, must be rendered motionless by the action of curare.

According to the recent researches of Engelmann the heart offers an example in which it is easy to demonstrate the absence of a muscular current.[10] To do so it is merely necessary to remove the pericardium, an operation which can be performed without inflicting any injury upon the muscular substance. The heart is currentless, but every injured spot in it possesses a negative electric potential in reference to the rest. The pre-existence theory can only explain this fact, and the previously mentioned fact of the want of a current in the fish, by the most improbable surmise made expressly to suit the cases, that no muscular fibre has its termination directed towards the surface.

1 "Arch. f. d. ges. Physiol.," iii. p. 37, 1870.
2 *Ibid.*, p. 16, 35. 3 *Ibid.*, xv. p. 227, 1877. 4 *Ibid.*, xv. p. 226, 1877.
5 Du Bois-Reymond, "Untersuchungen über thier. Electr.," ii. 2 Abth. p. 7.
6 "Untersuchungen," Heft iii. p. 6, 1868. 7 *Ibid.*, p. 14.
8 *Ibid.*, p. 14; "Arch. f. d. ges. Physiol.," iii. pp. 16, 23, 26, *et seq.*; iv. p. 149, 1871.
9 "Arch. f. d. ges. Physiol.," iv. p. 152, 1871.
10 Engelmann, "Utrecht'sche physiol. Onderzoek." (3), iii. p. 82, 1874.

No Electromotive Force pre-existent in Muscle

Another method of deciding whether a current pre-exists in muscle appeared to be to determine whether, immediately after a transverse section is made, the current is present in full force, or whether an interval, however short, is required for the development of it. Were the latter the case it would be impossible for the doctrine to be correct which assumes that electromotive molecules exist ready formed in muscle and are merely laid bare by the knife. The experiments,[1] which were made by me in the years 1875 to 1877, to decide this question, have settled it in opposition to the pre-existence theory. With the help of a special apparatus the galvanometer circuit was closed at the moment when an injury was inflicted upon a previously uninjured muscle and then opened again after a very minute interval of time. The deviation observed was smaller than in a second trial made after the muscular current had already been developed, and in which the current was allowed to act on the galvanometer for the same period of time. The muscular current, therefore, requires time for its development: it does not pre-exist.

The Currents of Nerves, of Glands containing Blood, of Plants, &c.

It was to be surmised that other protoplasmic tissues than muscle would exhibit the phenomenon that portions of the tissue which are in process of dying have a lower potential than the yet living parts. First in importance in this respect is nerve: the current of nerve was discovered by du Bois-Reymond, and, like that of muscle, explained by a molecular hypothesis. Uninjured terminations of nerves are, for many reasons, not available for electrical researches; nevertheless, on the ground of the analogy to muscles, no one doubted the existence of a current in nerves, nor the applicability to them of the molecular scheme. With the discovery of the absence of a current in uninjured muscles, however, the analogy cuts the other way.[2] Henceforward there was not the slightest ground to assume the existence of a current in nerves at rest, except that developed by artificial sections. We shall see that even the phenomena of electrotonus do not in the least justify the molecular hypothesis.

Besides nerves, two other groups of protoplasmic apparatus have been examined by myself; and it has been found that in them, also, artificial sections possess a negative potential when compared with the rest of the organs. In the cases of both groups it afterwards appeared that the observations had previously been made by others. The first case was that of the glandular organs of the frog,[3] in which Matteucci had already found artificial cross-sections to be negative. I made out that this character is only present when the vessels contain uncoagulated blood, to the changes in which at the exposed surface it seems the electromotive force is due. The second case was that of the negative potential of artificial cuts and of cauterised spots in plants,[4] facts first observed by H. Buff.[5] Both phenomena are of such a kind that it is absolutely inconceivable to apply a molecular theory to them; yet notwithstanding the attempt has been seriously made.

The Dependence of Currents upon the Contact of Normal and Injured Protoplasmic Tissue

When examining the artificial cross-sections of plants I observed that the lower potential of the exposed surface quickly disappeared, but that a new section soon restored the original condition. I explained this behaviour by supposing that, according to the fundamental law, the lower potential of the cross-section only persists so long as the cells which are implicated in the section possess a remnant of living protoplasm. If the cells are entirely dead, the current must cease. In this manner we can explain why, in plants with obviously long fibres, artificial longitudinal sections have a higher potential than artificial transverse sections;[6] for the cells which are split up lengthwise die much more rapidly than those which are cut across. The same transitory character of the current which I have discovered in artificial cross-sections through vegetable tissues has lately been observed by Engelmann[7] in the case of the heart and of organs possessed of unstriped muscular fibres, and has been similarly explained. These organs are composed

1 "Arch. f. d. ges. Physiol.," xv., p. 191, 1877.
2 "Untersuchungen," Heft iii., p. 25, 1868. 3 *Ibid.*, p. 88.
4 "Arch. f. d. ges. Physiol.," iv. p. 155, 1871.
5 Buff, "Ann. d. Chemie," lxxxix. p. 76, 1854.
6 "Arch. f. d. ges. Physiol.," iv. pp. 159, 163, 1871.
7 Engelmann, "Arch. f. d. ges. Physiol.," xv. p. 116, 1877.

of independent cellular elements placed one behind the other in rows, and the current of one section can therefore only last until the injured cells have died from end to end.[1] In the last place the same phenomenon was discovered, in the case of nerves, by Engelmann. Here the nodes of Ranvier constitute cellular boundaries which effectually confine the process of death[2] to the internode immediately injured during section, although they offer no greater barrier to the transmission of the excitatory condition than do the cell-boundaries in the heart, intestines, or uterus.[3]

Disappearance of Demarcation Currents (Demarcations-ströme) under the Influence of the Natural Reparative Processes of the Body

It was reserved for Engelmann to discover yet another fact opposed to the doctrine of the pre-existence of electrical forces in muscle.[4] If in a living frog a muscle be divided subcutaneously the negative potential of the artificial section diminishes continually, and ultimately disappears, under the influence of the blood circulating in the part and of the nerves supplying it. As, therefore, nature tends to render artificial sections currentless, it is clear that in the natural condition no muscle can be the seat of currents, but every muscular current observed during rest must spring from injuries.

Inasmuch as all currents exhibited by muscles and nerves in a condition of inactivity (except those caused by inequalities of temperature or by the passage of extraneous currents) depend upon the contact of dying and living matter, and since the electromotive force has its origin in the surfaces which form the boundary between the two, I have called these currents of rest "demarcation currents" (Demarcations-ströme).

Influence of Temperature

If the muscular substance within the same fibre exhibits differences of temperature the warmer spots possess[5] a higher potential than the colder, so long as the temperature does not attain the limits of heat-rigor, and the consequent negative potential ensue. In exactly the same degree as living substance acquires through heat a higher potential than other living substance, is its potential exalted as regards dying substance. Hence, it is not merely that the demarcation-current becomes more powerful by heating the whole muscle, as was in part revealed to du Bois-Reymond, and recently established by Steiner in regard to nerves, but the force of the demarcation-current is dependent only on the temperature of the living substance at the point of application of one galvanometer-electrode, and not on the temperature of the substance lying between the poles. In a word, portions of muscular substance in different conditions form together a voltaic series.[6]

The Currents of Entire Muscles

As has been already remarked, wholly uninjured muscular fibres possess no current. All currents of muscles at rest are, therefore, variations in temperature excepted, the results of injuries. The properties of the current are most simple in the case of a muscle with parallel fibres, and cut transversely at right

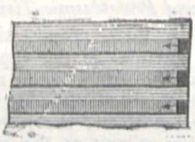


FIG. 2.

angles. In this case all the boundary surfaces between dying and living tissue are parallel to the section, and every point in the transverse surface has a lower potential than any point in the longitudinal surface.[1] As, however, the muscle possesses between its fibres and on its surface indifferent conducting tissues through which the demarcation-currents can in great part become equalised—such tissues as sarcolemma, perimysium, the dead tissue of the cross-section—two important results follow. In the first place the force of the currents obtained by applying the galvanometer poles to two spots of different potential represents but a fraction of the electromotive force of a single fibre. In the second place the positive potential of the longitudinal surface and the negative potential of the transverse surface are so distributed as to be most marked at the centre of the respective surfaces. Hence arise the so-called "weak currents" when the galvanometer poles are applied to unsymmetrical points on the transverse or longitudinal surface.[2] But the weak currents of longitudinal surfaces may, especially in nerves, be in part due to an electrotonic extension of the demarcation-current which will be the subject of discussion later on.

In oblique sections there occurs a peculiar arrangement of the level-lines[3] (Niveau-linien), inasmuch as there intervenes an electromotive force which is directed from the acute to the obtuse edge of the slanting section: such currents are called "currents of inclination." Du Bois-Reymond explains this force by the step-like arrangement which the terminal molecules form in the slanting section; but it is clear that the same mode of explanation is just as well adapted to the step-like arrangement of the boundary-surfaces between dying and living tissue in the successive sets of fibres (Fig. 3).

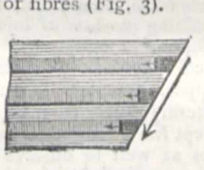


FIG. 3.

