THURSDAY, JULY 24, 1884

THE CONSTRUCTION OF ORDNANCE

A Treatise on the Application of Wire to the Construction of Ordnance. By James Ackman Longridge, M.I.C.E. (London: Spon, 1884.)

ABOUT thirty years ago, during the raging of the Crimean war, special attention began to be directed towards the improvement of our artillery. The old Board of Ordnance was abolished. The manufacturing departments at Woolwich were put under the control of a newly created Minister of War. That able and high-minded officer, Colonel F. M. Eardley-Wilmot, R.A., was appointed Superintendent of the Gun Factories, July 1855. He commenced his work in a thoroughly sensible and practical manner, and pursued his inquiries for suitable materials for guns both at home and abroad. He was ready to adopt anything, new or old, provided it was of the right sort. Sir H. Bessemer has remarked: "My early progress was known to only a few scientific men, among whom was Colonel Eardley-Wilmot, R.A., who took great interest in the invention." But in the summer of 1859 it was decided to adopt the Armstrong breech-loading system, and in November 1859 Colonel Eardley-Wilmot was requested to resign his post at the Gun Factories, to make room for Mr. (now Sir W.) Armstrong.

The 12-pounder Armstrong breech-loading field-guns appear to have given satisfaction, and the authorities at once proceeded to manufacture 110-pounders on the same system without exercising due caution, as explained by General Peel in his letters to the *Times* about September 1868. For, he says, the following sums were voted "for the purchase and manufacture of warlike and miscellaneous stores:—

In 1860-61 ... ... £2,830,625; and
In 1861-62 ... ... £3,006,049

a great portion of which was for the 110-pounder Armstrong guns, which had been adopted into the service without any sufficient trial of them." Among other things, the vent-pieces failed, no matter of what material they were constructed. All the while the nation had to abide strictly by the terms of its bargain—it had adopted the gun, and it must take the consequences. We have never heard that any variation in the principle of the invention was tried with a view to relieve the gun of the excessive pressure at the breech. It was said that there was a contraction of the bore just before the seat of the shot, so that there could be little doubt that the whole of the quick-burning powder then in use would be converted into gas before the projectile moved forward any appreciable distance. Something must therefore yield, and that was generally the vent-piece. Before abandoning the system it would not have cost much to take some disabled gun and remove the chief part of the obstruction to the initial motion of the shot. But the 110-pounders had failed, and there was end of the system—according to the decision of its own friends. But it will be seen that at least one system employing lead-coated projectiles of about 300 lbs. in weight was made to succeed.

The authorities then turned their attention to *muzzle-*loaders, with which they were more successful. Although they now used studded shot, they were careful to avoid all needless obstruction to the *initial* motion of the shot by the use of an increasing twist in the rifling. Also the high initial tension of the powder gas would in this case find some relief from windage.

About the year 1869 the Prussian Government instituted a comparative trial between the English 9-inch muzzle-loading gun and the 9¼-inch breech-loading gun of Krupp. Different opinions have been expressed respecting the fairness with which this competition was conducted. But this much must be said in favour of the decision arrived at, that the Prussians seem to have abided by it, and that they have not come to England to purchase muzzle-loaders constructed on the iron coil system. The striking fact was that Krupp could construct breech-loading guns to fire 200 to 300 lb. lead-coated projectiles from a 9¼-inch breech-loading gun with safety, whereas the Woolwich breech-loading guns failed with similar shot of 110 lbs. with a bore of about 7 inches.

Since that time breech-loading has ceased to be looked upon as an impossibility. We even learn incidentally that we have ships armed with guns constructed on that system.

About 1865 the Committee on Explosives was appointed, who continued their labours throughout many years. We are not aware that details of their observations, made with the chronoscope and crusher gauges, were ever published *in extenso*. So long as this remains the case, the conclusions of the Committee can never be completely accepted. But so many contradictory observations have been published that we are compelled either to doubt the results given by the crusher gauge or to suppose that the forces developed by fired gunpowder are liable to great variation, even where the initial velocity of the shot is the same. Observations with the chronoscope we put aside as of no value in obtaining an accurate measure of the forces, which vary rapidly, and, acting upon a body at rest, generate a high velocity in a space of 10 or 20 feet. Observations of that kind are only valuable when the force affecting the motion changes by slow degrees.

Throughout all these changes the Woolwich system has been in the main the Armstrong system of coils of wrought iron for both breech- and muzzle-loading guns, while the recommendations of steel by Krupp and Whitworth have been set aside partly on the score of expense. But now there are indications that the Woolwich system of coiling is not considered to be quite satisfactory.

Mr. Longridge says:—"Since 1862 millions upon millions have been spent, and we are now told that we are on the eve of a new epoch of expenditure, that the great array of weapons which we have provided are no longer up to the mark, and millions upon millions must again be disbursed before the nation is properly armed" (p. 2).

This seems therefore to be a favourable opportunity for the official consideration of Mr. Longridge's system of applying wire to the construction of heavy ordnance. No other system allows of the tension being so nicely and so readily adjusted. Mr. Longridge appears to have been the first to advocate this system of constructing guns, for so early as 1860 he presented a paper on the subject to the Institution of Civil Engineers. When he first applied to the Government, the objection to his proposals was their extreme novelty, but later on he was told that there was no novelty in the principle of his designs!

Mr. Longridge states the problem to be solved in the following satisfactory terms:—

"Suppose a coil of wire situated near to the inner tube of the gun. It is laid on under a certain tension, but its state is altered by each successive coil which comes over it, and when the gun is completed it is no longer in tension but in compression.

"There is in a finished gun a certain distance from the centre of the bore at which the wire is in a neutral state; it is neither in tension nor in compression. All the wires proceeding outwards from this point are in a state of tension varying, according to a definite law, according to the distance from the centre of the gun. All those proceeding inwards are in a state of compression, as is also the inner tube on which they are coiled.

"In a gun thus constructed the aggregate of all the tensions is exactly equal to that of the compressions whilst the gun is at rest, but when the strain of the explosion is brought into action the state of each wire is altered, all the compressions are reduced and eventually changed to tensions, and all the tensions increased; and, in a gun properly constructed, if the pressure inside were increased to the bursting point, every wire would be strained to its maximum tensile force, and would give way at the same time" (p. 15).

Afterwards Mr. Longridge gives elaborate calculations of the tension proper for each coil of wire.

The system of "chambering" large guns is now in use at Woolwich, Elswick, and Essen, but it appears most objectionable. We quite agree with Mr. Longridge, that "chambering is a poor and inefficient expedient for lengthening a gun at the cost of its durability." He found "that in the case of the 38-ton 12-inch gun the result of chambering out to 14 inches was to reduce the length of the charge from 27 to 20 inches . . . and that this would *cæteris paribus* increase the velocity of the shot about 7 or 8 feet per second" (p. 17). In such a case the mere chambering would give an increased longitudinal strain of nearly 820 tons in the chamber, allowing a pressure of 20 tons per square inch to the powder gas, while the tendency to burst the coil would be increased in the proportion 6 : 7, or nearly 17 per cent. The Committee on Explosives profess to have discovered a so-called "wave action" which may or may not exist in guns fired under the same conditions. And it is claimed for "chambering" that it (1) gives a higher initial velocity, and (2) prevents the abnormal very high local pressures induced by long cartridges. In the case mentioned by Mr. Longridge 7 inches was the gain in the space through which the powder gas propelled the shot. But the charge being in a more compact form, only 20 inches long, would probably explode more rapidly than it would in the bore 27 inches long, and consequently the powder gas propelling the shot at corresponding points in the bore would be greater with the chambering, and consequently in that case the initial velocity of the shot might be expected to be greater, especially with the increment of 7 inches in the useful length of the bore. But it is difficult to imagine in what way chambering could reduce the stress upon the gun. We have found by calculation what would be the lengths of the following guns, in order to allow the same internal volume:—

	ft.	in.	
71-ton Krupp gun, chambered	32	10	long.
,, ,, unchambered	33	11	,,
80-ton Woolwich, chambered	26	9	,,
,, ,, unchambered	28	1	,,
100-ton Armstrong, chambered	32	8	,,
,, ,, unchambered	33	10	,,

From this it appears that the saving in total length of gun due to chambering is not great.

The process seems to have been this. After much trouble guns were manufactured which with a uniform bore and slow-burning powder stood tolerably well. In order to obtain an increased initial velocity the gun was chambered and therefore weakened. Sir W. Armstrong says that the calculated strength of his 100-ton chambered gun, which failed, was "far in excess of what a normal pressure would demand." And then he goes on to state, March 1880, that "Nothing, in fact, wants investigation so much as this powder question" (*Proceedings* of the R.A. Institution, Woolwich, vol. xi. p. 197). If chambering is to be profitably used it appears that it will be necessary to adopt steel and abandon coiling—both wire and wrought iron.

As a uniform bore gives the strongest form of gun, it appears to be very desirable to obtain a slow-burning powder less bulky than that now in use. But if that be not possible, we would either slightly lengthen the gun or use a powder a very little more energetic than that now in use, and just sufficient to compensate for a want of chambering.

Mr. Longridge quotes the following remark of Messrs. Noble and Abel on air-spacing:—"In cases where there is a considerable air-space between the charge and the projectile, it has been found that the energy developed in the projectile is materially higher than that due to the expansion of the powder gases through the space traversed by the projectile, and the cause of this appears to us clear.

"When the charge is ignited at one end of the bore, and the ignited products have to travel a considerable distance before striking the projectile, these ignited products possess considerable energy, and a portion of this energy will be communicated to the projectile by direct impact" (p. 110).

Well may Mr. Longridge exclaim: "With all respect to these gentlemen, we are quite unable to accept this explanation." The explanation we have to offer is that when a moderate air-space is left there will be a delay in the initial motion of the shot, and consequently the explosion of the charge for every position of the shot will have proceeded further than if there had been no air-space, and consequently the pressure of the powder gas will on the whole be increased. But, on the other hand, there will be a slight loss of velocity, since the powder gas acts on the projectile through a slightly reduced length of bore corresponding to the air-space.

We have never made experiments on the pressure and action of fired gunpowder. But we hold that with "chambering" and "air-spacing," using the same powder, the gun must be distressed, if by these means any sensible addition of initial velocity of the shot is obtained.

Mr. Longridge appears with reason to recommend the adoption of a uniform twist of rifling, now slow-burning powder is used. The increasing twist of rifling was very probably effective in saving the gun when quickly-exploding powder was employed. But the importance of an increasing twist of rifling decreases as the action of the powder gas is rendered more nearly uniform. If the pressure driving the projectile throughout could be made perfectly uniform, then a uniform twist would exert a constant force to produce rotation.

Mr. Longridge says:—"So long ago as 17th March, 1860, the then Secretary of State for War, in his speech on the Army Estimates, said that 'these experiments proved that they had been wrong in using powder of so quick a detonating nature for artillery practice, and especially for rifled cannon, which required a weaker and slower powder than in the other cases" (p. 113). And twenty-four years later, March 20, 1884, the Secretary to the Admiralty said: "The old breech-loader had been found to be of no more use than a muzzle-loader, and the Government had adopted a gun twice as long as the old form of breech-loader." It is not very clear what all this means, but it is plain that vast sums of money will be required to provide long guns. Twenty years ago it might have been determined what effect every additional foot in length of a gun had in imparting increased initial velocity and increased steadiness to projectiles; but something more than the "rule of thumb" would be required to accomplish this.

England has of late come to acknowledge the value of technical training, and has shown a readiness to take a lesson from Continental nations. Is it not natural to suppose that some training of this kind might be found useful in settling the proportions of our guns, and in other matters of the same kind?

We think that Mr. Longridge has made out his case, and that his system deserves a fair trial in comparison with other promising systems. It has already been deemed worthy of a partial trial at Elswick, in France, and America. Experimental guns on different promising systems might in the first case be constructed of small calibre, and adapted to fire the service projectiles. If these proved satisfactory, then proceed to construct larger guns, and finally let that system survive which was found best fitted for its purpose.

F. B.

OUR BOOK SHELF

A History of British Birds. By the late Wiiliam Yarrell, V.P.L.S., F.Z.S. Fourth Edition. Revised to the end of the second volume by Alfred Newton, M.A., F.R.S., continued by Howard Saunders, F.L.S., F.Z.S. Parts XXI.-XXIV., January to July, 1884. (London: Van Voorst.)

ALTHOUGH, as we have said in a former notice of this work, it was a great pity that Prof. Newton could not be induced to complete his revised edition of Yarrell's well-known "History of British Birds,"—a subject in which he is before all other living naturalists at home, there can be no doubt that the task has fallen into good hands. Mr. Howard Saunders has not only completed a volume in about the same space of time that the former editor took to issue a single number, but has performed his work in a style to which, we think, little exception will be taken. The aim of Yarrell's "History of British Birds," we suppose, is to be sufficiently popular to be understood by all well-educated people, and at the same time to be thoroughly correct in scientific matters, so far as they are involved. As to Mr. Saunders' numerous remarks upon points of synonymy and distribution being entirely free from error, we should be very sorry to guarantee anything of the sort. But as we turn over the pages of his recent numbers, very few exceptional statements seem to present themselves, and most of these relate to what are to a certain extent matters of opinion.

Having finished his *Limicolæ* in Part XXI., Mr. Howard Saunders naturally proceeds to the Gaviæ, a part of his subject with which he is, as we all know, very familiar. An author who has worked out the Laridæ of the whole world in a thoroughly conscientious manner, and made this group his special study, is above all others qualified to prepare a special account of the "British" species. Of these Mr. Saunders recognises thirty as admissible into the list, though it is more than probable that this already large number will be still increased by the arrival in future years of stray individuals belonging to other species of this essentially wandering tribe of birds.