The molecular theory, therefore, is not needed to explain the currents of inclination of a *bundle* of fibres; it would only be indispensable in the case of a current of inclination of a *single* obliquely-cut fibre, did such a fibre possess one; but this is precisely what no one has demonstrated or can demonstrate. The circumstance that many muscular fibres present slanting facettes at their terminations in tendons[4] offers no opportunity to support the molecular theory; for such tendons possess no current of inclination in the uninjured condition, while, in the injured condition, the tissue of each fibre invariably dies down to a surface at right angles to the long axis of the fibre, and thus the conditions for the current of inclination arise (Fig. 3).

In all cases of partial injuries to muscle it is only the injured fibres which are the seat of electromotive action; the remainder merely form indifferent conductors which give facilities for local equilibrations. The weak currents of such muscles have, therefore, no regular relation to the surface of the muscle, as all depends upon the situation of the injuries: hence the irregular currents of so-called parelectronomic muscles.

When injuries, of whatever kind, affect the whole surface of a muscle, the probability is that a current will be detected in the muscle flowing from one end of it towards the longitudinal surface; and, in fact, when tested, this is found to be almost always the case. If a slight injury has been inflicted upon the lateral surface of a muscle the death-changes in fibres which have been opened longitudinally will speedily be checked at the boundary of the next fibre, while the death-changes which have been started at the ends or cross-sections will creep along the whole length of the fibres and occasion a lasting current. This has been previously alluded to, when the transitional nature of the demarcation-current in the heart, intestines, &c., was explained.

Local injuries to the external surface of a muscle give rise to local currents; but these currents, when a conductor is stretched from the longitudinal to the transverse surface, produce hardly any effect; whilst the demarcation-currents at the dying end of the muscle are under very favourable conditions for conduction, and

[1] I made an exactly similar observation in the spring of 1877 on the tissues of young Medusæ which were sent to me through the kindness of Prof. Hensen, of Kiel.

[2] Engelmann, "Arch. f. d. ges. Physiol, xiii., p. 474, 1876.

[3] Gad und Tschiriew ("Verhandl. d. physiol. Ges. zu Berlin," 1877, Nr. 21) deduce the disappearance of the current in nerves from the fact that, after the death of the divided internodes the seat of electromotive force, viz., the ends of the internodes of the next row are no longer in one transverse plane, whence the resulting current is much diminished by partial equalisations. The value of this observation is obvious when it is remembered that the length of the internodes of Ranvier is, generally speaking, only 1—1½ mm.

[4] Engelmann, "Arch. f. d. ges. Physiol.," xv., p. 328, 1877.

[5] "Arch. f. d. ges. Physiol," iv. p. 163, 1871. [6] *Ibid.*, p. 178.

[1] The best method of applying the electrode to an artificial transverse section of muscle; so as to avoid any abduction of current from the living portion, is to produce a heat-rigor of the end of the muscle, and to apply the electrode to the rigid part ("thermal cross-section"); cf. "Arch. f. d. ges. Physiol.," iv. p. 167, 1871.

[2] Du Bois-Reymond, "Untersuchungen," i. 1848.

[3] Du Bois-Reymond, "Arch. f. Anat. u. Physiol.," 1863, p. 521; "Monatsber. d. Berliner Acad.," 1866, p. 387.

[4] Du Bois-Reymond, "Monatsber. d. Berliner Acad.," 1872, p. 791.

the forces of the local currents are, on account of the usual oblique application of the muscular fibres to their tendons, generally summed into currents of inclination.

III.—ELECTROTONUS

Considerations opposed to the Molecular Theory of Electronus

The explanation adduced in the Introductory Remarks, in order to elucidate the electrotonic condition of nerves has many theoretical difficulties which cannot be here entered upon. The theory appears, however, to be amenable to an experimental proof. If, namely, the molecules of the portion of a nerve traversed by a current arrange themselves in the direction of the current, the electromotive force of the current should receive a very appreciable increase; or, in other words, the current should become very much greater when it passes through a piece of living nerve than when it traverses a dead piece of similar dimensions. On trying this experiment, however, I find no such difference; or the differences found are far from agreeing with the molecular theory.[1]

Electrotonic Phenomena observed in Conductors with Polarisable Cores

An experiment of Matteucci's[2] gave the clue to an explanation of electrotonic phenomena. He found that a metallic wire which is surrounded by a moist envelope exhibits currents possessing the characters of the electrotonic currents of nerves, whenever a galvanic current is passed, at any point, through the moist envelope. Matteucci discovered, in addition, that the currents cease when the wire is of amalgamated zinc and the envelope is moistened by a saturated solution of zinc sulphate. Hence it follows that the phenomenon depends upon a polarisation between the core and the fluid.

I examined the phenomenon more closely,[3] passing metallic wires through a glass tube filled with fluid and possessing lateral processes for the conduction of currents, and my experiments confirm the fact that electrotonic currents only occur when a polarisable core is present. Further, it was seen that the currents only extended so far as both core and envelope possessed unbroken continuity, whereas continuous contact of the two was not necessary. Lastly, I determined the laws regulating the time of development of these currents, their duration, their cessation on opening, their dependence upon the distance, and the length of the portion of core traversed by the polarising current, their combination and superposition, &c. All the phenomena may be grouped without difficulty under a simple theory.

As the current a E k (Fig. 4) applied to the envelope endeavours to reach the core K K, it splits up, if no polarisation be present,

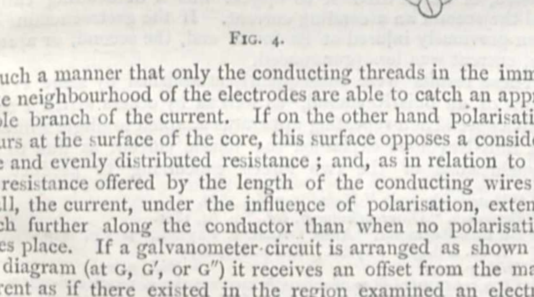


FIG. 4.

in such a manner that only the conducting threads in the immediate neighbourhood of the electrodes are able to catch an appreciable branch of the current. If on the other hand polarisation occurs at the surface of the core, this surface opposes a considerable and evenly distributed resistance; and, as in relation to it, the resistance offered by the length of the conducting wires is small, the current, under the influence of polarisation, extends much further along the conductor than when no polarisation takes place. If a galvanometer circuit is arranged as shown in the diagram (at G, G′, or G″) it receives an offset from the main current as if there existed in the region examined an electromotive force of like direction with that of the polarising current. This polarisational extension of the current only continues where both core and sheath are uninterrupted.

The abducted currents are at the same time, on mathematical grounds, a measure of the degree of polarisation at the points touched; and thus afford a means of tracing the extent of polarisation along the core. The curve representing the polarisational values at various points of the core—in general an exponential curve—has at the positive pole a positive maximum and a negative at the negative pole. In the region traversed by

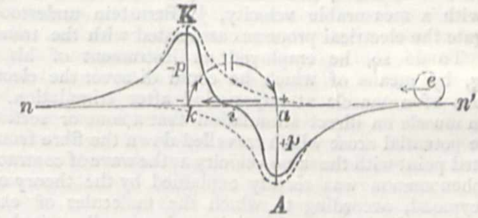


FIG. 5.

the current the curve cuts the axis at the so-called "indifferent point" (Fig. 5, *i*); and in the extra-polar regions it approaches the axes on both sides asymptotically. The curve is represented in Fig. 5, where, as a matter of subsequent convenience, the ordinates of positive polarisation are taken below the axis instead of above.

Internal Transverse Polarisation of Muscles and Nerves

In the year 1871 I discovered that the resistance offered by muscles and nerves to the passage of a current across their fibres was from five to nine times greater than the resistance offered by a current passing in direction of the fibres.[1] In the case of muscle this difference disappears almost entirely when rigor sets in; whilst in dead nerves it certainly persists, though reduced to one half. Further investigation of these facts disclosed their dependence upon a specific internal polarisability, which, in the case of muscle, is entirely associated with the living condition, and, in the case of nerve, in great part so associated. This fitness for polarisation by transversely-directed currents can only be due to a stratification of heterogeneous conductors across the tissue, which is wanting in its longitudinal axis. And since it is common to muscles and nerves, the stratification on which it depends must be sought in the typical structure which is common to the two organs, viz., the tubular nature of the fibres. We may assume, therefore, that polarisation takes place between the peculiar, active, substance of muscle- and nerve-fibres and the indifferent tissue ensheathing it.

Explanation of the Electrotonus of Nerves

As, accordingly, there exist in nerve-fibres all the essential conditions of the electrotonic extension of currents in conductors with polarisable nuclei, it may be assumed that the electrotonus of nerves is fully explained.[2] It is true that the core-substance of nerves is no better a conductor of electricity than the sheath-substance, while in the sheathed wire of Matteucci's experiment the core was of metal. But theory teaches that the electrotonic extension occurs even when the conducting powers of sheath and core are equal, if only polarisation takes place between the two.

This explanation of electrotonus, as I have shown in detail, completely covers all the phenomena. Especially does it account for the facts that the electrotonic state requires no appreciable time for its establishing;[3] and that it cannot extend past a ligatured spot. Whenever a nerve is crushed, the continuity of the core is broken, since, at the crushed spot, the core is killed and converted into indifferent tissue.

As muscle-fibres also possess polarisable cores, they must be endowed with electrotonic properties; nevertheless, neither du Bois-Reymond nor I at first succeeded in demonstrating them by galvanometric means; though, truly, just as little could their absence be distinctly affirmed. But theoretical considerations disclosed the reasons why muscle was less favourable to electrotonic phenomena than nerve;[4] and lately I have suc-

[1] "Untersuchungen," Heft iii. p. 67, 1868; "Arch. f. d. ges. Physiol.," vi. p. 328, 1872.
[2] Matteucci, *Comptes Rendus*, lvi. p. 760, 1863; lxv. pp. 151, 194, 884, 1867; lxvi. p. 580, 1868.
[3] "Arch. f. d. ges. Physiol.," v. p. 264, 1871; vi. p. 312, 1872; vii. p. 302, 1873.

[1] "Arch. f. d. ges. Physiol.," v., p. 223, 1871.
[2] *Ibid.*, vi. p. 328, 1872.
[3] "Helmholtz, "Monatsber. d. Berliner Acad.," p. 328, 1854; L. Hermann, "Arch. f. d. ges. Physiol.," viii. p. 272, 1874.
[4] "Arch. f. d. ges. Physiol.," vi. p. 350, 1872.

ceeded, by employing better contrivances, in demonstrating with the galvanometer the electrotonus of muscle.

An important addition to our knowledge of the electrotonus of nerves will be discussed at length in the sequel.

IV. The Electrical Currents of Organs in Activity.—A. Muscles

The Fall in Potential accompanying the Excitatory Wave

After Helmholtz had proved in the case of nerves, and Aeby in the case of muscles, that excitation is transmitted along the fibres with a measurable velocity, J. Bernstein undertook to investigate the electrical processes associated with the transmission.[1] To do so, he employed an instrument of his own devising, by means of which he could discover the electrical conditions of a muscle at any period after stimulation. He found in muscle on direct stimulation that a zone or section of negative potential arose which travelled down the fibre from the stimulated point with the same velocity as the wave of contraction. This phenomenon was readily explained by the theory of du Bois-Reymond, according to which the molecules of excited tissue suffer a diminution of activity, whence all excited spots must be electrically negative in relation to the inactive parts of the organ. Accordingly the phenomenon was designated "undulatory propagation of the negative variation."

On the assumption already made that excited tissue has, like dying tissue, a lower potential than the unchanged tissue, the fact is also at once explained, and I have named the currents called into being by the contact of excited with resting tissue, "functional currents" (Actions ströme).[2]

The Phasic and the Tetanic Functional Current

When a single excitatory wave runs over a muscular fibre which is connected at two points with the poles of a galvanometer, that point is of lower potential than the other beneath which the excitatory wave is passing at the time; or, if a wave happens to be passing both points at once, that point has the lower potential where the wave has the greater intensity or the stronger phase. Hence arises what may be called a "phasic functional current," the initial phase of which is a current proceeding *from* the stimulated spot, and the final phase a current in the opposite direction. The two phases are equal when the excitatory wave suffers no diminution in its course.

If a muscular fibre is tetanised, whether excitation travel in an undulatory form down the fibre or seize it as a whole, every galvanometer-pole applied to the muscle will be of higher or lower potential, according to the excitatory value of the points of application.

The Tetanic Functional Currents of Injured and Uninjured Muscles.

The first observations of du Bois-Reymond related to the tetanic functional current of muscles with artificial cross-sections. In such muscles the tetanic functional current is opposed to the demarcation-current, and manifests its influence in a "negative variation or deflection" of the latter. Since I regard the functional current as due to living muscle approximating in a certain degree to the condition of dying muscle, I have denominated such functional currents as diminish a demarcation-current "levelling," or "equalising," currents (ausgleichende).

Subsequently du Bois-Reymond discovered that uninjured muscles also exhibit a tetanic functional current proceeding from the stimulated point towards the end of the muscle. In order to reconcile this with his theory it became necessary to assume that the parelectronomic layer at the extremity of the fibre took part either not at all, or but slightly, in excitation. Finally the latter alternative was adopted, and it proved to be nearer the truth; for it was discovered that the functional current of uninjured muscles is less powerful than that of muscles cut across.[3] In a word, in order to explain the functional current of uninjured muscle, it was found necessary to assume that the extremities of a muscular fibre are less concerned in excitation than the middle.

While du Bois-Reymond was thus confining the limited participation in excitation to the extremities of the fibre, or, in other words, was locating the origin of the functional current in the end of the fibre, it occurred to me that the excitatory wave in its course over a muscular fibre might diminish in intensity;[1] whence it would follow, according to what was said in the foregoing section, that in tetanus an electrode placed near the stimulated point would have a lower potential or be electrically negative, to an electrode more remote. The direction of the diminutional or decremental current so obtained would agree both with observed facts and du Bois-Reymond's theory; but its force, instead of residing in the end of the fibre, is equally distributed over the whole course of the excitatory wave.

[1] J. Bernstein, "Monatsber. d. Berliner Acad." 1867, p. 72; "Arch. f. d. ges. Physiol." i. p. 173, 1868; "Untersuchungen ü. den Erregungsvorgang, &c.," Heidelberg, 1871.
[2] "Untersuchugen," Heft iii. p. 61, 1868; "Arch. f. d. ges. Physiol." xvi. p. 193, 1877.
[3] Du Bois-Reymond, "Arch. f. Anat. u. Physiol.," 1873, p. 548.

The Diminution in Intensity of the Excitatory Wave in Excised Muscles

Shortly after I had expressed my belief that the excitatory wave would be found to diminish in intensity in its passage down the muscle, Bernstein actually observed that it was so.[2] But du Bois-Reymond surmised that the phenomenon might be the result of the abnormal conditions of the experiment, and ought, in fact, to be attributed to the moribund state of the excised muscle; and in support of his surmise he stated that perfectly fresh muscle, on direct stimulation, exhibits no decremental functional current between any two points of its substance.[3] He persisted, therefore, in assigning the origin of the functional current to the parelectronomic layer. Moreover, he expressed a doubt whether, on stimulating a muscle through its nerve, excitation is propagated along the muscle in the form of undulations.

Meanwhile, in my own experiments I invariably detected the decrement of excitatory wave in excised muscles, a decrement, it need hardly be observed, which increased with the degree of exhaustion of the muscle.[4] Further, I hit upon the following proof that the force of the functional currents is evenly distributed over the whole fibre. If, while a muscle is being tetanised at one end, the points of application of the galvanometer electrodes be shifted in relation to one another and to the seat of stimulation, a functional current will invariably be discovered proceeding away from the stimulus; and the force of the current will be found to depend solely upon the interval between the galvanometer poles, irrespective of their position in relation to the end of the muscle.[5] The same observations may be made on a muscle which is tetanised through its nerve.[6] A functional current may always be abducted from the muscle, the force of which is exclusively determined by the respective distances of the abducting electrodes from the "nervous equator"[7] of the muscle.

The above experiments prove that excitation, even on nervous stimulation, proceeds in the form of a wave; that in excised muscles it always suffers a decrement; that the tetanic functional current is decremental in its nature; and that its origin is not restricted to the ends of the muscular fibres, but is distributed over the whole course of the excitatory wave.

The Phasic Functional Current developed on Stimulation through Nerve

The first examination of the phasic functional current of a muscle which is excited through its nerve was made by S. Mayer, under the supervision of Prof. Bernstein;[8] in their researches the gastrocnemii of frogs were used. They made out that stimulation was followed by the development of two currents in succession, of which the first to appear was a descending current and the second an ascending current. If the gastrocnemius had been previously injured at its lower end, the second, or ascending, current was less pronounced.

These results were subsequently established by some experiments of du Bois-Reymond,[9] as well as by others which I made with a special non-repeating apparatus adapted to single stimuli.[10] Du Bois-Reymond explained the phasic current as due to the asynchronism of the two forces concurring to produce the

[1] "Untersuchungen," Heft iii., p. 60, 1868.
[2] Bernstein, "Untersuchungen, &c.," p. 64, 1871.
[3] Du Bois-Reymond, "Arch. f. Anat. u. Physiol.," p. 369, 1876.
[4] "Arch. f. d. ges. Physiol.," xvi. p. 194, 1877.
[5] *Ibid.*, p. 217.
[6] *Ibid.*, p. 229.
[7] Each constituent fibre of a muscle receives the motorial end-organ of a nerve-fibre. The motorial end organs of all the fibres are not absolutely in the same plane; and by the term "nervous equator" I have designated their *mean level* in a given muscle. The "nervous equator" is that equatorial section of a muscle in relation to which the distances of the various motorial plates, when algebraically summed, amount to nothing. See "Arch. f. d. ges. Physiol.," xvi. pp. 234, 414, 1878.
[8] S. Mayer, "Arch. f. Anat u. Physiol.," 1868, p. 655.
[9] Du Bois-Reymond, "Arch. f. Anat. u. Physiol.," 1873, p. 584.
[10] "Arch. f. d. ges. Physiol.," xv. p. 235, 1877.

functional current. These forces were assumed to be located in the two extremities of the muscular fibres and to be directed each to the correspondent end of the fibre, on which account they would of necessity overlap. The descending functional current belonging to the lower end was supposed to arise more quickly and to disappear earlier than the ascending current of the upper end; and hence the appearance of phases. Inasmuch as injury to one of the ends of a muscle (or in other words, removal of the parelectronomic layer), according to Du Bois-Reymond, intensifies the functional current proper to that end, it is clear that, when the inferior extremity is injured, the lower (descending) functional current obscures the upper.[1]

My own explanation[2] is essentially different from du Bois-Reymond's. According to my views the muscle must exhibit a descending current when the excitatory wave is at the upper end of the muscle, and an ascending current when at the lower end. Hence it is not the first, but the second phase, which is proper to the lower end of the muscle. The former, as I have shown, pertains to the moment when the excitatory wave is in the neighbourhood of the upper electrode—a condition most advantageously secured, owing to the peculiar structure of the gastrocnemius, by placing the electrode so as to abduct a current from the mid point of the fibres rather than from their upper end.