Congratulating our author on the accomplishment of the first volume of his portion of this excellent work, we may venture to express a hope that he will bring the long-delayed fourth edition of "Yarrell's Birds" to a speedy and satisfactory conclusion.

Bulletin of the United States National Museum. No. 19. "Nomenclator Zoologicus." By Samuel H. Scudder. 8vo. (Washington, 1882-1884.)

MR. SCUDDER'S "Nomenclator Zoologicus," which has been issued as No. 19 of the *Bulletins* of the United States National Museum, is not of a generally attractive nature, but will be of great use to working zoologists. It consists of two parts: the first of these, or "Supplemental List," contains the names of genera in zoology established previous to 1884, which are either not recorded or erroneously given in the previously issued Nomenclators of Agassiz and Marschall. To each generic name is added a reference to the work in which it is to be found. The second portion of Mr. Scudder's volume, or "Universal Index," contains an alphabetical index of all the names included in the "Supplemental List," together with those given in the Nomenclators of Agassiz and Marschall, and in the Indices of the Zoological Records. This second, most important part, contains about 80,000 entries, and, if correctly drawn up, as we have no reason to doubt is the case, will enable a naturalist who has recourse to it to determine at a glance whether any particular name has been already employed in zoology or not. All working naturalists will at once acknowledge the value of such an index as this, and will join us in thanking Mr. Scudder for having produced it. Could Mr. Scudder's index be magnified into a "Lexicon Zoologicum," giving the references to all the 80,000 terms in a single volume, a still more meritorious and useful work would be the result. Until this shall have been accomplished, it will still be necessary for a naturalist to refer to half a dozen or more different works in order to ascertain where any particular generic term has been employed in zoology.

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 insure the appearance even of communications containing interesting and novel facts.]

Krakatão

I FORWARD a letter recently received from a former pupil, Dr. Stanley M. Rendall, which gives so graphic a description of the sea of pumice which resulted from the eruption of Krakatoa, that you may perhaps not be indisposed to print it in NATURE.

University of Edinburgh, July 17 WM. TURNER

71, *Rue de Genève, Aix-les-Bains, June* 24, 1884

DEAR PROFESSOR TURNER,—I have been so occupied since meeting you in Edinburgh that it has been impossible to send sooner notes of my trip to Java. The first intimation that I had of anything unusual having occurred was on our way out to Australia. Making our way north again after having done our "easting" in about 45° S., we were all much struck by the splendidly vivid sunsets, and by the distinct interval of time between the actual disappearance of the sun below the horizon and the appearance of the deep red or crimson glow. This phenomenon was more striking as we sailed north. On reaching Queensland we heard of the volcanic eruption in the Sunda Straits and received the explanation of the so-called "Krakatoa Sunsets." I left Newcastle, N.S.W., for Batavia in a steamer about November 10, 1883, *viâ* Cape Leeuwin, sailing up the west coast of Australia. We first came across distinct evidences of the eruption about 200 miles before we entered the Straits of Sunda, in small isolated pieces of pumice-stone, which became much more numerous and finally took the form of yellow patches constituted by morsels of pumice varying in size from a pea or even smaller up to a cocoa-nut, rarely larger. As we neared Krakatoa itself, these patches were certainly more numerous and larger in size, but still the actual amount of debris was small, much smaller than I had expected to find after the account I had heard from persons who had previously traversed the Straits. The yellow patches were few and far between, and composed chiefly of a coarse dust with here and there larger lumps amongst it. Krakatoa, formerly the most fertile of all the lovely isles which one passes, rose like a vast cinder, still smoking. Not a blade of grass or a leaf was to be seen, just a grayish seared-looking mass. A large portion of the island had disappeared, and I was told that over the sunken part 300-fathom soundings had been taken. Between the island and Batavia we passed a few more floating patches of pumice as above described. After about eight days at Batavia we steamed down the coast to different ports, Cheribon, Tegal, and Samarang, being on the whole about three weeks away from the time we left Batavia to our return there, which took place, so far as I can remember, on January 1. On nearing Batavia again we passed through large patches of pumice-stone, patches of several acres in extent, some of the lumps forming them being of large size, roughly speaking about as big as a cwt. sack of coals, and all sizes below that down to coarse dust. We anchored for the night just outside the port in clear water. Early in the morning one of the officers called me to look at an immense floe of pumice-stone that was bearing down upon the ship, and very soon we were entirely surrounded, and formed the centre of about, I should think, a square mile. Though covering a large surface, there was evidently no great depth of matter. One could pick it up by throwing a bucket or heavy pail into the mass, and a small steam launch easily made her way through it to our side. We left Batavia early in the morning, and passed through two or three such collections, all making their way in the same direction by the action of a current, as there was no wind, the sea being perfectly calm. When about thirty miles from Batavia, we met coming towards us an immense field, similar, except for its greater extent, to those already described. I could not tell you by any means exactly how large a surface it covered, but at one time could only just make out the edge we had entered it at with the naked eye, and could not see its termination in the opposite direction with the ship's glass, so that it was at least several miles in extent. Also the depth of the pumice-stone bed was very great, offering considerable resistance to the ship's progress, as shown by its diminished speed. An iron fire-bar thrown over the side rested on the surface of the mass, instead of sinking. Large trunks of trees were not floating in the water, but resting on the surface of the pumice. The passage of our vessel left a wake of only a few feet, which speedily closed in again, so that to see it at all I had to lean over the stern and look under it as it were. It seemed exactly as if we were steaming through dry land, the ship acting as a plough, turning up on each side of her a large mound of pumice, especially noticeable on looking over the bows. Our passage through this made no great noise—just a soft sort of crushing sound. The effect was very striking and queer. I only regret that I did not time our passage through this, the largest mass we met. We passed through one more but smaller field in the Straits of Sunda, and after that do not remember again meeting with any even small patches of pumice-stone. I thought it curious meeting such immense quantities of the debris in the same place where, a month or five weeks earlier, only a few scanty, isolated patches existed. It was not due to a new eruption, so must be accounted for by the currents massing together a large number of scattered patches; or perhaps a certain amount had first sunk, and then, later on, had risen to the surface. I hope these short notes may be what you want; if I can give you any more information, I shall be delighted to do so.

With kindest regards,

Believe me yours sincerely,

STANLEY M. RENDALL

The Laws of Volume and Specific Heat

THE former, known as the "law of Avogadro," implies that any given volume at the same temperature and pressure must contain the same number of molecules. It includes the law of Chasles, viz. equal expansibility for equal increments of heat; and the law of Boyle or Marriotte, that the volume of any gas must vary inversely as the pressure.

The other is that of Dulong and Pettit; and as the former necessitated equal volumes, so this latter implies constant heats for parallel conditions. But, finding that few elements approximated this law, it was an early device to double, treble, or quadruple the old atomic weights to secure a supposed uniformity; and thus the law found this expression, viz. that the specific heat of any solid element would prove to be a measure of its atomic quantity.

This, put in plausible fashion, will be the stock instruction of the superficial books for some time to come; but in the higher circles of chemical life it is being admitted more and more that a great change has come over the spirit of this dream. Departures from the normal 6·4 are no longer attributed to errors of observation, and that constant is replaced by a range of 5·5 to 6·9; while, to keep within this, M. Weber has proved that the doubled carbon equivalent must be tested at a range of temperature exceeding 1000° C. He has found that within the limits of −50° and 600° its heat value increases sevenfold! Well indeed may he say, "The idea that temperature can be overlooked must no longer be entertained;" also, "That the specific heats are not generally expressed by constant numbers; the physical condition of the elements influence their specific heats as much as their chemical nature."

These be great admissions from one of the highest authority, but they are as nothing compared with the new demands of physical chemistry. Mr. J. T. Sprague, an able and determined new chemist, has been the first in England to challenge attention to the recent researches of M. Berthelot, L. Troost, and others of the very highest chemical authority.

In a recent paper he admits that the new results "strike at the root of the most favourite chemical doctrines of the day, doctrines which are the foundation of the modern atomic weight and molecular theory, and consequently of the doctrines of atomicity, and the complicated molecular theories which have been based upon the supposed atomicity and specific bonds of different atoms."

The laws of Avogadro and Dulong and Pettit are offshoots of one principle, and one really implies the other. *If* true, it would follow that the atomic heat must be the same for all substances, or, if otherwise, the same quantity of heat would not produce equal expansions; also that the specific heats must be equal at all temperatures, or equal quantities of heat would act differently at different temperatures, or else it must vary equally for all gases, or they would expand unequally for equal quantities of heat.

Now it is a misfortune for these laws that none of these conditions subsist over wide areas. As a consequence of the two laws, an air thermometer should measure all temperatures by equal rates of expansion, and a given expansion should correspond to a fixed quantity of heat; such a thermometer should also read equally if filled with any other perfect gas.

In other words, these laws can only be true if the relation between the weight and volume of different gases be constant, and if the heat absorbed in producing a given change of volume is equal at all temperatures; that is, if the specific heat is constant.

These conditions are practically fulfilled by air, O, N, and H, between 0° and 200° C., so that the scale of temperature derived from the change of volume is the same as the scale derived from quantities of heat; but between 200° and 4500° there is a gradual growth of changed conditions which proves fatal to both laws, and there is apparently an absorption of energy which does not appear either in the form of expansion or of sensible heat as temperature. At this high stage the specific heat of some of the simple gases has increased threefold, while some gases have a greater rate of expansion than others.

The same thing occurs with other simple gases, but at a much lower temperature, as, even within 0° and 200°, where dissociation cannot be entertained, chlorine and other halogens differ considerably from N or H, and at 1600°, if an air thermometer indicated 1600° for a given expansion, a chlorine one would register by expansion 2400° for an equal temperature, though with a much greater absorption of heat by the chlorine.

This difference is dependent on the fact that at 1600° the comparative density of chlorine has diminished one-third; or, in other words, that its volume, as compared with H, instead of being 1, has become 1·5; or, to put it in another way, that under these conditions, the specific heat of Cl is threefold that of H.

Quite apart from these extreme cases the specific heat is never a constant value; it takes more heat to raise a given weight of substance 1° at one temperature than another.

The specific heat increases with temperature, but differently for different substances:—

	0° to 100°	0° to 300°
Iron	= ·1098	·1218
Platinum	= ·0335	·0343
Mercury	= ·0330	·0350

The differences here are both distinct and small, but Be (glucinium) increases twofold within a moderate range, and we have seen that between − 50° and 600° carbon increases its specific heat sevenfold, or, as Mr. Sprague expresses it: "The heat relation of each substance is described by a particular curve; and the small differences observed in some cases are not errors, but actual differences of the several curves, and where there is approach to identity it is accidental, due to the temperature of observation being within a limit at which the curves are near their commencement, and have barely begun to separate."

However tempting or fashionable it may be to rush into hypothetic *explanations* of half-digested truths, yet I have taken some pains to keep within *facts*, which are in some respects incipient and but little understood.

If the causal differences in the production of light and sound had been fairly or patiently entertained, the "luminiferous ether" would never have been invented, which now crosses our path, as an "opaque fact, stopping the progress of further knowledge."

If a little more humility and patience had been evinced in respect of the expanding facts connected with gaseous volumes and specific heats, the old equivalents would never have been doubled, trebled, or quadrupled, to mar the symmetry of a beautiful science.

I quite agree with M. Troost, who, in repudiating the hasty references to dissociation, &c., observes: "The only consequences which *necessarily* flow from the experiments at high temperatures, or at low pressures, are that the coefficient of expansion is variable with the temperature, or that the coefficient of compressibility varies with the pressure." Also with the final conclusion of M. Berthelot: "The only law absolutely and universally applicable to the elements is the invariability of the relations of weight according to which they combine. This notion, and that of the energy brought into play in their reactions, are the sole and only firm foundations of chemical science."

SAMUEL E. PHILLIPS

A Carnivorous Plant

WITH reference to Prof. Moseley's letter in your issue of May 22 (p. 81) on "A Carnivorous Plant preying on Vertebrata," I may mention that in 1881, when surveying at the Paracel Islands in the South China Sea, I saw a somewhat similar occurrence. The tide was low on the reef on which I was strolling and admiring the lovely forms of coral existence. As I neared a pool cut off by the tide from the sea, I noticed amongst other submarine verdure a very ordinary-looking flesh-coloured weed about one foot high and of similar girth. My appearance alarmed numbers of tiny fish, which darted to the cover of overhanging ledges, but I noticed about half a dozen apparently seeking cover in the weed. Bending down closer, I saw that they were lying helpless about the fronds, with very little life left in them. Putting my hand down to pick up one of the half-dead fish, I found my fingers sucked by the weed, the fronds of which closed slightly on them. The fish were not caught by the head especially, but held anywhere round the body. The death seemed to be slow and lingering, and where the fish had been held its skin was macerated. These captives may have been caught some time, and were in different stages of exhaustion. I regret being unable to name the plant, or the young fish. They were from an inch to an inch and a half long. The plant had a dirty and rather slimy look about it.