According to this theory it is clear that the descending phase must precede the ascending: for every excitatory wave is started at the middle point of the muscular fibre where the nerve enters, and only reaches the ends of the fibres at a later period. If, however, the lower end of the fibre have suffered injury, the excitatory wave running towards the injured part will be powerless to cause a current, owing to the constant negative potential of the injured end, and hence the second, ascending phase comes to nothing.

The fitness of this explanation was placed beyond doubt by experiments on the phasic functional current of regularly-constructed muscles.[3] In such muscles there invariably appeared in each half first an atterminal and then an abterminal phase

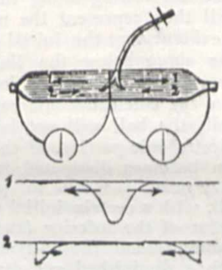


FIG. 6.

(Fig. 6). The atterminal phases in both halves (1 in Fig. 6) coincide in time, arising, as they both do, in the mid-point of the fibre at the starting of the excitatory wave; in other words, the middle point of the fibre becomes negative in comparison with either end.

In like manner the abterminal phases of both halves coincide (2 in Fig. 6), being produced by the arrival of the excitatory waves at the extremities of the fibre: in other words, either end of the fibre becomes negative in comparison with the mid-point.

In this manner the wave-like propagation of the excitatory condition in muscle was established for the case of muscle stimulated through nerves, and, at the same time, another proof was afforded that the force of the functional current does not exclusively reside in the ends of the fibres.

Furthermore, it was directly shown in these experiments that the excitatory-wave in excised muscles, while traversing the fibres, experiences a diminution; for the second, abterminal phase was invariably much weaker than the atterminal, as is indicated in Fig. 6 by the length of the arrows and the height of the representative curve, and it invariably further diminished in the course of an experiment.

The Functional Current in wholly Uninjured Muscle in Man

In the case of man the currents of normal resting muscle were secured from investigation by the obstacle of the skin. But Du Bois-Reymond found, during the violent voluntary contraction of the muscles of an arm or a leg, that the limb exhibited an ascending current. This he took to be the algebraical sum of the tetanic functional currents of all the muscles exerted, although such an explanation only became very probable by the exclusion of certain other experiments designed to elucidate the matter.[1] But the current could never be demonstrated under the most favourable conditions of abduction, viz., by the application of the galvanometer wires to individual groups of muscles.[2]

[1] Du Bois-Reymond, *loc. cit.*, 1873-76.
[2] "Arch. f. d. ges. Physiol.," xvi. p. 236.
[3] *Ibid.*, p. 239.

The question whether the diminution of the excitatory wave only occurs in excised muscles as a result of death changes, could, of course, only be settled by experiments on living human beings. And since the manifold disturbances inseparable from the method of experiment rendered the tetanic functional current almost useless for this investigation, I undertook to examine the *phasic* current in the muscles of the fore-arm.[3] I found that the same relationship held for the muscles of man as had before been shown to exist in the case of the frog. The first phase is an atterminal current in which the region of the nervous equator—about 10 cm. below the elbow—becomes negative in comparison with the two ends; the second phase is abterminal, *i.e.*, the ends of the muscles become negative in comparison with the equator (Fig. 7). But in the perfectly

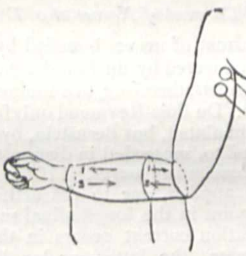


FIG. 7.

normal muscles of man the second phase was *not* weaker than the first—a relation which was constant in the excised muscles of the frog. And hence we may conclude that in absolutely normal muscles the excitatory wave does not diminish in intensity. These experiments, which constitute the first regular examination of muscular action in living man, further taught approximately the rate of propagation of the excitatory wave in human muscles, viz., from 10 to 13 metres per second.

The Absence of the Functional Current when none of the above Conditions of Electrical Inequality exist in Muscle

If an uninjured, currentless muscle be thrown into the active condition by a stimulus affecting its whole mass at once, it never exhibits any functional current,[4] whether the stimulus be single or tetanic. The explanation of this is obvious. In such a totally excited muscle the whole substance passes at the same moment into the same degree of excitation; and, hence, is nowhere the opportunity given for the contact of excited with non-excited or imperfectly excited tissue.

If, on the other hand, the muscle possesses an artificial transverse section with the associated boundary current, then indeed a levelling or equalising functional current arises on total excitation and diminishes the current of injury.[5]

When muscles are tetanised through their nerves, functional currents only appear where the excitatory wave has not the same intensity throughout the tetanised mass. Hence in man, whose muscles when under absolutely normal conditions exhibit no diminution or decrement of wave, it is impossible to demonstrate a tetanic functional current. I have, indeed, when using very powerful and fatiguing stimulation, now and then succeeded in getting indications of such a decremental functional current, but from some cause or other, we cannot depend upon this experiment to lead to a constant result, perhaps for the reason that the conductivity of human muscles is but slightly hampered by fatigue, or possibly because the collateral effects of stimulation mar the experiment.[6] I may be allowed to remark here that certain experiments now in course of publication show very clearly that stimulation of human muscles causes a secretory cutaneous current directed from without inwards. This current is the true

[1] Du Bois-Reymond, "Untersuchungen," ii., Abth. 2, p. 267.
[2] "Arch. f. d. ges. Physiol.," xvi., p. 257, 1877.
[3] *Ibid.*, xvi., p. 410, 1878.
[4] "Arch. f. d. ges. Physiol.," xvi., p. 203, 1877.
[5] *Ibid.*, xv., p. 238; xvi., p. 203, *et seq.*, 1877.
[6] *Ibid.*, xvi., p. 416, 1878.

cause of the negative potential exhibited by the voluntarily contracted muscles of one limb when compared with the opposite but unexerted limb, and is therefore the current which du Bois-Reymond took for the muscular functional current of man.[1]

B.—Nerves

The Functional Current of Nerves remote from all Transverse Sections

In the nerves of the frog, according to Helmholtz, excitatory waves are propagated at the rate of twenty-eight metres per second. Hence, if the two ends of a galvanometer circuit were laid upon two points of a nerve a functional current should be manifest on stimulation of the nerve, and should consist of two phases according as the excitatory wave was passing one or the other of the electrodes. Nevertheless the functional current of nerves, owing doubtless to its exceedingly fleeting character, has hitherto escaped detection.[2] Since the excitatory wave of nerves does not diminish in its course, it is to be expected that the two phases of the nervous functional current will be equal; and hence also it is that in tetanic stimulation, where we have to do with the algebraical sum of these two equal and opposite phases, we obtain no functional current whatever in uninjured nerves.

The Functional Current of Nerves at a Transverse Section

The functional current of nerves bounded by an artificial transverse section was discovered by du Bois-Reymond; it is an equalising current, and consists, therefore, in a diminution of the constant demarcation current. Du Bois-Reymond only found this current in nerves tetanically stimulated, but Bernstein, by means of his apparatus already referred to, succeeded in demonstrating its presence in the case of single excitatory waves.[3] If the poles of the galvanometer circuit are applied, one to the artificial cross-section, and the other to a point in the longitudinal surface, the diminution of the demarcation current occurs in the instant that the excitatory wave passes the latter, or longitudinal pole. By altering the position of this pole, the progress and the course in time of the excitatory wave may be examined. The rate of progression so deduced was found to agree with that determined in other experiments by varying the distance between the point of the nerve at which a stimulus was applied and the fixed point at which the result of stimulation was manifested, viz., the dependent muscle, or the pole applied to an artificial cross-section. And this similarity of result established the identity of the process occurring during excitation, and the wave of negative deflection.[4] The way in which the wave comports itself on approaching the artificial cross-section will be explained below.

The Functional Current of Polarised Nerves: the Polarisational Increment of Excitation

In 1866 Bernstein found [5] that the electrotonic currents of nerve, on stimulation of the nerve, suffer diminution like the demarcation-currents. As a disciple of the molecular theory he explained this phenomenon in the following way: Since the electrotonic currents depend upon an altered arrangement of the molecules, and since the force of each molecule diminishes on stimulation of the nerve, therefore the electrotonic currents must also be lessened during excitation. And so the new phenomenon seemed to be completely covered by the molecular theory. In my view, however, the electrotonic currents are merely offsets diverted from the main polarising current owing to the internal polarisation of the nerve itself. Since these offsets could not be supposed to be modified during excitation, I concluded that every apparent diminution depended upon a functional current which arises owing to the polarised condition of the nerve, and which is opposite to the polarising current in direction. I assumed, as the cause of this functional current, that the excitatory wave failed of maintaining its magnitude while passing through the polarised portions of nerve; it increased as it reached more positively or less negatively polarised areas, and diminished under the opposite conditions. This is called the doctrine of the "polarisational increment of excitation,"[1] and it is clearly competent to explain Bernstein's observations.

[1] These experiments have been recently published; cf. Hermann and Zuchsinger, "Arch. f. d. ges. Physiol.," xvii. p. 310, 1878.
[2] I have succeeded in detecting these currents by extending the rate of propagation in the nerve by cold; and by using a bundle of four or six nerves together. Cf. "Arch. f. d. ges. Physiol.," xviii., p. 574, 1878.
[3] J. Bernstein, *loc. cit.*
[4] The new experiments referred to in the last note confirm this indirect conclusion in a more direct manner.
[5] J. Bernstein, "Arch. f. Anat. u. Physiol." p. 596, 1866.

If this assumption be reasonable, the excitatory condition travelling along the nerve should be most intense at the anode of the polarising current, and least intense at the cathode; and hence there should be present in the intrapolar region a powerful functional current of like-direction with the polarising current and reinforcing it. Such an intrapolar current I did, in fact, discover to be constantly present;[2] though afterwards it appeared that a similar observation had previously been made by Grünhagen, by whom, however, the current was otherwise explained as the effect of a diminished resistance in the nerve during excitation, leading to an increase in the polarising current.[3] Before I had any knowledge of this early observation of Grünhagen, the probability of the explanation which he assigned to it had been tested by me, and numerous indications had been found that the intrapolar increase of current was indeed an electromotive phenomenon and not due to a diminished resistance.[4] But later I was enabled to settle the question in the most direct manner, by the discovery that the transverse resistance of nerves is *not* diminished during excitation—excitation having in general no manner of influence upon the resistance offered by the nerve.[5]

Further Physiological Support of the Doctrine of Polarisational Increment

In order to grasp the doctrine of polarisational increment, let us regard the axis $n\,n'$ in Fig. 5 as representing a nerve, the conditions of polarisation of which are indicated by the vertical ordinates, positive polarisation being exceptionally represented by descending lines, and negative by ascending lines. With these ordinates we can trace out the polarisation curve, $n\,K\,i\,A\,n'$ (already spoken of in describing Fig. 5, which see), the lowest point of which corresponds to the anode, and the highest to the cathode. Let us now suppose a ball, *e*, devoid of friction, and travelling through space with a certain horizontal initial velocity, to be set rolling along this curve. The *vis viva* of the ball will then represent the magnitude of excitation. It is at once evident that the initial velocity is increased in the part of the curve below the line $n\,n'$, *i.e.*, in the anelectrotonic region, but is diminished in the upper portions of the curve, *i.e.*, in the catelectrotonic region. If the initial velocity is too small, the ball will not be able to reach the summit of the catelectrotonic portion of the curve, or, in other words, the excitation becomes dissipated in the corresponding region of nerve, and never succeeds in passing the cathode. Moreover, if the ball, with a certain initial velocity, were to be set going at some point of the inferior (anelectrotonic) portion of the curve, it would reach the outlying parts beyond the polarised region with a diminished velocity; while, if it were set going upon a part of the curve (catelectrotonic) superior to the line $n\,n'$, it would reach the outlying parts with an increased velocity.

All these deductions from the doctrine under discussion have been verified, in part by already established facts and in part by recent observations. The experiments by Eckhard and Pflüger have shown that a certain stimulus applied to a nerve produces a greater effect in the catelectrotonic region than in the anelectrotonic. And it is clear that these phenomena are as intelligible under my theory as under the assumption usually made to explain them, viz., that the irritability of the nerve itself is diminished during anelectrotonus and increased during catelectrotonus.[6]

Moreover, certain facts are known which seem to imply that, with a sufficient degree of polarisation, or with a sufficiently slight stimulus, the excitatory wave becomes blocked at the cathode.[7] If to this we add that excitation does not indefinitely increase with the stimulus, but soon reaches a maximum, we may further conclude that, under certain conditions, a diminution of excitation must take place even during the passage of the wave through the anodic area.[8]

In the last place it is to be noticed, that the artificial section of a nerve induces a negative polarisation or catelectrotonus of

[1] "Arch. f. d. ges. Physiol.," vi., p. 359, 1872; vii., p. 323, 1873.
[2] *Ibid.*, vi., p. 560, 1872; vii., p. 355, 1873; x., p. 215, 1875.
[3] Grünhagen, "Zeitsch. f. rat. Med." (3), xxxvi., p. 132, 1869.
[4] "Arch. f. d. ges. Physiol.," x., p. 215, 1875.
[5] *Ibid.*, xii., p. 151, 1875.
[6] *Ibid.*, vii., pp. 325, 497, 1873.
[7] *Ibid.*, vii., p. 354, 1873; x., p. 226, 1875.
[8] *Ibid.*, vii., p. 361, 1873.

the fibres in the neighbourhood of the section, owing to the extension of the demarcation-current along the nerve.[1]

By this electrotonic extension we can explain—or for the most part explain—the so-called "weak currents" of the longitudinal section.[2] A stimulus applied to the nerve near the line of section, according to the law of polarisational increment, should have a greater effect than when applied to points more remote, and this experiment shows to be the case. Finally, an excitatory wave travelling along the nerve towards the cut end of it must, according to the same law, gradually diminish before it disappears entirely in the area of section itself.

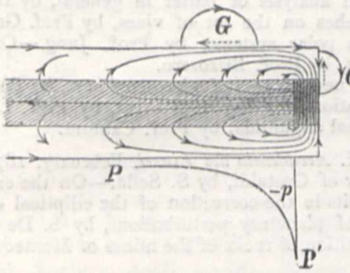


FIG. 8.

V. CONCLUDING REMARKS

The whole of the electrical phenomena of muscle and nerve, therefore, may be readily deduced from a few very simple propositions. Irritable protoplasm responds both to destructive and to exciting influences by an electromotive sign. The altered substance takes on a negative potential with respect to the unaltered. This, together with the doctrines of internal transverse polarisation and of the polarisational increment of excitation, appears fully competent to explain all the facts hitherto observed.

That these fundamental doctrines have the closest reference to the whole life of irritable tissues no one will be disposed to doubt. Yet much examination will be needed to disclose the exact nature of the interdependence.

Although it must now be confessed that the theories which were based upon facts discovered more than thirty years ago, have failed to withstand the criticism of a wider experience, the domain of animal electricity has not lost, but rather gained in interest. And the services of the man who not only discovered this region of physiology, but created the means of conquering it, and who made himself master of its most important fundamental features, are in no danger of becoming dimmed in our estimation by the theoretical changes we have been compelled to accept.

BAROMETRIC PRESSURE

IN a work of great importance,[3] recently published by Prof. Bert, on the physiological effects of barometrical pressure, the author sums up the conclusions to be drawn from his researches as follows:—

A. The diminution of barometric pressure acts on living beings only by diminishing the tension of the oxygen in the air which they breathe, in the blood which animates their tissues (*anoxytienne* of M. Jourdanet), and by thus exposing them to the dangers of asphyxia.

B. The increase of barometric pressure acts only by increasing the tension of the oxygen in the air and the blood. Up to about three atmospheres this increase of tension gives rise to intra-organic oxidations a little more active. Beyond five atmospheres the oxidations diminish in intensity, probably change in their nature, and, when the pressure rises sufficiently, are completely arrested. It follows that all living beings, aërial or aquatic, animal or vegetable, complex or mono-cellular—that all the anatomical elements, isolated (blood-globules, &c.) or grouped in tissues, perish more or less rapidly in air sufficiently compressed. This rule appears only to suffer exception for the reproductive corpuscles of some microscopic beings. For the higher animals death is preceded by tonic and clonic convulsions of extreme violence. Among vertebrates the rapid accidents due to the too great tension of oxygen only commence to manifest themselves at the moment when the hæmoglobin, being saturated with oxygen, that gas enters into the state of simple dissolution in contact with the tissues.

C. Diastases, poisons, and true virus resist the action of oxygen at high tension.

D. The inconvenient effects of diminution of pressure may be efficaciously combatted by the respiration of an air sufficiently rich in oxygen to maintain the tension of that gas at its normal value (20·9). Those of the increase of pressure may be combatted by employing air sufficiently poor in oxygen to arrive at the same result.

E. Generally the favourable or noxious gases (oxygen, carbonic acid, &c.) act only on living beings in accordance with the tension which they possess in the surrounding atmosphere, a tension which is measured by multiplying their centesimal proportion by the barometric pressure; the increase of one of the factors may be compensated by the diminution of the other.