ALFRED CARPENTER

H.M.S. *Myrmidon*, Suakim, Red Sea, June 24

Phosphorescence of the Jelly-Fish

THE conclusions arrived at by Mr. Verrill (NATURE, July 17, p. 281) cannot fail to be of interest to all who have ever speculated on the significance of the luminosity displayed by so many *Acalephæ*, *Medusæ*, and other marine organisms. When in the tropics, in 1875, very similar ideas occurred to me, and in an address on the phenomena of cyclical propagation delivered to the Essex Field Club on January 28, 1882, I ventured to put forward the following views, which, as the address is still in manuscript, I will beg permission to quote:—"It was in the Bay of Bengal, when on the Eclipse Expedition of 1875, that I first saw shoals of *Medusæ* in their full splendour. Speculating on the meaning of the vivid colours and brilliant phosphorescence of these creatures, I came to the conclusion that both these characters might be protective danger-signals of the same nature and fulfilling the same function as the bright colours of distasteful caterpillars according to Wallace's well-known theory, or the phosphorescence of the *Lampyridæ* according to Thomas Belt ('Naturalist in Nicaragua,' p. 320). The 'urticating' powers of the jelly-fish would certainly make them unpleasant, if not absolutely dangerous, to predatory fish, and their bright colours and luminosity at night may thus be true warning characters."

R. MELDOLA

London, July 21

Fireball

RECORDED personal observations, such as that of Miss Annie E. Cocking (NATURE, p. 269) last week, must needs be so rare that every detail of them—especially where the description is clear and simple—is of weight and value. What strikes my own mind as of much interest in this one is that, as the strange and fateful visitant sank towards the carpet, "at this instant a peal of thunder crashed *over the house*—it was the very loudest the writer had ever heard." This would seem to show that, whatever the nature of the insulator which envelopes these floating Leyden jars, their connection is maintained unbroken with the cloud of origin until the moment of discharge; and that, whatever causes the "crash," a peal of thunder takes effect rather in the cloud than at the point of contact. This agrees also with the descent of a fireball in the sea at Margate, mentioned in to-day's papers, where the crash of thunder occurred while the ball was yet in sight. But it is still another question whether these floating globes, which only discharge themselves *on contact*, do not in some important respect differ in their nature from the commoner "fireball" discharged with the directness, if not all the speed, of a lightning flash out of a thundercloud. It is a question towards the solution of which only observations such as that for which we are indebted to Miss Cocking can materially help us.

HENRY CECIL

Bregner, Bournemouth, July 21

Animal Intelligence

THE following instance of animal intelligence may interest some of your readers. While walking through the forest here the other day, I found a young jay upon the ground scarcely able to fly. As I stooped down to examine it I was somewhat startled by a swoop made at my head by the old birds, their wings actually touching my hat. Determined not to be driven away, I remained by the young bird, whereupon a succession of like swoops were made at my head; these I easily succeeded in parrying with my stick, although the old birds frequently came in different directions. After about a couple of minutes the old birds seem to have come to the conclusion that nothing could be achieved in this fashion, and one of them, flying to some little distance, kept calling to the younger one, who half hopped, half flew after her. I of course followed; and now occurred what seems to me a striking instance of animal sagacity. The pines here are covered with lichen and a long, hairy kind of moss, which easily crumbles into dust. The cock bird perched himself on the tree over my head, and began pecking with wonderful rapidity at this lichen and moss, so that, the moment I looked up, a shower of fine dust fell on my face. As I followed the young bird, the old one followed me, got on a branch as close to my head as he could, and sent a shower of dust down upon me. I can scarcely doubt that the dust, like the previous swoops, was intended rather *to blind me* than to distract my attention. Have instances of like sagacity—*i.e.* the apparent knowledge of the organ of vision and the means of injuring it—been noticed in *jays* before? KARL PEARSON

Saig, Schwarzwald, July 14

Munro and Jamieson's Electrical Pocket-Book

As Mr. A. Gray's criticism of our "Pocket-Book" is chiefly confined to literal errors practically unavoidable in a work of the kind, we take the opportunity of stating that we have lately been correcting these for the second edition, which, we are happy to say, has already been called for.

J. MUNRO AND A. JAMIESON

I OBSERVE that in my article in the last number of NATURE the third sentence of the third paragraph of p. 263, beginning "In the particular case, &c.," should have the words "corrected for the heat of combination of copper oxide and sulphuric acid" inserted after the word "this." A. GRAY

Glasgow, July 21

THE GREELY EXPEDITION

SUCCESS has at last attended the efforts to rescue the expedition to Lady Franklin Bay under Lieut. Greely; but, alas, out of the twenty-five men who started three years ago nineteen have perished. The party had left their station, Fort Conger, in August last, but did not succeed in getting further south than Cape Sabine, in Ellesmere Land, at the entrance to Smith Sound, about 150 miles from Lady Franklin Bay, and some 300 or 400 miles from Upernivik, the nearest Danish station. It is easy now to say that it would have been much better for the expedition to have stayed on in their comparatively comfortable quarters at Discovery Bay; the chances are that they would all have survived, and probably all have been rescued this summer by the relief party in the *Bear* and the *Thetis*.

We may remind our readers that the Greely expedition was sent out by the Government of the United States as one of the series of International Arctic expeditions, the main purpose of which was to take regular observations, according to a preconcerted plan, on the meteorological and other physical conditions of the Polar area. As the Greely expedition had to go much further north than any of the others, it started a year earlier in order to be sure to reach its post in time and be able to begin observations not later than August 1882. It was thoroughly equipped, both with scientific apparatus and with the material for a comfortable life under unusually trying conditions. The provisions supplied could have easily been made to last until the present summer, and we know from letters from Lieut. Greely, written shortly after his arrival, that the region around Lady Franklin Bay, 81° 44′ N. lat., abounded in musk oxen. In the summer of 1882 strenuous efforts were made to reach the station, but with no success. Last year two vessels were sent out, but the state of the ice was such that one was completely crushed and the other was glad to escape southwards almost as soon as it had entered the threshold of the intricate channel that led to Fort Conger.

The expedition which has been so fortunate as to rescue the six survivors consisted of the United States ships *Bear* and *Thetis* and Her Majesty's ship *Alert*, which was presented to the United States Government for the purpose. The condition in which the few survivors were found is almost too harrowing to record; how very nearly too late the rescue party were is impressively shown by the fact that Lieut. Greely, surrounded by his prostrate companions, was reading the service for the dying. "The red syenite rock forming Cape Sabine," Sir George Nares tells us, "and the islands in the neighbourhood of Payer Harbour is sterile and barren to the last degree. During the three days we were detained there, although parties from the ships explored the whole of the immediate neighbourhood, very little animal life was seen." The end of the cape or peninsula is cut into by a bay in which are several islands—Brevoort, Payer, Stalknecht, &c. Here Sir George Nares in 1875 left 250 rations, which do not seem to have been discovered by the Greely party; and of the 50,000 lbs. of food buried for them by the rescuing parties Lieut. Greely succeeded in finding only 250 lbs.

For full details as to the work accomplished by the unfortunate expedition during its almost three years' stay in so high a latitude we must await the publication of the records. Happily all the records have been saved, and thus the gain to science is likely to be of unusual value. What are the hardships to be met with, and the aspects of nature to be witnessed in this remote latitude, we know something of already from the records of our own expedition ten years ago under Sir George Nares. But the present expedition, profiting by the experience of its predecessors, and working on a carefully prearranged plan, is likely enough to tell us much that we never dreamt of. While the main work of the party was to make regular observations in physical science, it is evident that they have taken advantage of their exceptional position to push back the limits of our ignorance of Arctic geography. The lowest temperature experienced is stated to have been 61° below zero F. We all remember the exciting narrative of the painful scramble of Commander Markham and his brave men over the "palæocrystic ice" in order to make the attempt at least to reach the Pole. After about sixty miles they had to return baffled, glad to escape with their lives. Markham and Parr and their men had, however, the satisfaction of having attained the highest latitude ever reached—83° 20′ 26″. Lieut. Lockwood, however, succeeded in getting some four or five miles (83° 24′) beyond Markham's farthest, and 19° to the east of the English route.

Lieut. Lockwood, unhappily among the dead, seems to have been one of the most active and enterprising members of the expedition. He followed Lady Franklin Bay in its continuation, Archer Fjord, ninety miles beyond Beatrix Bay, Nares's furthest, quite to the other side of Grinnell Land, which he found to be an island, separated by Archer Fjord from the land to the south, now named Arthur Land. This was confirmed by the view obtained from Mount Arthur, 5000 feet high, west of the Conger Mountains, which may possibly be the range named after the United States by Sir George Nares. This Grinnell Land seems in many ways to be an interesting region; there are evidently several peaks or mountain ranges reaching a height of 5000 feet. A considerable area both on the north and south shores is covered by an ice-cap 150 feet thick, while, so far as we can judge from the report, there is a belt of comparatively open country in the interior some sixty miles wide. Even so late as March last, when the members of the expedition were dying one by one on Cape Sabine, exploration was not neglected. From Mount Carey to the north-west of the cape Sergeant Long obtained an extensive observation in the direction of Hayes Sound, which showed him that the Sound extends twenty miles further to the west than is shown on Sir George Nares's chart.

On his journey northwards Lieut. Lockwood succeeded in reaching 7° further east than Lieut. Beaumont's furthest in 1875. From a height of 2000 feet he saw no land to the north or north-west of Greenland, but away to the north-east, in lat. 83° 35′, and long. 38° 82′, he saw a cape which he named Robert Lincoln. These observations are interesting. They seem to show that to the north of the American coast the sea is comparatively landless; while to the north-east the archipelago which borders the north coast of Greenland probably extends for a long distance, perhaps to meet the north-west extension of Franz-Josef Land. Lieut. Greely himself passed the summer of 1882 in the interior of Grinnell Land, in the east of which his station was located. Here he discovered a lake, sixty miles by ten, which he named after General Hazen, the Chief of the Signal Service of the United States.

From all this it is evident that, besides carrying out their strictly scientific work, the geographical explorations of the Greely expedition have been very extensive. From Fort Conger they extended east and west over some 40° of longitude and northward over 3° of latitude. They have enabled us to give more precision on our maps to the north coast of Greenland, and to extend it to the east and north-east. Grinnell Land they have found is an island largely covered by a thick ice-cap with a great lake in the interior, and separated by a narrow channel or fjord from the newly-named Arthur Land to the south. The "palæocrystic ice" of the Nares expedition is a myth, and it is evident that the ice of any part of the Arctic area is for no two successive seasons the same. It must necessarily be continually on the move, piled up in some parts to "palæocrystic" dimensions, while in other parts the sea may be comparatively open. One point seems to us conclusively settled. It is evident from what we know of the present expedition, and of the attempts to rescue it, added to the experience of previous expeditions, that there is no way to the Pole by the Smith Sound route for either ships or sledges. What Lieut. Lockwood saw from his vantage-ground to the north-eastwards seems to us to show that the route by Franz-Josef Land is more hopeful than ever, and that, if another attempt is made to reach the Pole, the choice of a starting-point will probably lie between that land and the New Siberian Islands.

L'ABBÉ MOIGNO

FRANÇOIS NAPOLÉON MARIE MOIGNO, mathematician, physicist, linguist, and ecclesiastic, was born at Guéméné (Morbihan) on April 20, 1804; as he died on Sunday, the 13th instant, he is worthy of a place among the English mathematicians whose names figure in Prof. Sylvester's British Association Address (Exeter, 1869). He was descended from a good old Breton family. Moigno first studied at the Collège de Pontivy, then proceeded to the Jesuit seminary of St. Anne d'Auray. In 1822 he went to another house of the fathers at Montrouge, where he passed his novitiate. In addition to theology he studied with great enthusiasm both the physical and mathematical sciences; in these he made rapid progress, and in 1828 arrived at a new mode of getting the equation to the tangent plane to a surface. Leaving Paris in 1830 on account of the Revolution, he spent some time in Switzerland, and here turned his wonderful powers of memory to the acquisition of some eight new languages, at the same time perfecting his knowledge of Latin and Greek. In 1836 the Jesuits appointed him to the Mathematical Chair in their house in the rue des Postes, Paris. Here he published the first volume of his great work, "Leçons de Calcul differentiel et intégral," following the methods used by, and utilising published and unpublished papers of, Cauchy. As his Superior was opposed to his scientific work, Moigno broke with the order, and gave himself up to his favourite pursuits. Having in 1845 become scientific editor of *L'Époque*, he was sent on account of that journal on a visit to England, Germany, Belgium, and Holland, and furnished to its columns his observations on these countries. About 1850 he filled a similar post on the staffs of *La Presse* and *Le Pays*. In 1852 he became editor-in-chief of *Cosmos*, a weekly scientific review. His connection with this journal closed in 1862, and in 1863 he founded a new journal called *Les Mondes*.

From the above hasty sketch it will be seen how active Moigno was as a journalist. In 1864 he was made a Chevalier of the Legion of Honour. Moigno wrote a number of works bearing on the relation of science and religion. Of his other works we give a few titles:—The continuation of the "Leçons," noted above, the fourth volume containing a part on the Calculus of Variations (written in conjunction with M. Lindeloef, 1861). "Leçons de Mécanique analytique, redigées principalement d'après les Méthodes d'A. Cauchy et étendues aux Travaux les plus recents—Statique." To Liouville he contributed a "Note sur la Détermination du Nombre des Racines réelles ou imaginaires d'une Équation numérique comprises entre des Limites données: Théorèmes de Rolle, de Budan, ou de Fourier, de Descartes, de Sturm, et de Cauchy" (v. 1840), and on a like subject ("Caractère analytique simple et sûr auquel on reconnait que la Méthode de Newton est applicable") to the *Nouvelles Annales de Mathématiques* (x. 1851). But the great part of his writings, by which he is generally known, is physical. The Royal Society's Scientific Catalogue gives the titles of some twenty-five papers, which are concerned mostly with light, electricity, heat, and the solar spectrum; one title only we copy, "Navigation aérienne avec ou sans Ballon," from *Les Mondes*. The "Répertoire d'Optique moderne ou Analyse complète des Travaux modernes relatifs aux Phénomènes de la Lumière" (1847-1850) took him some years to write, and is a work of considerable importance. Another useful summary of results is the "Physique moléculaire, ses Conquêtes, ses Phénomènes, et ses Applications, résumés des travaux accomplis dans les vingt dernières années" (1868).

From his *actualités scientifiques* we single out here "Science Anglaise, son Bilan au mois d'Août, 1868:" this gives from the Norwich meeting of the British Association (Moigno was a Foreign Associate, but was not able to be present at the gathering) the Presidential and seven Vice-Presidential Addresses, and the evening discourses by Huxley and Odling. Dr. Hooker's address was not at all acceptable to Moigno, and he prefaces his translation ("pour effacer quelque peu le fâcheux vernis du positivisme de M. Hooker") with an article of his own, contravening the address of a Positivist Professor, Signor Govi, delivered at Turin.

It is in this last character of a translator of English scientific works (he translated also Père Secchi's work on the Sun) that Moigno did us Englishmen a great service: the following titles will prove this:—"Sur la Radiation" (Tyndall's Rede Lecture); "La Calorescence—Influence des Couleurs et de la Condition mécanique sur la Chaleur rayonnante" (Tyndall); "La Force et la Matière," and "La Force (Tyndall), avec une Appendice sur la Nature et la Constitution intime de la Matière" (by Moigno); "Analyse spectrale des Corps célestes" (Huggins); "Sur la Force de Combinaison des Atomes (Hoffmann), avec addition d'un Aperçu rapide de Philosophie chimique" (by Moigno); "Le Son" (Tyndall); "Six Leçons sur le Chaud et le Froid" (Tyndall). In 1852 appeared a second edition of the "Traité de Télégraphie électrique . . précédée d'un Exposé de la Télégraphio ancienne de Jour et de Nuit," with an atlas; in 1850 he had published his "Proclamation patriotique. Belle Invention française." This is a pamphlet on the invention of tubular bridges by M. J. Guyot. In 1861 he wrote another pamphlet entitled "Cotonisation du Lin," which treats of a practical substitute for cotton. From the titles of these last pamphlets, as well as from those of many of the preceding works, it will be seen that Moigno's mind was of a very practical cast, and that he was not immersed in the consideration of theories to the neglect of what is more useful.

THE COMPOSITION OF OCEAN WATER[1]

I.

ALTHOUGH ostensibly a report on the composition of ocean water, this memoir includes in its 250 large quarto pages the record of a far more extensive research than the title implies. It contains a detailed account of seventy-seven complete analyses of sea water, largely accomplished by the use of new and specially invented methods, the record of several independent researches into purely theoretical matters, and a number of exhaustive experimental criticisms of methods employed in similar work by other chemists. Taken altogether, the Report reads like the account of a life-work, and it is wonderful how the immense amount of work described in it could possibly be accomplished in the six years which have elapsed since the return of the Expedition. The rapid completion of the work is in great measure due to Prof. Dittmar's custom of having all the routine determinations made by assistants under his immediate supervision, while he devoted himself specially to the invention and trial of new methods and the repetition of doubtful experiments. The gentlemen who assisted in the research, and whose services Prof. Dittmar is scrupulously careful in acknowledging, are Messrs. John M'Arthur, Robert Lennox, Thomas Barbour, W. G. Johnston, James M. Bowie, James B. M'Arthur, G. A. Darling, and Moses T. Buchanan.

What first strikes a chemical reader on looking through the volume is the essentially mathematical treatment of the whole subject. The value of the statistical method in discussing experimental results has been gradually realised by chemists, but it is questionable if it has ever been applied more fully or with more satisfactory effect than here. The first care in every case, after taking all possible precautions to insure the utmost attainable accuracy, was to ascertain the limiting values of the probable error of the analytical method, and for this purpose there were never less than two and frequently more than four determinations made of each constituent. The utmost pains has been taken to represent the numerical results in as many aspects as possible, in tables, in mathematical formulæ, and by means of curves.

It is only possible here to indicate the principal contents of the six chapters into which the memoir is divided. The consideration of Chapter II. "On the Salinity of Ocean Water," may be conveniently reserved for a subsequent article, where it will be taken up along with Mr. Buchanan's report on the specific gravity of ocean water, which forms Part II. of the volume.

Although sea water had been subjected to many analyses in the earlier part of the present century, the only research of permanent importance until very recently was that of Forchhammer, who analysed a great number of surface waters from all parts of the ocean in 1864. Prof. Dittmar avowedly took this research as a guide, and intended his work to be merely supplementary to it; but from the circumstances of the two chemists the later work tends rather to supersede than to supplement the earlier. Forchhammer dealt with surface water only, collected and brought home in corked bottles by seafaring men who, however willing to do their best, could not be altogether trusted to observe requisite precautions, while Dittmar was supplied with water from all depths of the ocean collected at exactly known positions under the constant supervision of Mr. Buchanan, who secured each sample as it was drawn in a carefully stoppered bottle. We must take into account also the greater delicacy of the balances, and the more perfect analytical methods which are now available. The following table quoted from p. 203 of the Report, shows the most recent numbers assigned to the components of ocean-water salts compared with those given by Forchhammer:—

	Per 100 parts of total salts. Dittmar	Per 100 parts of halogen calculated as chlorine. Dittmar	Forchhammer
Chlorine	55·292	99·848	not determined
Bromine	0·1884	0·3402	,,
Sulphuric acid (SO_3)	6·410	11·576	11·88
Carbonic acid (CO_2)	0·152	0·2742	not determined
Lime (CaO)	1·676	3·026	2·93
Magnesia (MgO)	6·209	11·212	11·03
Potash (K_2O)	1·332	2·405	1·93
Soda (Na_2O)	41·234	74·462	not determined
(Basic oxygen equivalent to the halogens)	−12·493	—	—
Total salts	100·000	180·584	181·1

More than thirty elements are known to exist in solution in the ocean, but most of these are present in such minute quantity that it was hopeless to attempt to determine them in a number of small samples. Attention was accordingly confined to the chlorine, sulphuric acid, soda, potash, lime, and magnesia, which were estimated with very great accuracy and always by the same method, so that if more exact processes should be discovered at any future time the error of the method used may be calculated once for all, and applied as a correction to each analysis.

This rule of rigid adherence to one system was broken through in one case, that of the potash, where the ordinary process, which was first adopted, proved so unsatisfactory that it was worse than useless to continue to employ it, and the later analyses were conducted by a modification of Finkener's method that gave better results, through a curious balancing of the errors.

For the particular methods employed in each case it is necessary to refer to the memoir itself, where they are described with the utmost detail; but reference must be made to the great improvement which Prof. Dittmar has introduced in what was formerly called volumetric analysis, but which he now prefers to name *titrimetric*. It may be defined, somewhat paradoxically perhaps, as volumetric analysis by weight. The standard solutions are made up as usual by weighing the salt and measuring the water, but the whole solution is afterwards weighed, and its strength is thus determined with great accuracy. A balance combining strength and delicacy to an unusual degree is of course necessary for this purpose. By performing the titration in a weighed phial containing a weighed amount of liquid, and weighing it again after the reagent has been added to the proper amount, the burette error is obviated, except in those cases where the method of zig-zag titration is adopted, and then it only affects the measurements of the few drops of each reagent that are added in turn to produce and destroy the coloration which marks the end-point. All the chlorine determinations were made in this way by Volhard's method of precipitating the halogen by excess of silver nitrate, and estimating this excess by means of a standard solution of ammonium sulphocyanate in presence of iron alum.

The result of the seventy-seven complete analyses of ocean water, the description and discussion of which forms Chapter I., confirms Forchhammer's discovery that the percentage composition of the salts of sea water is the same in all parts of the ocean, and extends it to water from all *depths*. The application of the principle of constant composition to depth is subject to a slight but very important exception. The proportion of *lime* was found by Dittmar to be greater in very deep water than in that near the surface. Although the difference found exceeded

[1] "The Physics and Chemistry of the Voyage of H.M.S. *Challenger*. Vol. i. Part i. Report on the Composition of Ocean Water." By Prof. W. Dittmar, F.R.SS.L. and E.

the sum of all the probable errors of analysis, it was considered necessary to apply a more stringent test in order to make sure that the increase in lime was really in relation to the depth. For this purpose three mixtures were made, each of about seventy samples of water from all parts of the ocean, but the first consisting entirely of surface waters, the second of samples from between 300 and 1000 fathoms, and the third of waters from a greater depth. The exact analysis of these proved beyond question that the proportion of lime increases with the depth. The same bathymetrical mixtures were used for determining the bromine, as it, of all the minor components, is the one which might be supposed to vary most with the depth, owing to the fact of its being so largely absorbed by marine vegetation; but the proportion was found to be invariable within the limits of error. The details of this very difficult and interesting series of experiments occupy Chapter III.

The question of the amount of carbonic acid in sea water is one which cannot even yet be said to be definitely settled. The simple and elegant adaptation of Tornoe's modification of Berchert's and Classen's apparatus, which Prof. Dittmar made, and which is figured in the memoir, gets over the difficulty of determining the total carbonic acid in sea water; but unfortunately it had not been invented when the *Challenger* sailed. The daily determinations of carbonic acid in sea water which Mr. Buchanan made were performed by a method that only took account of what must be called, for lack of a better expression, the loosely-combined carbonic acid; that is, the portion of the gas existing in a state of absorption in the water, and the part combined with the normal carbonates to form bicarbonates. The immense number of determinations, made in the same way under exceptionally favourable conditions, form a valuable series for purposes of comparison, and Prof. Dittmar has not failed to utilise it. His critical experiments on Mr. Buchanan's method made with the view of ascertaining its limits of uncertainty were, he acknowledges, insufficient for the purpose. This is to be regretted, for an exhaustive series of carbonic acid determinations performed on the same water by the two forms of apparatus under favourable conditions might be expected to produce valuable results. Prof. Dittmar saw that it was useless to employ samples of *Challenger* water which had been kept for several years in order to estimate the total carbonic acid. But instead of giving up the research on this account he proceeded by an ingenious use of synthetic sea waters to study the behaviour of bicarbonates in solution. He says (p. 212):—

"I am aware that this part of my work lacks the degree of precision which would be desirable for my present train of reasoning. But I had not the time to embark in the far more elaborate investigation which would have been desirable. I have, however, quite lately resumed the matter on a new basis, and hope before long to be able to formulate the exact conditions of stability in sea-water bicarbonates as they exist when dissolved in real sea water, and amongst others to decide the question whether in this process they quite directly tend to become normal, and do not perhaps more directly gravitate towards the state of sesquicarbonate. In the meantime we must reason on what data we have."

And reasoning on these data he produces a most interesting theoretical disquisition on the dissociation-tension of dissolved bicarbonates at various temperatures, and shows how the ocean acts as the great regulator of atmospheric carbonic acid. The three main results of the *Challenger* observations on this subject are given (p. 220) as:—

"1. Free carbonic acid in sea waters is the exception. As a rule the carbonic acid is less than the proportion corresponding to bicarbonate.

"2. In surface waters the proportion of carbonic acid increases when the temperature falls, and *vice versâ*.

"3. Within equal ranges of temperature it seems to be lower in the surface water of the Pacific than it is in the surface water of the Atlantic Ocean."

In relation to Mr. Murray's theory of coral-reef formation and of oceanic deposits generally, it would appear probable that bottom waters contained more carbonic acid than those near the surface, and that this carbonic acid was the agent which dissolved the calcium carbonate of shells at great depths. Prof. Dittmar thinks otherwise. In his opinion Mr. Buchanan's numbers prove bottom water to contain no more carbonic acid than surface waters, and he supposes that the solution is effected by prolonged contact with the sea water itself, for by experiment he found that it was capable of dissolving calcium carbonate, though very slowly. It is not quite plain that Mr. Buchanan's numbers do warrant this conclusion, and there seems to be room for further research in this direction.

Chapter V. treats of the alkalinity of ocean water. The seventy-seven complete analyses showed that in sea-water salts there is a distinct preponderance of base over fixed acid, the difference being presumably due to carbonates; and the direct determination of the extra base by standard hydrochloric acid at the boiling point, after the method devised by the chemists of the Norwegian North Atlantic Expedition, brought out precisely the same result. The alkalinity of bottom waters was found to be distinctly greater than that of those from the surface, and this increase was exactly proportional to the larger quantity of lime present in the former. The alkalinity determinations give the only satisfactory measure of the carbonate of lime which exists as such dissolved in sea water.

The last and longest chapter is by no means the least important. It deals in a very exhaustive manner with the whole question of the absorption of oxygen and nitrogen by pure water, as well as by sea water. Finding that all previous determinations of the coefficients of absorption of these gases were more or less unsatisfactory, Prof. Dittmar entered on an elaborate series of experiments, which is fully detailed in the memoir, having as an aim the determination of the desired coefficients at different temperatures for both pure water and the water of the ocean. The second part of the research consisted of the exact analysis of the samples of air which had been extracted from sea water on the cruise by Mr. Buchanan, using Jacobsen's ingenious apparatus, which he has since simplified and improved.

There is an element of uncertainty about the extraction of gases which Prof. Dittmar scarcely seems to emphasise sufficiently. The water in every case was collected in one vessel and then transferred to another in which the gases were boiled out. The danger of atmospheric gases being absorbed was obviated in great measure by the precautions used; but if highly aërated water were brought up from a great depth some of the absorbed gases would be certain to escape during transference. The only remedy would appear to be the collection of the water in the gas-extraction flask itself, and there is no method as yet by which this can be done.