F. When animals possess reservoirs of air either completely closed (swimming bladder of acanthopterygians, &c.) or in communication with the air during decompression alone (swimming vessel of the Cyprini, intestines of aërial vertebrates, &c.), or in communication with the air during both compression and decompression, but by very small orifices (lungs of aërial vertebrates, &c.), the diminution or increase of pressure may have physico-mechanical effects.

G. Sudden decompression from several atmospheres has only the effect (except for some cases comprised under conclusion F) of allowing to return to the free state the nitrogen which was, under favour of pressure, dissolved in the blood and the tissues.

H. The beings actually existing in a wild state on the surface of the globe are accommodated to the degree of oxygenated tension under which they live; all diminution, all increase, appears to be unfavourable to them when they are in a state of health. Therapeutics might make something out of these modifications in various patholgical conditions.

I. Barometric pressure and the proportion per cent. of oxygen have not always been the same on our globe. The tension of that gas has apparently been, and will without doubt continue to go on, diminishing. There is here a factor which we have not yet taken into account in biogenetic speculations. The power of reaction against these various modifications leads to the supposition that microscopic beings must have appeared first, and that they will be extinguished by the insufficient tension of oxygen.

K. It is inaccurate to teach, as is ordinarily done, that vegetables must have appeared in the earth before animals, in order to purify the air of the great quantity of CO_2 which it contained. In fact, germination, even that of mildew, does not take place in air sufficiently charged with CO_2 to be fatal to warm-blooded animals. It is quite as inaccurate, as I have observed long ago, to explain the anteriority of reptiles with warm-blooded animals by the impurity of the air tainted with too much CO_2; reptiles, in fact, are more injured by this gas than birds, and still more so than mammals.

SCIENTIFIC SERIALS

THE *Sitzungsberichte* of the Vienna Imperial Academy of Sciences (Natural History Section, vol. lxxvi. parts 1–5, and vol. lxxvii. parts 1–4) contain the following more important papers:—Addenda to our knowledge of annelids, by Dr. Aug. v. Mojsisovics.—On the orthoptera of the Senegal River, by Dr. H. Kraus.—On the fauna of the Cypris slates of the Eger tertiary strata, by O. Novák.—On the natural history of glimmer, by G. Tschermak.—Researches on cystolithes and some similar formations in the vegetable kingdom, by K. Richter.—On the genesis of salt deposits, particularly of those in western North America, by F. Posepny.—On the fresh-water fish of South-Eastern Brazil, by Dr. F. Steindachner.—On the "Salse di Sassuolo"

[1] "Arch. f. d. ges. Physiol.," vii., p. 363, 1873. This polarisation, of course, still occurs even when the demarcation-current is not abducted, or when the abducted portion is counterbalanced by an opposite current. In the latter case, according to Bosscha's law, the nerve behaves just as if no abducting circuit were applied to it. "Arch. f. d. ges. Physiol.," ix., p. 29, 1874; x., p. 237, 1875.

[2] In Fig. 8 the core of the nerve-fibre is obliquely shaded. Even in the absence of polarisation of the core the boundary current would become distributed after the manner shown in the figure, and would pass into the galvanometer circuits G and G′ as the so-called weak longitudinal and transverse currents of du Bois-Reymond. But, with polarisation, the extension along the core is very much greater than without it, and at the same time the polarisational curve pp' is produced.

[3] "La Pression Barométrique; Recherches de Physiologie Experimentale." Par Paul Bert, Professor à la Faculté des Sciences de Paris. (Paris: G. Masson. 1878.)

and the "Argille scagliose," by Theodor Fuchs.—On the flora of the countries round the Mediterranean and their dependence from the soils, by the same.—On the fossil flora of Parschlug, in Styria, by Dr. C. von Ettingshausen.—On the development of the embryo of *Asplenium shepherdi*, Spr., by F. Vouk.—On the internal cells in the antheridium cell of the pollen grain of certain coniferæ, by A. Tomaschek.—On the origin of aptychus-limestone, by Th. Fuchs.—On the light line in the prism cells of seed scales, by Dr. R. Junowics.—On the encircled specks in the wood of trees, by Dr. J. Kreuz.—On the firmness and elasticity of vegetable tissues and organs, by Th. Weinzierl.—On the resinous ducts of certain coniferæ, by Dr. Kreuz.—On the development of the pollen of *Colchicum autumnale*, L., by A. Tomaschek.—On some accessory appendages to the skull of Leporidæ, by Dr. A. von Mojsisovics.—On cork and cork tissues, by Dr. F. von Höhnel.—Histo-chemical researches on xyllophiline and coniferine, by the same.—On the phanerogamic flora of the Sandwich Islands, by Dr. H. W. Reichardt.—On the protoplasm of the pea, by Dr. Ed. Tangl.—On the undulating nutation of the internodes of the stems of plants, by J. Wiesner.—On the behaviour of Phloroglucine and of some similar substances towards the woody cell membrane, by the same.—On the degeneration in the leaf-shoots of some Amygdaleæ, caused by species of Exoascus, by E. Rathay.—Researches on Tunicata, by C. Heller.—On some new genera and species of Neuroptera, by Dr. F. Brauer.—On the originals to Ign. von Born's Testaceis Musei Cæsarei Vindobonensis, found in the Imperial Zoological Museum, by the same.—On the embryology of ferns, by H. Leitgeb.—Geological researches in the western part of the Balkan and the surrounding districts, by Franz Toula.—On some peculiar apertures in the corolla leaves of *Franciscea macrantha*, Pohl, by M. Waldner.—On the basaltic lava of the Eifel Mountains, by E. Hussak.—On the origin of holes and indentures in the leaf of *Philodendron pertusum*, Schott, by F. Schwarz.—Ichthyological researches, by Dr. F. Steindachner.—On the subterranean water-courses and basins, as well as on the clearness and transparency of certain lakes, and on the formation of lakes generally, by Dr. A. Boué.

Sitzungsberichte der physikalisch-medicinischen Societät zu Erlangen (part 10, November, 1877—August, 1878) contain the following more interesting papers:—On the fertilisation and division of the ovum of *toxopneustes*, by Dr. E. Selenka.—On the history of development of Jacobson's organ, by Dr. R. Fleischer.—On the theory of absorption and fluorescence, by E. Lommel.—On the physiological action of nitro-benzole and of aniline, by W. Filehne.—On the so-called soor-fungus and its identity with *Mycoderma vini*, by M. Reess.—On the changeability of the angles of crystals, by Dr. Fr. Pfaff.—On the theory of normal and abnormal dispersion, by E. Lommel.—Various mathematical papers, by M. Noether and Prof. E. Lüroth.—On the modification of sound phenomena in the human body, by F. Penzoldt.—On the theory of double refraction, by E. Lommel.—On the equations of the seventh degree, by F. Klein.—On some experiments made with *drosera*, by Drs. C. Kellerman and E. von Ramner.—On chelidonic and malic acids, by Dr. O. Liezenmayer.—Thermophysiological investigations, by J. Rosenthal.—On the derivates of cymol and of toluylic acid, by E. von Gerichten.—On the sexual organs of dibranchiate cephalopoda, by Dr. J. Brock.—On two new fluorescent substances, by E. Lommel.—On the influence of the changes in temperature and pressure upon the double refraction of light, by Dr. E. Pfaff.

Jahrbuch der k.k. geologischen Reichsanstalt (vol. xxviii. part 4, October—December, 1878) contains several highly interesting treatises, viz.:—On Alpine phosphates, by J. Gamper.—On the production of common salt from the Russian steppe lakes, by Dr. C. O. Cech.—Observations on the Jurassic formation in the Carpathian cliffs, by Victor Uhlig.—On the artesian well in the Stadtwäldchen near Budapest, by Wilhelm Zsigmondy.—On Emanuel Kaiser's views on the hercynian fauna, and the limit between the Silurian and Devonian formations, by Dr. E. Tietze.

Reale Istituto Lombardo di Scienze e Lettere. Rendiconti. Vol. xii. fasc. iii. We note the following papers in this number:—New phenomena observed in treatment of wine and must, with lime (continued), by Prof. Pollacci.—New physio-pathological researches on pulmonary phthisis (continued), by Prof. Giovanni.—Project of an electrical indicator of the level of water in a flood, by Prof. Ferrini.—Amplitude of oscillations of the declination-needle during 1877 and 1878, at the observatory of Brera, in Milan, communicated by S. Schiaparelli.—Determination of the difference of longitude between Milan Observatory and those of Padua, Monaco, and Vienna, by Prof. Celoria.

Fasc. iv.—First lines of introduction to the study of Italian bacteria (continued), by S. Trevisan.—Composition of butters in Lombardy, and analysis of butter in general, by Dr. Menozzi.—New researches on the rot of vines, by Prof. Garovaglio.—Researches on polar systems, by Prof. Jung.—On provision against trichina, by Prof. Bizzozero.

Fasc. v.—A new process of microscopic art, by Prof. Golgi.—Fruitful copulation of a dog with a cat, by Prof. Lemoigne.—On the intestinal anguillula, by Prof. Cantoni.