Prof. Dittmar and Mr. Lennox constructed a modification of Doyère's apparatus for the analysis of gases, which was found to work well. It is described and figured in the memoir. The results of the analyses are discussed in the light of the coefficients of absorption found in the earlier part of the research. The amount of air which ought theoretically to be absorbed by sea water of the temperature and at the pressure at which each sample was collected was first calculated, and then, from the actual amount of nitrogen found, the quantity of oxygen which should be associated with it was arrived at. The quantities of air found in solution were usually in defect of calculation, as might be expected when it is recollected that the water of the ocean is always in motion, the temperature and pressure to which it is exposed being very different at different places; and the fact that absorptiometric exchange had not gone far enough to reproduce equilibrium would account for the few cases in which the dissolved gases exceeded the amount calculated. The interpretation of his results seemed unsatisfactory to Prof. Dittmar. He says (p. 182):—

"I am sorry to have to confess that I have not been as successful as I should have wished in drawing general conclusions from my numbers, and if I here reproduce my endeavours in this direction, I do so chiefly in the hope that some other person, having more experience than I in dealing with statistics, may take up the problem after me, and perhaps be able to extract the latent propositions which are therein concealed. In the tables which I propose to give, he will find all the data arranged in the most convenient form, so that all he needs is at hand."

The problem of the dissolved gases is very difficult when deep waters are considered. The method pursued by Dittmar was to find the amount of nitrogen absorbed, and to calculate the temperature at which that quantity would be taken up by water at the surface; then to find the corresponding amount of oxygen, and compare that with what was found by experiment. It is evident that if the ocean were stagnant in any part the processes of oxidation always going on would tend to reduce the amount of absorbed oxygen finally to nothing, while the amount of dissolved nitrogen would be unaltered, unless it were slightly increased by the decomposition of animal matter. In many cases the oxygen deficit was found to assume very large dimensions, though oxygen was never wholly absent from the dissolved gases.

Part I. of the volume closes with a summary of the chemical work, a note by Mr. Buchanan on the determination of carbonic acid, and an appendix describing some analytical methods. The summary contains a number of valuable suggestions for future work. These are divided under two heads, the first comprising such observations of water density and rough volumetric determinations of the alkalinity as can be carried on by any intelligent seafaring man after a little instruction. The second head includes work requiring the services of a skilled chemist for its accomplishment. It embraces further researches on the composition of ocean salts by determining with the utmost precision the amounts of the principal constituents for one particular station in the ocean, water from which could be collected in large quantity at various seasons; then it could be compared with water taken at various seasons from a widely distant station, and thus the interesting question as to whether there is *any* difference in the proportion of the salts in different oceans could be settled. The minor constituents should also be estimated if possible, and very particular attention ought to be paid to alkalinity and carbonic acid determinations in freshly drawn samples. Prof. Dittmar concludes with this significant suggestion:—

"Meanwhile the best thing that could be done in regard to all the analytical problems referred to would be to work many times on samples of the same kind of water, with a view of improving on the methods and ascertaining the extent to which that one water fluctuates in its composition."

The only way in which this can be done properly is in a laboratory on shore situated within easy reach of an abundant supply of sea water, and the support of such laboratories ought to be a leading feature in the marine stations several of which, it is to be hoped, will soon be in working order on our coasts. A beginning has already been made at the Scottish Marine Station at Granton, where the special chemical problem under investigation is estuary water. The *Challenger* results may be regarded as final, for the present at least, for ocean water proper, and the results of the German and Norwegian North Atlantic Expeditions have put the waters of partially inclosed seas on a permanent basis; but the study of estuary water has been almost neglected. This is the more regrettable because of the practical importance of a correct knowledge of the conditions of the water of an estuary, on account of its bearing on the migration of fishes into firths and up tidal rivers.

There could be no better field than the estuaries of the British coast for carrying out Prof. Dittmar's suggestion of continuous work on one kind of sea water with a view to the perfecting of analytical methods; and the perfecting of analytical methods, important though it be, may safely be predicted to be one of the least valuable results of such researches.

HUGH ROBERT MILL

ORNITHOLOGICAL NOTES

SEVERAL new magazines have made their appearance during the present year, the most important of them being undoubtedly the *Auk*, which is the name proposed for the journal of the American Ornithologists' Union, and which is to represent in America our old friend the *Ibis* of this country. The *Auk* is in fact a continuation of the *Bulletin* of the Nuttall Ornithological Club, and the general style of the work is the same. The papers seem to be interesting enough, but what strikes us as being decidedly above the average is the quality of the reviewing, which is developing into an art with our American brethren. Mr. Cory describes some new species of birds from Santo Domingo, the plate which accompanies his paper being scarcely up to the level of American illustration. Mr. Barrows continues his useful papers on the birds of Uruguay, and Prof. Merriam criticises Dr. Coues' "Check List," calling forth a sharp rejoinder from the last-named author in an article called "Ornithophilologicalities." In No. 2 many of the above-named papers are further continued along with others by Dr. Stejneger, who advocates some startling changes in ornithological nomenclature, and who also writes a useful paper on the genus Acanthis. Altogether, although the American ornithologists have elected to name their quarterly journal after a bird whose powers of flight were small, the excellence of the two numbers which have appeared reminds us of the perfection of that bird's powers of swimming and diving, so that they have taken as their symbol a species of lusty prowess which argues well for a continuation of the life and enterprise which is visible in the new magazine. We do not forget also that the Auk was a species common to Great Britain and North America, and therefore the very title is suggestive of a bond of union between British and American ornithologists which is certain to be strengthened with each succeeding year.

We have also received No. 1 of the *Bulletin* of the Ridgway Ornithological Club, which has been started in Chicago, and is named after Mr. Robert Ridgway, the well-known Curator of the Ornithological Department in the United States National Museum. The secretary of the new club is Mr. H. K. Coale, who is well known as a zealous and painstaking ornithologist, and under whose auspices there is doubtless a useful future before the infant society which he represents. The first number of the *Bulletin* contains only a single paper by Messrs. W. W. Cook and Otto Widmann, entitled "Bird Migration in the Mississippi Valley."

Mr. J. H. Gurney has just issued a "List of the Diurnal Birds of Prey, with References and Annotations; also a Record of Specimens preserved in the Norfolk and Norwich Museum," consisting of 187 pages. The *raison d'être* of this most useful work consisted in the publication of the first volume of the "Catalogue of Birds in the British Museum," by Mr. R. Bowdler Sharpe. The Norwich Museum, as is well known, contains one of the finest series of birds of prey in the world, and it will always be an imperishable monument to that true and self-sacrificing naturalist, Mr. J. H.

Gurney, through whose instrumentality this splendid collection has been brought together. The author commenced in 1875 an elaborate review of Mr. Sharpe's volume, giving a vast amount of additional information, principally founded upon the series of *Raptores* contained in the Norwich Museum. The complete list of the birds of prey which Mr. Gurney has now published contains an exact reference to these numerous critical papers in Mr. Sharpe's volume, but adds some of the principal synonyms, and gives the number of specimens contained in the Norwich Museum. The publication of this volume is certain to have one effect, which will take the form with all ornithologists of a hope that Mr. Gurney may feel able to continue his "Catalogue of the Raptorial Birds in the Norwich Museum," of which one part appeared some years ago; as it is certain that everything that emanates from his pen will be received with the greatest respect by his brother ornithologists, who have so long looked up to him as the greatest authority on the birds of prey.

UTRICULARIA VULGARIS

IT was proved many years ago that several of the aquatic and terrestrial plants distributed over various quarters of the globe preyed upon flies, larvæ, worms, crustaceans, and other species of small invertebrates.

For the greater part of the knowledge we have already received on this head we are indebted to the researches and experiments of Mr. Darwin, and I would refer any of my readers who may feel interested in the subject to his "Insectivorous Plants."

But until a few weeks since, when it was discovered by myself, and noted in NATURE by Prof. Moseley, that the bladder traps of the *Utricularia vulgaris* (Fig. 1) caught and destroyed newly-hatched fish, it was unknown that any of the recognised carnivorous plants possessed the power of also entrapping vertebrate animals, no single instance of the kind having been recorded by previous observers; yet it might at once have been naturally inferred, that, provided the experiment was made with creatures of a strength and size proportionate to the capacity of the organs of capture belonging to the plant, their action in every case would be precisely the same on either vertebrates or invertebrates. The *Utricularia vulgaris*, together with several other members of the same family bearing the generic name of Utricularia, and the specific, *neglecta*, *major*, *minor*, and *clandestina*, are very local in their habitat, growing in isolated patches in ponds and sluggish ditches, the type of place invariably selected by coarse fish to deposit their ova. This at once constitutes it as great an enemy to the small fry as the water-fowl and otters are to the larger fish in the streams, because for a considerable period after they emerge from the egg the young fish remain in the shallow water, and during this time innumerable quantities must be killed by the vesicles of the Utricularia.

Since I have been acquainted with the plant, I have noticed several peculiar circumstances in connection with it, which appear to have been entirely overlooked by all the botanical writers whose works I have consulted.

In the first place I have never seen it growing, unless displaced by the action of the wind, except on the darkest and shadiest side of the pond from whence I obtain my specimens, and then it is almost invariably hidden beneath other aquatic vegetation, as if its deeds caused it to shun the light. It also exhibits the same tendency to avoid particular spots which frequently is evinced by snakes in selecting only one side of a field or part of a hedge to the entire exclusion of the remainder, and by fish in choosing the dirtiest and most unlikely ditches as a spawning bed in preference to those which are cleaner and apparently in every respect better suited to the purpose.

I am of opinion that an excess of light is prejudicial to the plant, because, if when kept in an aquarium it is exposed to the full glare of the daylight, the valves appear to lose their elasticity, and the vesicles become detached from the stem, and drop off.

Another predominating cause for this strange habit of growing in only one or two spots may perhaps be ascribed to this, that wherever I find the Utricularia there is always a luxuriant mass of Confervæ around it which harbours numberless insects, and, having no roots at any time of its life, is entirely dependent upon its vesicles for its sustenance; hence it only flourishes where prey is plentiful.

In confinement it is impossible to keep it in a healthy state unless the glass is darkened; and as nearly as possible its artificial condition is assimilated to its natural one. Where young fish are kept, it is anything but a desirable inmate of the vessel in which they are confined. One eminent piscicultural authority states that he had several

FIG. 1.

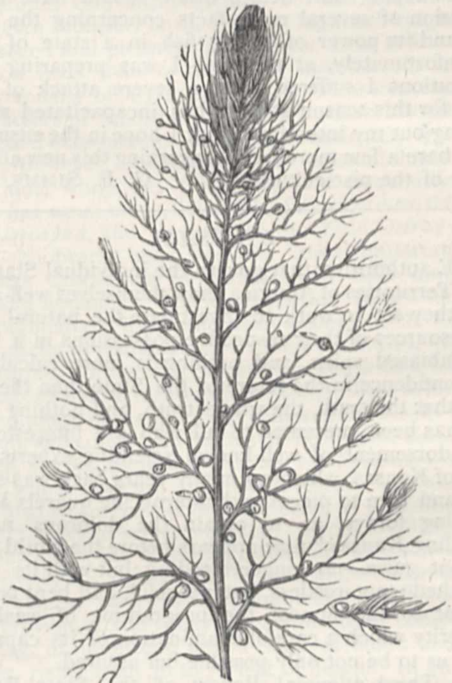

FIG. 3.

FIG. 2.

plants in his aquarium with some young axolotls, and he noticed that the small salamanders gradually disappeared; now he can give a very good guess where they went to.

My friend Mr. Kelson, who has recently had charge of my aquariums during my absence from home, agrees with me that the foliage possesses some poisonous properties detrimental to fish. Whether it does so or not I hesitate to assert, but all I know is that out of a batch of young roach placed with some freshly-gathered *Utricularia*, many of them in a little while lay dead on the branches.

With regard to its method of catching insects or anything upon which it preys, I believe that the processes are armed with tiny spines similar to the recurved teeth of a pike, or the serrations of an awn of barley, and these utilise the struggles of the creature caught to push it further on but prevent its return.

When a fish once touches one of the processes, whether by the head (Fig. 2) or by the tail (Fig. 3), the result is precisely the same, it can never escape; and so tenacious is the grip with which it is held, that I have only once observed an insect get away after being caught. Otherwise I cannot conceive how, without some such arrangement, if the processes were perfectly smooth, they could retain anything so delicate even as the body of a young fish, much less would they be able to hold the larger creatures. I am the more inclined to this view because, when a fish emerges from the egg it is nothing but a transparent line of light, a substance without a substance, into which the most microscopically minute projection would enter without difficulty; and when it is borne in mind how easily the hair-like sting of the common nettle can penetrate the human cutis, taking into consideration the relative thicknesses of the two, I am satisfied that my argument, though open to contradiction, has at least the beauty of possessing some slight amount of probability.

I was hoping that before this I should have been in possession of several more facts concerning the *Utricularia* and its power of killing fish in a state of nature, but, unfortunately, at the time I was preparing for my observations I suffered from a severe attack of illness, which for this season at least has incapacitated me from carrying out my intentions; but I hope in the ensuing one to lay bare a few more facts concerning this new and novel enemy of the pisciculturist. G. E. SIMMS, JUN.

KANSAS

THE authorities that govern the individual States and Territories of America show themselves well-advised when they set to work to investigate the natural history and resources of their respective possessions in a healthy and unbiased spirit, and nothing is more calculated to give confidence in the future of the State than the knowledge that the truth, the whole truth, and nothing but the truth has been presented to all who are interested, with the indorsement of well-known scientific experts. The State of Kansas, which not many years back was so exercised and torn to pieces with internecine quarels and fillibustering forays, as to obtain the dolorous name of "bleeding Kansas," now appears before the world in very different guise—no longer bleeding, but with its wounds staunched; not restless, but peaceful, and bent on carrying out to the utmost the programme of wealth and prosperity which a careful examination of its capabilities shows us to be not only possible but assured.

The Third Biennial Report of the State Board of Agriculture is a portly volume of great value in many ways, although those points that deal with the geology and natural history will of course offer the most interest to the readers of NATURE.

From the geological sketch given by Mr. O. St. John we learn that Kansas, a parallelogram in shape, and containing no less than 80,000 square miles or 52,531,200 acres, lies wholly within the prairie region that intervenes between the Rocky Mountains and the Missouri; and although, to the ordinary observer, it appears to be an exceedingly flat region (Kansas City has only an elevation of 751 feet above the sea), there is, in reality, a gradual and regular ascent of the surface to the north-west corner, where the land assumes a maximum height of 4000 feet. What configurative irregularities there are, are principally due to erosion, as there is a remarkable absence of any geological displacement sufficient to produce mountainous folds, and thus give origin to local drainage systems. The most salient features of the landscape are bluffs (seldom above 500 feet in altitude), though in the larger valleys they are sometimes precipitous and intersected by ravines. The prevailing characteristic, however, is that of grassy uplands in billowy stretches, the drainage being provided for by numberless narrow channels called "draws." The general drainage system is easterly, and pretty well divided between the Missouri and Arkansas basins. The northernmost half of the State is watered and drained by the Kansas River, with its tributaries, the Delaware or Grasshopper, Blue, Solomon, Republican, and Saline on the north, and the Smoky Hill on the south; and these, with a small area drained by the head waters of the Osage River, all form part of the Missouri system. The basin of the Arkansas is met with a little to the south of the Smoky Hill, the river itself having a general south-east course into the Indian territory. The volume of the Arkansas from its distant source in the Rocky Mountains far exceeds that of the Kansas, though its valley is very little deeper, nor has it such important tributaries as the latter river. About the centre of the State, the Arkansas makes a considerable bend, receiving previously the Walnut and Pawnee Rivers, while east of the bend are the upper valleys of the Neosho, Verdigris, White-water, Little Arkansas, and Cimarron, though, as a matter of fact, nearly all these streams effect their junction with the Arkansas outside Kansas, and in the Indian Territory. The Neosho is locally famous for its valuable water power and its rich agricultural valley, and the Cimarron for its deeply eroded bed and the variegated sculptured strata of its cañon walls. The two typical rivers of Kansas State are therefore the Kansas, its valley consisting of a wide belt of low-terraced alluvial land, of great fertility, bounded by beautiful slopes terminating in frequent rocky bluffs, and the Arkansas with its magnificent reaches of level bottom land, whose depth of soil is composed of travelled sediments brought from the mountains and plains lying to the westward. Here and there the border uplands encroach upon the valley, showing shelly limestone strata, and deep, iron-dyed sandstone ledges.

The geology of Kansas is of a simple nature, and almost entirely composed of three principal formations, the Carboniferous, Cretaceous, and Tertiary. The Palæozoic rocks, as represented by the Carboniferous, appear at the surface over an area of about one-third of the entire extent of the State, entering it from the south-east, and eventually passing beneath the Dakota sandstone, which is the line of demarcation between the Palæozoic and Mesozoic series. After the disappearance of the Carboniferous rocks underneath this sandstone, they are not seen again until the Rocky Mountains, where their upraised edges have been bared by denudation at the foot of the ranges. The lowest member of the Carboniferous (Lower), as seen in Kansas, is the Keokuk limestone, which occupies a small area of about forty square miles in the extreme south-east corner, and consists of bluish-gray siliceous limestone, interbedded with cherty layers above, and often associated with brecciated siliceous matter. Limited as the Keokuk area is, it is of exceeding value to the State, for it includes the ore district of lead and zinc, and has already brought a considerable population to the newly-founded towns of Empire and Galena, on the banks of the Short Creek, a tributary of the Arkansas. Not only has a busy mining district been here established, but, owing to the excellence and accessibility of the Cherokee Coal-measures, a little to the west, the ores are enabled to be speedily and cheaply reduced at the furnaces of Weir and Pittsburgh, a few miles to the north. Galena, the ordinary sulphuret of lead, furnishes almost all the ore of that metal, together with its derivatives, cerussite or carbonate of lead (the "dry bone" of the miners), and pyromorphite or phosphate of lead. As is usually the case, the lead carries a small percentage of silver, from one to one and a half ounces to the ton of ore. The zinc ores consist of the common blende or sulphuret, "black jack," calamine (hydrous silicate), smithsonite (carbonate), and zinc bloom, many of the ores being of great beauty, from their amber and garnet tints. Associated with the ores are chalcopyrite or copper pyrites, green carbonate of copper, bisulphuret of iron or mundic, calcite or "glass-tiff," dolomite, quartz, and bitumen. The base rocks of the district consist of a deposit of limestone 100 feet in thickness, charged with characteristic Keokuk fossils, which, however, are much comminuted and splintered, and bear evidence of the pressure and tension to which the strata have been subjected. The Kansas ores are similar in almost all parts to those of the Missouri district, and it is considered quite possible that time will reveal the existence of other ore-bearing strata.

The large area of Upper Carboniferous series may be roughly divided into Upper and Lower Coal-measures, the latter occupying between 4000 or 5000 square miles, and passing, in the west, conformably beneath the Upper Measures. The series is largely made up of shales and sandstones, with occasional thin beds of limestone and iron ores, but its chief economic value consists in possessing workable beds of coal. These are mostly distributed in the lower 400 feet of strata, and are somewhat irregular and variable in thickness. Some of the coals indeed are found in little isolated basins or pockets, filling trough-like depressions surrounded by ledges of the older formation; but as a rule, the thinner coal-beds are remarkable for their persistence over a large extent of ground. The Cherokee coals are of a very superior quality, and they (together with most of the Kansas lower beds) contain less sulphur than the coals of either Illinois or Iowa. Naturally there is a great demand for coking purposes and local consumption, while pretty heavy shipments are made to the towns and cities on the Missouri River. These Lower Coal-measures also contain excellent building-stone and hydraulic limestone, which is extensively utilised for making cement. The general inclination of the strata is north of west, with a dip that seldom exceeds 10°. The estimate of the Lower Coals, from an aggregate thickness of four feet, is 20,000,000,000 tons, and if the area be extended to that occupied by the overlying Upper Measures, so as to reach the Lower Coals accessible from 500 to 1000 feet, the product may be fairly estimated at double.

The Upper Coal-measures have an aggregate vertical thickness of at least 2200 feet, the exposed area extending for 24,000 square miles; but in the character of the component strata they present a marked contrast to the Lower series, on account of the limestone ledges which form such striking features in the landscape. The lower beds are characterised by frequent and thick deposits of gray limestone, succeeded in the middle portion by darker, rusty, weathered ledges, and in the upper by light, buff-gray rock. The sandstones occur in some half-dozen well-developed horizons along the line of the Kansas valley, usually in the condition of arenaceous shales, and affording local supplies of building and flagging stones. In Osage County these have an additional interest, as being marked with casts and tracks of gigantic Batrachians. The limestone beds are somewhat deteriorated for building purposes by cherty deposits, but, on the other hand, they contain ironstone nodules of hæmatite and carbonate ores, with crystals of sulphate of lime and beds of massive gypsum, varying in thickness from five to fifteen feet. These gypsum deposits are capable of affording inexhaustible supplies, which are used most beneficially as manure for the soil. Where the cherty concretions are not met with, the limestone beds yield magnificent building-stone, the texture and colouring of which can be seen to great advantage in the State House of Topeka and many other public buildings. The Upper Coals are distinguished from the Lower by their more brittle texture and a larger percentage of ash and impurities. Though there are several valuable and persistent seams, such as the Blue Mound and Osage coals, thinness is a decided characteristic of the Upper Measures, few, if any, being above thirty inches, and the greater number not exceeding ten inches. But, although the Upper Measures are clearly of not so much economic importance as the Lower, it is quite possible to reach the Lower by tolerably deep borings through the Upper, and indeed this has been already successfully demonstrated.

The Mesozoic age in Kansas is represented solely by Cretaceous formations, which, however, occupy the largest area of any in the State, being no less than 40,000 square miles. The series is composed of three divisions, viz. the Dakota, Benton, and Niobrara, all belonging to well-recognised lower members of the Cretaceous rocks of the Upper Missouri region. The Dakota beds consist of sandstone interbedded with variegated shales, with occasional layers and pockets of impure coal. The sandstones are permeated and deeply stained with ferruginous matter, the iron being often concentrated around nuclei, forming singularly-shaped concretions. The proximity to the ancient land area is denoted by the rather extensive fossil flora usually found in these concretions, but the fauna is more limited in variety, comprising, so far, a few fishes, a large Saurian, and several species of Mollusks. The sandstones vary lithologically, but are usually compact and often intensely hard, forming highland ridges marked by rugged and picturesque features. Less is known of the Benton beds than of the other members of the series. They consist of argillaceous and calcareous shales, with thin layers of limestone, overlaid by dark-coloured shales, but good exposures of these rocks are rarely found. They have, however, yielded to the palæontologist several Saurians, while the limestones are frequently charged with fine ammonites, the shells of *Inoceramus*, the gigantic *Haploscapha*, and myriads of the little *Ostrea congesta*. The Niobrara beds are the most important of the Kansas Cretaceous formations, and offer much better-marked horizons. The lower portion shows alternations of fragmentary limestone and shales, which above pass into shelly limestone, and, in some localities, into chalky limestone. All these layers are charged with a wonderfully numerous and varied Vertebrate fauna, allied to forms which are common in the Colorado shales of the Rocky Mountain region, and consist of remains of Teliosts or common bony fishes, sharks, Saurians, and an extraordinary species of bird, whose jaws are armed with teeth. The mineralogist will also be interested in these beds, as furnishing beautiful examples of selenite crystal. From a landscape point of view, also, the Niobrara beds are instructive, as they are frequently intersected by miniature cañon labyrinths, and exhibit varieties of monumental forms detached by the erosion of the valleys, some of these, composed of a coping of limestone and a shaft of chalk and compact shale, rising from 20 to 70 feet in height. In an economic sense the Cretaceous series is of considerable value. The Dakota deposits contain three beds of lignite, the Benton shales yield quantities of septaria, used for making the finer qualities of cement, together with excellent chalk applicable for whiting, while the Niobrara beds furnish vast supplies of pure lime. All the divisions yield excellent building-stone, and throughout the formation a productive supply of salt occurs, from the brines of which there is already a brisk annual trade of 35,000 bushels.

The most recent formation of Kansas is principally in the north-west of the State, where there is a Kainozoic area of Pliocene beds of about 11,500 square miles, extending thence from Colorado and Nebraska, where a vast stretch of country is occupied by the White River formation. Its typical features are loosely-aggregated sands, more or less calcareous, forming irregular strata of brown and gray sandstone, while in some places siliceous beds occur, associated with several varieties of chalcedony, and containing fragments of the tusks of a very large mammal. The fauna is most interesting in this respect,—beaver, rhinoceros, camel, deer, wolf, and turtle being all represented. The district is noted for its eroded mounds and columns, the most striking being the Sheridan *Buttes*, which rise in perfect isolation to 200 feet above the Smoky Hill River, the summit capped by a heavy ledge of light gray, very hard siliceous rock, which has been weathered into miniature grottoes in the higher of the two cones. Underlying the Pliocene beds is a thick deposit of chocolate-coloured shales, with concretionary masses of limestone and septaria, and splendid crystals of selenite. Among Post-Tertiary deposits, examples are to be found, in the eastern portion of the State, of the Drift and Loess, the latter being strikingly displayed in the bluffs that bound the Missouri River valley for so many hundreds of miles in the States of Iowa, Nebraska, Kansas, and Missouri.

An appendix to the foregoing geological account is added on the botany of Kansas, by Prof. J. H. Carruth, but it is very short, for the reason that the catalogue of Kansas plants was made in 1880, and the present notice is merely to record certain additions (about 36) to the 1430 plants already found, of which only 30 are non-flowering. Considering that New York, with its varied surface and qualities of soil, can only show 1450, it is most interesting to note that Kansas, with its comparatively uniform soil and surface, produces almost as many.

A valuable report on the Kansas entomology is given by Prof. Popenoe, who furnishes detailed accounts of certain insects that commit ravages upon the crops. Among these figure prominently the large poplar-borer (*Plectrodera scalator*), which is a great tree-destroyer, making innumerable holes in the trunks of the willow and cottonwood. A singular fact is recorded of the buck moth (*Hemileuca maia*), viz. that as a larva it possesses a peculiar means of defence. The coarse, black prickles with which the body is covered are very sharp, and when they penetrate the skin on the back of the hand or elsewhere, they produce little pustules and a sharp nettle-like sting, though not of any duration. The red-lined tree-bug (*Lygæus trivittatus*) is a relative of the well-known squash-bug, and does infinite damage to the elder-tree, besides evincing a strong partiality for the interiors of greenhouses, where it destroys geraniums, ipomeas, abutilons, and other horticulturists' pets. The chequered snout-beetle (*Aramigus tesselatus*) has usually been known to infest leguminous plants, and more especially the silver-leafed prairie pea (*Psoralia argophylla*). Latterly, however, it has been noticed to pay great attention to the sweet potato, and has inflicted considerable havoc on that crop. The harlequin cabbage-bug (*Strachia histrionica*) attacks the Cruciferæ, and especially the wild cress (*Lepidium*), mustard, radish, turnip, and cabbage. The abundant little beetle known as the corn-root worm (*Diabrotica longicornis*) has only recently been discovered to be a corn-pest of the first magnitude, attacking the roots about the period of "earing," and causing a partial development of the grains.