Atti della R. Accademia dei Lincei, February, 1879.—Necrological memoir of Gastaldi, by S. Sella.—On the expression of one of the limits in the correction of the elliptical co-ordinates in the theory of planetary perturbations, by S. De Gasparis.—On the composition of rocks of the mines of Montecortini, by S. Cossa.

Rivista Scientifico-Industriale, Nos. 4 and 5, 1879.—We note in these numbers a memoir by Prof. Perotti, on governing combination of the elements of gaseous mixtures.

No. 6.—On a baricentric property of the triangle, by Prof. E. Cavalli.—On a new experiment on electrolysis with weak electromotors, by Prof. A. Bartoli.—On the telephone and microphone as musical instruments, by G. Mocenigo.—Description of some new plants recently introduced into horticulture, by E. O. Fenzi. There plants are *Gentiana algida*, *Primula capitata*, and *P. stuartii*, *Nicotiana acutifolia* and *N. suaveolens*, *Eremurus robustus*.—On two new species of Myriapoda, *Polydesmus siculus* and *Atractosoma nigrum*, by Prof. F. Fanzago.—On a new reagent for cobalt, by Mr. Tattersall.—On poisonous colours, by the editor.

Archives des Sciences physiques et naturelles, March.—From this part we notice the following papers of interest:—On the influence of coloured light upon the development and growth of animals, by Emile Yung.—On the effects of induction coils upon the nervous system, by M. Schiff.—On an acceleration of the process of tanning by means of phosphoric acid, by E. Ador.—On methyl-aniline and toluidine and the colouring-matters derived from these compounds, by MM. Reverdin, Monnet, and Nölting.—On alizarine blue, by M. Graebe.—The other papers contained in the part have been noticed by us elsewhere.

SOCIETIES AND ACADEMIES

London

Mathematical Society, April 10.—C. W. Merrifield, F.R.S., president, in the chair.—Mr. Donald McAlister was elected a Member, and Messrs. A. J. C. Allen and E. Anthony were proposed for election.—The following communications were made:—Notes on quantics of alternate numbers, used as a means for determining the invariants and covariants of quantics in general, by the late Prof. Clifford, F.R.S. (communicated by Dr. Spottiswoode, P.R.S.).—Note on geometrical maxima and minima, Mr. J. Hammond.—On a class of fractions, Mr. R. Tucker.

Linnean Society, April 3.—William Carruthers, F.R.S., vice-president, in the chair.—Mr. W. T. Thiselton Dyer exhibited the inflorescence of *Gynerium saccharoides*, grown at Kew, but which had died during the winter severe weather. Excepting through Mr. Spruce's researches on the Amazons, little is known respecting this handsome plant, which differs from the Pampas grass in habit, and is tropical like maize, &c.—Dr. H. Trimen, in dealing with the subject of the myrrhs of commerce and pharmacy, showed the unique *Balsamodendron myrrha*, Nees. It was gathered by Hildebrandt in Somali Land, 1873, and possesses but few leaves and a single fruit; the traveller, however, saw the myrrh exuding from the tree itself. The original type specimens of *B. myrrha*, collected by Prof. Ehrenberg in Arabia, were also exhibited, and, according to Dr. Trimen, Hildebrandt's late statement of their identity with the foregoing seems well founded. Ehrenberg's other myrrh plant, the *B. Ehrenbergianum*, Berg., with his notes attached, and the *B. Playfairii*, Hook. fil., from Somali Land, with its gum called "Hotai," and other examples of varieties of myrrh and bdellium were placed before the Society and commented on by Dr. Trimen. He specially adverted to the liberality of the authorities of the Royal Berlin Herbarium and of the Hanbury Collection for being enabled to study the rare valuable specimens laid before the Fellows of the Linnean Society.—The account of a remarkable peat flood in the Falkland Islands, by Mr. Arthur Bailey, was communicated by Mr. W. T. Thiselton Dyer. About midnight, November 29, 1878, it was discovered that a black moving mass of peat, several feet high, was making its way towards the settlement at the rate of between four and five miles an hour. The next morning (30th) it was found that the town of Stanley was cut in two, intercourse between its east and west ends alone being possible by boats. Fortunately no lives were lost, and by the energy and activity of the inhabitants in the formation of a trench, much injury and destruction were considerably arrested.—The Secretary read in abstract some notes on Moquilea, with a description of a new species by Mr. John Miers. The author specially compares and marks the differences between the genera Moquilea and Licania, they having often been confounded, and he afterwards points out the distinctive characters constituting his new species, *Moquilea organensis*.

Chemical Society, April 3.—Mr. Warren De La Rue, president, in the chair.—The following papers were read:—On terpin and terpinol, by Dr. Tilden. The author has continued his previous researches, and has succeeded in obtaining crystals of terpin hydrate from essence of lemon; the author considers terpinol to have the constitution of an alcohol. Oil of lemon cajeputol, oil of coriander, and citronella contain bodies closely resembling terpinol.—On a gold nugget from South America, by Mr. G. Attwood. These nuggets are found in alluvial soil in Venezuela. Numerous gold-bearing quartz-veins are found in the neighbouring hills. About one-half of the nuggets are covered with a dark brown substance resembling a silicate of iron. When this is dissolved much finely divided gold separates, and the nugget is partly covered with dull fine gold. The gold obtained from the quartz is less pure than that of the nuggets. The author concludes that gold nuggets gradually increase in size owing to the accumulation of fresh particles of finely-precipitated gold.—On lead tetrachloride, by Mr. W. W. Fisher. The author has not isolated this compound, but has obtained it in solution by dissolving lead dioxide in hydrochloric acid; the yellow solution thus formed precipitates brown hydrated peroxide of lead when treated with solutions of alkalis, &c. The author also suggests the use of chlorine or bromine in the presence of sodium acetate as a means of quantitatively determining lead by precipitation as a peroxide.—On the transformation of aurin into trimethyl pararosanilin, by Messrs. Dale and Schorlemmer. This is effected by the action of an aqueous solution of methylamine at 125° on aurin.—On the solution of aluminium hydrate by ammonia and a physical isomeride of alumina, by C. F. Cross. By boiling the ammoniacal solution of aluminia hydrate a precipitate is obtained, which on drying and ignition furnishes alumina which is extremely hygroscopic, absorbing 35 per cent. of water.—Researches on dyeing, Part ii. Note on the emission of colouring matter, by Dr. Mills and Mr. Campbell. The experiments were made with silk and a dilute solution of Nicholson's blue. The authors affirm that a real and uniform dyeing effect can always be obtained with silk and Nicholson's blue, the heat and souring used by dyers being unadvisable. The authors recommend the addition of common salt to the vat.

Geological Society, March 26.—Henry Clifton Sorby, F.R.S., president, in the chair.—William Adamson Barron, Gregory Dent, Julian John Leverson, and Rear-Admiral Francisco Sangro Tremlett, R.N., were elected Fellows of the Society.—The following communications were read:—Results of a systematic survey (in 1878) of the directions and limits of dispersion, mode of occurrence, and relation to drift-deposits of the erratic blocks or boulders of the west of England and east of Wales, including a revision of many years' previous observations, by D. Mackintosh, F.G.S. The author's researches lead him to the following conclusions:—Boulders from the North-Criffel range and Lake-district can be traced from the Solway Firth to near Bromsgrove (about 200 miles), and over an area in greatest breadth (from near Macclesfield to Beaumaris) of 90 miles, those from Criffel being particularly abundant near Wolverhampton. Boulders from the Arenig occupy a triangular area, limited by a line drawn northward from Chirk to the Dee estuary, and to the south-east of that town are found as far as Birmingham and Bromsgrove. The dispersion of the more distant Criffel boulders would require submergences of from 400 to 1,400 feet; of the Lake-district a little deeper; while the distant dispersion of the Arenig boulders took place at submergences between 800 and 2,000 feet. The author describes several of the more local drifts, and correlates the lower boulder-clay of the north-west with the chalky boulder-clay of the east of England. He considers floating ice, not land ice, to have been the agent of dispersion.—On the glaciation of the Shetland Isles, by B. N. Peach, F.G.S., and John Horne, F.G.S. After an account of previous opinion on the subject, the authors proceeded to describe the different islands, reviewing in succession the physical features, geological structure, the direction of glaciation, and the various superficial deposits. From an examination of the numerous striated surfaces, as well as from the distribution of boulder-clay and the dispersal of stones in that deposit, they inferred that during the period of extreme cold Shetland must have been glaciated by the Scandinavian Mer de Glace, crossing the islands from the North Sea towards the Atlantic. The authors described the order of succession in the Old Red Sandstone formation in Shetland, and referred to the discovery of an abundant series of plant-remains in rocks which have hitherto been regarded as forming part of the series of ancient crystalline rocks. The plant-remains are identical with those found in the Old Red Sandstone rocks in Caithness, Orkney, and Shetland, from which it was inferred that the quartzites and shales in which the fossils are imbedded must be classed with this formation. The authors also described the great series of contemporaneous and intrusive igneous rocks of Old Red Sandstone age, adducing evidence in proof of the great denudation which has taken place in the members of this formation in Shetland.—On the southerly extension of the Hessle boulder-clay in Lincolnshire, by A. J. Jukes-Browne, B.A., F.G.S.