Though only the points that bear most on Kansas natural history have been noticed here, it should be stated that the volume gives an exhaustive account of the resources and statistics, commercial, social, and educational, of each county in the State, and that the whole is illustrated by an admirable series of maps.

G. PHILLIPS BEVAN

NOTES

THE death is announced of Ferdinand von Hochstetter, the German mineralogist and geologist, whose name is intimately associated with the geology of New Zealand. Hochstetter was born in Würtemberg in 1829. In 1857 he joined the *Novara* expedition, but quitted it at New Zealand, the geology of which he spent a considerable time in investigating. In 1860 he was appointed Professor of Mineralogy and Geology in the Polytechnic Institute of Vienna, and in 1867 was made President of the Vienna Geographical Society. Among his published works are: the "Topographico-Geological Atlas of New Zealand"; "Geology of New Zealand"; "Palæontology of New Zealand"; "The Geology of the *Novara* Expedition"; "Rotomahana and the Boiling Springs of New Zealand"; besides works on the geology of Eastern Turkey, the Ural, and various popular publications.

IN the name of fair criticism, in the interests of true science, and in defence of a man who has grown gray in the public service, and who has recently retired full of years and honour to the rest he so well merited, a protest should be made against the language in which the *Mining Journal* last week permits itself to speak of Mr. Robert Hunt, F.R.S. We do not choose to discuss the relative merits of the new "Mineral Statistics" and those with which his name is so familiarly conjoined. But by all who know how entirely Mr. Hunt's heart and soul were in his work at the Mining Record Office and how unwearied were his labours on its behalf, an emphatic and indignant repudiation will be made of the charge brought by the anonymous critic that he failed to do his duty and set a bad example to his subordinates. Mr. Hunt needs no defence from such an odious charge. We cannot but express our regret that it should have been made in the columns of a respectable journal and under cover of an anonymous review.

WE are still a long way from admitting that a little elementary physiological knowledge is a desirable element in general education. But it is not often that such a glaring example of the want of it is met with as is revealed by the following extract from a despatch of the Acting Consul at Panama recently presented to Parliament. It would not be easy to find its parallel among the worst answers in the May examinations of the Science and Art Department:—"Many essays have been written on this appalling scourge [yellow fever], its origin, and its existence, but nothing seems more probable, more reasonable to me, than comparing the human blood to milk, which under influence of temperature and circumstances becomes curdled. In the like manner, the human blood, the human frame and organism, under certain abnormal, adverse, and unfavourable circumstances, become curdled, and enter into a state of dissolution, more or less rapid; the blood, owing to its component parts, coagulates, being impregnated with bile, phosphate, and albumen, through the stagnation of the liver and kidneys. This my theory is the one I certainly believe in. *Savants* assert that the disease is generated by spores of the marine mushroom (*Mycenium fungi maris*), which multiply in thousands per minute. Others profess it to be animalculæ termed 'microbes.'"

MR. JOSEPH THOMSON, the leader of the Geographical Society's expedition to East Africa, has arrived in this country. Mr. Thomson has suffered greatly from the hardships which he had to endure, and it will be several weeks before he regains his usual vigour. Mr. Thomson's expedition has been completely successful, and he himself estimates the results as of far greater scientific importance than those of his first expedition. The region traversed by him, from Mombassa to the north of Victoria Nyanza, is entirely volcanic, and his observations therein will be of great geological interest. There is still one volcano, west of Kilimanjaro, which shows signs of activity. Mount Kenia, though covered with trees, stands amidst a desert. The Masai, the leading people of the region explored, are of special interest. Their features, customs, dwellings, religion, language, differ markedly from those of any other African people with whom Mr. Thomson is acquainted. Fortunately besides his copious notes he has brought home many photographs, so that his forthcoming narrative is sure to be of unusual interest and value.

THE Conference on Water Supply by the Society of Arts will be held at the Health Exhibition to-day and to-morrow. The Conference will meet each day at 11 a.m., and will sit till 1.30, then adjourn till 2, and sit again till 5 p.m. The papers and discussions will be arranged under the following heads:—1. Sources of Supply. 2. Quality of Water; Filtration and Softening. 3. Methods of Distribution; modes of giving pressure, house fittings, discovery and prevention of waste, &c., &c. The proceedings will be continued on Friday, and if necessary on Saturday. The readers of papers will be restricted to twenty-five minutes. Speakers will be restricted to ten minutes. The papers to be read will, in most instances, be printed and distributed in the room.

LORD REAY has received additional names of foreign delegates to the International Conference on Education from Austria, Baden, Belgium, France, Netherlands, and Switzerland. Prussia and Denmark contribute reports on the state of education in those countries. Lord Carlingford will preside at the opening meeting on August 4, at 11 a.m.

AT the request of the Council of the British Association for the Advancement of Science, Admiral Sir Erasmus Ommanney, C.B., F.R.S., has consented to act as Treasurer during the meeting at Montreal, Canada. We learn that Prof. W. G. Adams of King's College will be unable to give the Friday evening lecture at Montreal, and that Prof. O. J. Lodge will take his place. The subject of Prof. Lodge's lecture will be "Dust." Prof. Bonney sails for Montreal to-day.

THE death is announced of the Swedish chemist, Prof. Sten Stenberg, born in 1825.

ACCORDING to a note contributed to a recent number of the *China Review* by M. A. Fauvel of Hankow, the Foreign Office and the authorities at Kew are anxious to know the name of the tree from which the well-known tea-chests are manufactured. The Chinese name is of little use for classification, as it applies to the *Acer*, *Liquidambar*, and perhaps to other species. A branch of the tree and some old leaves and fruits were submitted to M. Fauvel, but the fruits had lost their seeds, and the leaves were too old and decayed to be considered as good specimens for identification. But at first sight he recognised the fruits as those of a *Liquidambar;* the leaves were all trifid, palmately nerved, some slightly serrated, some with a smooth edge. But they were too old to show any signs of gland in the serration. They differ from those given to the *Liquidambars* in general, and from the *L. Orientale* and *L. Chinensis* varieties. M. Fauvel thinks the wood may belong to the *L. Formosana*, but must defer any definite opinion until the leaves and flowers are out. It is somewhat curious that there should be any mystery at this time of the day about so common a substance as the wood of a Chinese tea-chest.

THE last number (16) of the *Excursions et Reconnaissances*, the official publication of the Colonial Government of Cochin China, contains as usual several papers of scientific interest on that region. The first is a report by two engineers, MM. Viénot and Schrœder, of a survey undertaken for railway purposes of the country from Haiphong to Hanoi. The first part of the line from Haiphong to Haidong is about 45 km. in length, and the writers of this report describe the physical features of the district, the courses of the rivers, the villages, towns, and cities, the various productions—in short, everything bearing on the question of the construction of a line through the place. This is followed by a translation of a Chinese work on the mines of Cochin China, from which it appears that useful and precious metals are to be found there, and were at one time worked with success, although owing to the defective native methods the work had to be given up. M. Aymonier also contributes some interesting notes on the customs and superstitious beliefs of the Cambodians.

ACCORDING to the *Japan Weekly Mail*, the meteorological system of Japan now comprises twenty-three observatories in the most important places throughout the country. Reports are sent from each district to the central observatory in Tokio three times a day, and are there thrown into suitable form for publication by the leading journals in the capital and the open ports. To a German, Dr. E. Knipping, belongs the credit of elaborating and perfecting the whole system. In China, the Shanghai Chamber of Commerce has also assisted Père Dechevrens in his meteorological work by making him an annual grant of about 300*l*.

A RECENT writer in the *North China Herald* discusses the part played by mercury in the alchemy and *materia medica* of the Chinese. Cinnabar was known to them in the seventh century before the Christian era, and its occurrence on the surface of the earth was said to indicate gold beneath. Their views on the transformation of metals into ores and ores into metals by heat and other means took the form of a chemical doctrine about a century before Christ, and there is now no reasonable doubt that the Arabian Geber and others (as stated by Dr. Gladstone in his inaugural address to the Chemical Society) derived their ideas on the transmutation of metals into gold and the belief in immunity from death by the use of the philosopher's stone from China. Among all the metals with which the alchemist worked, mercury was pre-eminent, and this is stated to be really the philosopher's stone, of which Geber, Kalid, and others spoke in the times of the early Caliphs. In China it was employed excessively as a medicine. On nights when dew was falling, a sufficient amount was collected to mix with the powder of cinnabar, and this was taken habitually till it led to serious disturbance of the bodily functions. In the ninth century an Emperor, and in the tenth a Prime Minister, died from overdoses of mercury. Chinese medical books say it takes two hundred years to produce cinnabar; in three hundred years it becomes lead; in two hundred years more it becomes silver, and then by obtaining a transforming substance called "vapour of harmony" it becomes gold. This doctrine of the transformation of mercury into other metals is 2000 years old in China. The Chinese hold that it not only prolongs life, but expels bad vapours, poison, and the gloom of an uneasy mind.

THE Peabody Institute of the City of Baltimore is an educational institution founded in his native city by the rich philanthropist, and worked for the advantage of a rather higher class of students than those of the ordinary free library. It combines under one government, as we have before urged the advantage of combining, the library, the lecture-room, music, and art, besides an annual expenditure in prizes for certain schools in Baltimore; and each department is managed by a sub-committee so small as to make every member of it probably feel himself greatly responsible for its success. The lecture committee provided six lectures each upon "The Sun and Stars," and "The Yosemite Valley," &c., and four lectures each upon "The Crusades," "The Minds of Animals," and "Shakespeare's Plays," all except the last assisted by illustrations. These formed a series of two lectures weekly during the four winter months, and season tickets were sold at a price not much exceeding threepence a lecture, the expense to the Institute being about 100*l*. The Conservatory of Music sets itself a high ideal, and claims considerable success. It employs five professors of music, who have had 160 pupils under them, but no pupil reached the level of earning their diploma. A series of fifty-one lectures, concerts, and rehearsals were given, to all of which annual subscribers are free at a small cost similar to that of the lectures, with a charge upon the Institute of about one-seventh of the entire amount spent in the cultivation of music. Upon a Gallery of Art open for eight months during the year, and helped by a loan of pictures, the Trustees were unable to spend any capital sum, and the expenses were limited to the care-takers. Over 1200 dollars were spent according to

Mr. Peabody's will in premiums and medals given to four schools in Baltimore. The library, however, is the object of largest expenditure, and aims at being a high-class one in every respect, 12,000 dollars, or one-quarter of the entire expenditure, having been laid out in the purchase of books. Important and uncommon works are added, supplying the demands of scholars for minute information. Such students are its most numerous users, and there were but few works of fiction among the 2700 volumes added during the past year. The library now reaches a total of 82,000 volumes. A catalogue of these is being compiled, the first volume of which, heartily recommended by many scholars and bibliographs, and already leading to greater use of the library periodicals, contains 868 pages and 61,184 references, yet only takes in A–C. We are told that it is offered under cost price at seven dollars to subscribers, but the Provost's remark which follows, that, besides being very expensive, "it is not desirable to sell many copies," shows how little the Institute aims at popularity. And in no department, truly, can this be boasted of! The lectures seem to have been the most successful. The Report observes that the annual members of the Conservatory of Music ought to rise to 400 or 500 instead of 87; and 70 visitors a day is not many, out of a population of nearly 400,000, to the Gallery of Art. Less than 60,000 issues have been made out of the great library, and the Provost thinks that the public will be surprised to hear that a total of 100,000 persons have visited the buildings for its various purposes during the year! These numbers show how, in America as well as in England, a small rise in requirements brings one into a much rarer, less crowded stratum of society. However, in all departments increased interest and "remarkable progress" are reported, which we trust may increase tenfold.

At a meeting of the Vaccination Officers' Association held on Saturday last, a cordial vote of thanks was given to the National Health Society for issuing their pamphlet entitled "Facts concerning Vaccination," and the Association expressed their appreciation of "the thoughtful kindness which prompted the Society to assist the vaccination officers of the metropolis in the discharge of their often difficult duties." We are informed that the pamphlet in question has now been distributed from house to house in most of the districts in the metropolis where small-pox is epidemic, and that the demand for it still continues. Something like 150,000 copies have already been issued since the present epidemic began.

As a supplement to our note of a meteor seen on the west coast of Norway on May 27 (p. 200), it will be interesting to read the following particulars supplied by Mr. Gjestland, residing at Tysnas, in the province of Bergenhus. This gentleman states that he too saw the fire-ball a little after eight o'clock, and subsequently heard a report as of distant rolling thunder. A couple of days after he happened to be on a farm, Midtvaage, in Onarheims parish, where a woman told him that she had seen the "ball" fall a few feet from the house. On learning this Mr. Gjestland, in connection with the parish engineer, began a search in the direction indicated, and discovered, in a spot where the turf covers the mountain ridge to a depth of about 20 cm., a hole where the turf and mould had been as it were blasted away from the rock, and in it a handful of pulverised stone, which, however, in every respect seemed to resemble the mica schist of the mountain. Two days after he learnt that a girl on the same farm had found a very peculiar stone near the same spot, which was thought to be the one searched for. Mr. Gjestland at once proceeded to the farm, and has succeeded in obtaining the valuable specimen. He states that in shape and size it is like the fourth part of a large Stilton cheese, cut vertically from the centre to the side. The height as well as the diameter is 20 cm. A fresh fracture on the surface shows that a bit has been broken off, probably by striking the rock, while the other side shows an uneven, undulating surface partly polished. The exterior is sooty and dark in colour, indicating that it had been exposed to great heat, whilst the interior is grayish brown and interspersed with bits of metal having the appearance of iron, some of which are 1 mm. in length. The block has a considerable specific weight, resembling that of iron-stone, is brittle, and may be cut with a knife. The weight is 19·5 kilos.