Manchester

Literary and Philosophical Society, January 8.—Charles Bailey, F.L.S., in the chair.—Mr. Thomas Rogers read a paper on, and exhibited many specimens of, ballast plants collected at Cardiff in September, 1878.

February 25.—E. W. Binney, F.R.S., in the chair.—On the mean temperatures of the winters of the last twenty-nine years, by the Rev. Thomas Mackereth, F.R.A.S., &c.

March 4.—J. P. Joule, F.R.S., president, in the chair.—On a modification of Bunsen's calorimeter, by Prof. Balfour Stewart, LL.D., F.R.S.—The poisonous qualities of the yew, by William E. A. Axon, M.R.S.L., F.S.S.

March 18.—J. P. Joule, F.R.S., president, in the chair.—On siliceous fossilisation, part 2, by J. B. Hannay, F.R.S.E., F.C.S., Assistant Lecturer on Chemistry in the Owens College.

Edinburgh

Royal Society, March 17.—Prof. Kelland, president, in the chair.—Sir William Thomson communicated a paper on vortex motion, gravitational oscillations in rotating water. This paper contained an investigation of oscillations under the influence of gravity, of a mass of rotating liquid; former communications having been chiefly directed to the discovery of the vortex theory of atoms. In Laplace's great work on the theory of the gravitational oscillations of a mass of water spread over an approximately spherical body, he takes account of the fact that the earth is rotating and of the effects produced thereby on the motions of the ocean, and how these motions are affected by the great continents. Sir William Thomson finds that vortex motion due to the rotation of the earth affects the tides very considerably, even in such comparatively small areas as those of the English Channel and the North Sea. He shows that in a limited basin without an aperture, covering from, say, one to ten degrees of latitude, any tidal phenomenon which there may be, due to the gravitation attraction of the moon, is greatly affected by the rotation of the earth, if the greatest period of free oscillation of liquid in the basin is comparable with the period of rotation of the earth. It is to this fact that the peculiar phenomenon of the tides in the English Channel is due. The peculiarity is this, that for instance when it is high water at Dover, there is low water at the other end of the channel, and simultaneously a nodal line at St. Alban's Head, *i.e.*, no rise or fall there; moreover, there are currents across this nodal line towards the end of the channel at which the tide is rising, *i.e.*, water is flowing east across this line when tide is rising at Dover, and west when it is rising at the other extremity. This phenomenon holds true only for ten or twenty miles on the English side of the Channel. On the French side there is nothing of this kind but a gradual transition of the time of high tide along the coast. On the English coast, within a comparatively short distance, not more than thirty miles, on either side of the nodal line referred to, there will be high tide on the east simultaneously with low tide on the west. He explains this by showing that in a canal of uniform breadth and depth, along which a wave is travelling, the effect of the rotation of the earth is to make the wave cling to the right hand side in whichever direction the wave is travelling. This manifests itself by the crest of the wave not being of equal amplitude all across the canal, but falling off from the right side down to nothing on the other side if the breadth of the canal is great enough. Where y is the distance of a point from the right bank and x the distance along the bank, the expression for the height of the crest is $e^{-my}\sin(px - qt)$. In a canal which has non-parallel sides, *i.e.*, in which the sides converge, the effect is more marked. This is true of the English Channel or of any other where the time of an oscillation running across from one side to the other and back, is comparable with the period of rotation of the earth. He has worked out the problem in the case of the canal mentioned above, and also for forced and free oscillations in a circular basin.—The next paper was one by Dr. Joseph Coats, Dr. Wm. Ramsay, and Prof. McKendrick, on the action of anæsthetics on the blood pressure. The question they originally wished to solve was whether, in cases where the use of chloroform destroyed life, the result is due to its effect on the respiration or to the action on the heart. They found that at first sight it affected the respiration, but by keeping up artificial respiration they found that it also had an action upon the heart. They experimented both on rabbits and on dogs with the following results:—Chloroform and ethydene chloride reduce the blood pressure, while ether has no appreciable effect. Chloroform reduces the blood pressure much more and much more rapidly than ethydene. It has also an apparently capricious effect on the heart's action, the blood pressure being reduced to nothing and pulsation being very rapid. Sometimes the heart's action was affected as much as a minute or more after the chloroform had ceased to be administered and after the blood pressure had recovered nearly its normal state. The effect of ethydene was to reduce gradually the blood pressure. Chloroform causes death in dogs primarily by paralysing either the heart's action or the respiration according to the individual's peculiarities. The respiration generally stops before the heart's action ceases. They found that artificial respiration was very effective in restoring animals in danger of dying from the effects of chloroform. Ethydene never produces absolute cessation either of the heart's action or of respiration. The results obtained confirm and amplify those of the Committee of the Royal Medical Chirurgical Society of 1864.—Prof. McKendrick showed some experiments by Mr. Aitken on the physiological action of rotating disks on the retina.—Mr. Thomas Muir gave some general theorems on determinants, viz., an expression for the product of a determinant by one of its minors; a theorem for the reduction of the order of a determinant, another for the multiplication of a determinant by an expression of a number of terms equal to the order of the determinant. He laid on the table a note on alterants.

PARIS

Academy of Sciences, April 7.—M. Daubrée in the chair.—The following papers were read:—On the iodides of stannpropyls, by M. Cahours.—On complementary pirouettes, by M. Chevreul. A disk having one half painted with colour a, and the other half white, and being rotated not more than 160 times a minute, nor less than 60, the complementary c of a appears on the white half.—Consequences of experiments made to imitate terrestrial fractures, with regard to various characters of exterior forms of the ground, by M. Daubrée. He points out several examples of the influence of diaclases and paraclases in determining the form of land, their directive influence on erosion, &c.—M. de Lesseps presented a *brochure* of the International African Association, containing a recent lecture by him, and a catalogue of African products at the recent exhibition.—The following elections were made:—M. Alphonse Milne Edwards, member in anatomy and zoology, in place of the late M. Gervais; M. Abich, Correspondent in Mineralogy, in place of M. Damour, elected Free Academician; Mr. Lawes, correspondent in rural economy, in place of the late Marquis de Vibraye.—Analysis of the physiological action of sulphates of magnesia and soda, by M. Moreau. This describes an experiment wherein, some time after ingestion of magnesian sulphate into the intestine, he introduced yellow cyanide of potassium as a test of absorption. The urine afterwards showed no trace of cyanide. The sulphate causes afflux of liquid in the intestinal cavity; so that this occurred in the present case without manifest absorption.—On the summation of a particular species of series, by M. André.—On displacements produced in the interior of an elastic ground by normal pressure exercised at a point of its surface, by M. Boussinesq.—Heat-centre produced by molecular shocks, by Mr. Crookes.—Reply to M. Flammarion's note on the declination of the magnetic needle, by M. Marié-Davy. The reason of the alleged different action of the needle at Paris he finds in the dissimilarity of the methods employed in calculation of the averages grouped in M. Flammarion's tables.—On the gravivolumeter, by M. Houzeau. In this instrument liquid is forced up out of a vessel into a siphon by blowing through a caoutchouc tube, which is then closed with a spring pincer; on pressing the latter, air enters, and the liquid comes from the siphon drop by drop, with great regularity; the numeration of the drops gives precisely the weight of the liquid.—On determination of the presence of fire-damp in the atmosphere of mines, by MM. Mallard and Le Chatelier. They use a lit jet of hydrogen, which gives a larger and more distinct blue aureola than the flame of a common safety-lamp in presence of fire-damp, and reveals the presence of even 0·25 per cent. of the latter gas. The flame, within a cylinder of copper, is viewed through a lens closing a lateral orifice.—On some conditions of alcoholic fermentation, by M. Richet. Oxygen renders more rapid lactic fermentation of milk. Boiling, by coagulating an albuminoid matter originally soluble, diminishes by one-half the activity of the fermentation. Digestive juices which give soluble albumen and peptones increase the rapidity of lactic fermentation.—On the amylaceous and amyloid granules of the egg, by M. Dastre. He opposes M. Dareste's affirmation of the presence of *amyloid* bodies in eggs, maintaining that they are certainly not starch, and have not even the appearance of it.—Determination of sugar in the blood, by M. d'Arsonval. He defends a method of the late Claude Bernard's against recent objections by M. Cazeneuve.—On the method used by Claude Bernard for determination of reducing sugars in the blood, by M. Picard. If there are some animal substances which have the same action on cupric liquors as glucosic solutions, there are a very large number which have rotatory power.—On the distribution of phosphates in the different elements of the blood, by M. Jolly. Alkaline phosphates predominate in the aqueous part of the blood. All the elements contain a variable quantity of phosphate of iron, but it is chiefly accumulated in the corpuscles.—On the formation of a peculiar amyloid matter in the asci of some Pyrenomycetes, by M. Crié. What distinguishes this essentially is (1) its formation in profound darkness by a protoplasm without chlorophyll, and (2) its insolubility in the cellular liquids. This amyloid matter, the physiological *rôle* of which is not yet known, M. Crié calls amylomucine.—On ancient glaciers in the Maritime Alps, by M. Desor.

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