On July 3, at 9.32 p.m., a brilliant meteor was seen in Stockholm, crossing the sky from south-east to north-west, about 22° from the zenith. The colour was first red, then yellow and green, and became finally white as the meteor parted into halves about 45° above the horizon. It afterwards burst into fragments. When at its point of culmination, the meteor had the appearance of a kernel about a third of the moon's disk in size, with a trail of about the same width and ten times the diameter in length. The whole lasted about four seconds.

The French Northern Railway Company have begun experiments on motive power generated by electricity at the Chapelle Station. The Company have established an electric lift with two Siemens electro-magnetic machines, one for elevating the weight, and the other for moving the machinery alongside the railway.

During the night of July 19 an earthquake was felt at Agram. It lasted four seconds, and was accompanied by subterranean rumblings. No damage was done.

An unknown benefactor recently offered to give 100,000 marks to the University of Heidelberg, on condition that ladies should be permitted to study there. The University has declined the offer.

The additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus* ♂) from India, presented by Mrs. A. Edwards; a Gray Ichneumon (*Herpestes griseus*) from India, presented by Lieut. A. H. Oliver, R.N.; a Short-toed Eagle (*Circaetus gallicus*), South European, presented by Mr. W. R. Taylor; a Bronze-winged Pigeon (*Phaps chalcoptera*) from Australia, presented by Mr. J. Latham; five Natterjack Toads (*Bufo calamita*), British, presented by Mr. W. Stanley; three Striolated Buntings (*Emberiza striolata*) from Africa, deposited; a Four-horned Antelope (*Tetraceros quadricornis*) from India, a Maccarthy's Ichneumon (*Herpestes maccarthiæ*) from Ceylon, three Common Squirrels (*Sciurus vulgaris*), British, six Aldrovandi's Lizards (*Plestiodon auratus*) from North-West Africa, purchased; two Virginian Deer (*Cariacus virginianus*), an Argus Pheasant (*Argus giganteus*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN

Brorsen's Comet of Short Period.—We are now within about two months of the probable time of the next perihelion passage of this comet, and after the middle of August, when the moon draws away from the morning sky, it may be within reach. So far, however, no ephemeris for this return has been published. The perturbations since its last appearance in 1879 will not have been very material, and the mean motion in that year would fix the approaching perihelion passage to about September 14·5 G.M.T. If the longitudes in Dr. Schulze's orbit for 1879 are brought up to 1884·75, the following expressions for the comet's heliocentric co-ordinates result:—

$$x = r \,.\, [9{\cdot}94286] \,.\, \sin (v + 207^\circ\ 56'{\cdot}7)$$
$$y = r \,.\, [9{\cdot}98506] \,.\, \sin (v + 126\ \ 22{\cdot}0)$$
$$z = r \,.\, [9{\cdot}73705] \,.\, \sin (v + \ \ 60\ \ 33{\cdot}4)$$

Taking September 14·5 for the epoch of perihelion passage, the comet's approximate positions are:—

12h. G.M.T.	R.A. h. m.	Decl. ° ′	Distance from Earth	Distance from Sun
August 16	7 7·7	+ 8 8	1·282	0·815
18	7 20·0	8 46		
20	7 32·5	9 25	1·280	0·766
22	7 45·2	10 2		
24	7 58·0	10 37	1·284	0·720
26	8 11·0	11 10		
28	8 24·2	11 40	1·295	0·679
30	8 37·5	12 8		
September 1	8 51·0	+12 33	1·312	0·644

If we suppose an acceleration of four days in the time of perihelion passage, the effect on the geocentric position is—

	in R.A. m.	in declination ° ′
On August 16	+ 15·1	+ 2 1
On ,, 28	+ 16·7	+ 1 41

The theoretical intensity of light expressed in the usual manner would be 0·92 on August 16, and 1·40 on September 1.

During the above period, with the places assigned, the comet would rise at Greenwich from 2h. 10m. to 2h. 20m. before the sun. In 1873, when the circumstances approached nearest to those of the return in the present year, the comet was detected at Marseilles on the morning of September 2, the distance from the earth being 1·02, and that from the sun 0·94, the intensity of light 1·08. At its last appearance in 1879 it was seen by Tempel at Arcetri, on January 14, when the intensity of light was only 0·13, an exceptional case, since at no previous appearance had it been observed under a less value than 0·33.

From the first discovery of the comet in 1846 by Brorsen, an astronomical amateur at Kiel, the period of revolution has gradually diminished from the effect of the planetary perturbations; subjoined are the times of perihelion passage in those years when the comet has been observed, and the sidereal periods corresponding to those times:—

		Days
1846 February	25·37 G.M.T.	2034·1
1857 March	29·25 ,,	2022·7
1868 April	17·41 ,,	2002·4
1873 October	10·48 ,,	1999·4
1879 March	30·54 ,,	1994·9

From its unfavourable position the comet was missed at its returns in 1851 and 1862. It is well known that the present orbit is due to the action of the planet Jupiter in 1842: at the perijove passage at 6 p.m. on May 27 in that year the comet's distance from Jupiter was 0·0547 of the earth's mean distance from the sun; consequent upon this near approach, the inclination of the orbit in which it previously moved was diminished nearly 15° according to the calculations of Dr. Harzer, who has very fully investigated the circumstances It is probable that there had been a great perturbation of the elements from the same cause in 1759-60, and that in 1937 (according to D'Arrest) this may again occur.

THE BINARY-STAR β DELPHINI.—Dr. Dubjago, of the Observatory at Pulkowa, has published a first orbit of this star, the duplicity of which was discovered by Mr. Burnham in 1873; more than 180° of the orbit have been described since that year. The period found is 26·07 years, the periastron passage at 1882·19. After that most rapid of all the known revolving double-stars δ Equulei, to which Mr. Burnham attributes a period of only 10·8 years, there is only one, 42 Comæ Berenicis, that has a shorter revolution attached to it, and β Delphini may be eventually proved to have the less period. In 1873 Mr. Burnham estimated the distance of the components 0″·7; they have since closed until the star has been beyond the powers of any but the largest telescopes. Dr. Dubjago's elements assign for 1884·6 position 219°·4, distance 0″·28.

RED SUNSETS[1]

THE equatorial diameter of the earth is 7901 miles and the circumference is 24,825, and as she revolves once on her axis in twenty-four hours, a place on the equator moves through 1034 miles in an hour: but at any depth beneath the surface the velocity is less in proportion to that depth; in like manner, if we look on the atmosphere as part and parcel of the earth, at a certain height the velocity is greater in proportion to that height.

The whole world has been greatly interested during the last seven or eight months with the beautiful phenomena of coloured suns and brilliant sunsets; and the liveliest interest has been exhibited as to their origin. Lockyer was the first, I believe, to point out the fact of the phenomenon of coloured suns appearing first in the east and then gradually shifting to the west. He traces them to Panama, and speaks of them as having been seen on a north-south line; but it strikes me that after leaving Panama the phenomenon passed still further westward, was seen on September 3, 4000 miles west of Panama, and at Honolulu on September 5, and struck India and Ceylon on the 8th, thus performing more than a complete circuit of the globe; moreover, I am of opinion that it may be traced still further westward, where it was seen in lat. 24° 6′ N., long. 140° 29′ W., by Capt. Penhallow of the barque *Hope*, on September 25, having then performed 2¾ revolutions of the globe.

All the information that I have collected, and from which I have compiled the following tables, has been obtained from NATURE. The time column has been deduced from the time and date of the phenomenon appearing at the different stations, reduced to Krakatoa time; in some instances great difficulty has been experienced, especially in reference to the time at Maranham in Brazil, and at Trinidad, and it has been concluded that at those stations the times are late, because it was seen at Panama before the time given at them, which we suppose to be an error. Likewise in the case of the Gold Coast, in one place the date given is August 30, and in another September 1, but from the general result it would appear to have reached that locality about midnight August 30–31.

The tables, I trust, are sufficiently clear; the first column of miles represents the mean diurnal velocity that the cloud travelled at between Krakatoa and the different localities *en route*; and in the subsequent columns are given the same from each station in rotation. Of course it will be understood that a small error of an hour or two in the time at the stations comparatively close to the eruption would make a large difference where we show the *diurnal* velocity; and as I have had only a week's notice to prepare this paper, I trust that any errors that may be hereafter found will be treated with that consideration.

TABLE I.—*Showing the Mean Diurnal Velocity in English Miles of the Phenomena of Coloured Suns and Brilliant Sunsets in the Northern Hemisphere*

	Time from Java to	Java	Seychelles	E. Coast of Africa	Gold Coast	Maranham	Trinidad	Panama	4000 miles W. of Panama	Honolulu	India
	h.										
Seychelles	45	1802									
E. Coast of Africa...	58	1817	1873								
	days										
Gold Coast	4	1846	1969	1932							
Maranham	5	2020	1950	1896	1904						
Trinidad	5½	1968	2080	2040	1940	2176					
Panama	6¼	2059	2040	2176	2324	1930	1986				
4000 miles W. of Panama ...	8¼	2061	2424	2210	2493	2370	2338	2000			
Honolulu	9½	1900	2084	2080	2036	1909	1748	1716	1122		
India...	12¼	2162	2278	2192	2328	2212	2084	2200	2310	2244	
Lat. 24° N., long. 140° 30′ W. ...	29⅔	2132	2246	2206	2268	2165	2400	2170	2460	2316	2192
Arithmetical means...		1976	2105	2091	2185	2127	2111	2022	1964	2280	2192
True mean...		2095									

Arithmetical mean for Northern Hemisphere 2105 miles per day.

The true mean of the first column, viz. that under the head of Java, is obtained by adding the distance between Krakatoa and each separate station together, and dividing the aggregate by the gross total number of days. The way by which the distance between any two stations is derived is by multiplying the difference in degrees of longitude by the value of a degree in English miles for the mean latitude of the two places. It must be remembered that between India and the last-named locality on the list the dust cloud is supposed to have performed over a revolution and a half of the earth.

I place great confidence in the result obtained from the observations deduced from India, because there there are scores of trained meteorological observers whose duty it is to immediately report any phenomena that may take place, and such as that concerning which I speak could not have escaped their immediate

[1] Paper read by Alexander Ringwood at an ordinary meeting of the Canterbury Philosophical Institute, New Zealand, on May 1, 1884.

notice; so we may conclude that the hour of its arrival there is very accurately determined, which gives a mean daily velocity of 2162 miles; and taking the velocity from its journey and a half round the world, from India to lat. 24° N., long. 140½° W., we find it to be 2192 miles per day, or 30 miles only in excess of the other computation. But if we take the whole journey from Krakatoa to that locality, about 2¾ revolutions round the globe, we find the mean to be 30 miles less than the first, or 2132 miles, and that will be accounted for through the diminished value of the degree in longitude at the mean latitude between Java and lat. 24° N., long. 140½° W.

The mean diurnal velocities obtained from the intermediate stations, between Java and India, agree very closely; when we consider that at those several places the phenomenon was wholly unexpected, and thus in most instances the dates and times given appear to be somewhat late, it is quite possible and natural that it escaped notice at least once; in India, however, we may conclude that they were on the alert, and consequently the mean velocity deduced from that place ought to bear great weight. There is another thing that ought not to be lost sight of, viz. that without this list of stations, more than encircling the globe, one might suppose that the *cloud* after leaving Krakatoa stretched away westward, and as I gather from Lockyer's paper by his *north-south* line, to have extended to the north and south, forming a letter V with the apex at the Straits of Sunda. Now Lockyer tracks it to Panama, to which place we see it to have had a diurnal velocity of 2059 miles, and from Panama to India I made it 2200 miles per day, which makes me believe that the cloud was performing a spiral path northward round the globe.

Before proceeding I will now turn to the observations in the Southern Hemisphere, in order to see whether the same has taken place there. This table has been prepared in like manner to the former, viz. the dates and times are reduced to that of Krakatoa, and the distances in English miles obtained from the difference in degrees of longitude reduced to the value of the mean latitude of the two places.

TABLE II.—*Showing the Mean Diurnal Velocity in English Miles of the Phenomena of Coloured Suns and Brilliant Sunsets in the Southern Hemisphere*

	Time from Java to	Java	Mauritius	Adelaide	Cape of Good Hope
	hours				
Mauritius	44	1680			
	days				
Adelaide	21¼	2041	1980		
Cape of Good Hope	24	2082	2047	2010	
Christchurch	29¼	2134	1990	2120	2070
Arithmetical means		1984	2005	2065	2070
True mean		2100			

Arithmetical mean for Southern Hemisphere 2031 miles per day.

The marked similarity between these two tables is most striking, and, as in the first table, the greatest discrepancy is found between Krakatoa and Mauritius, where the data are reckoned in so many hours, in which case an hour or two makes a material difference in the diurnal velocity. At present I cannot find any station reporting the phenomenon between Mauritius and Adelaide, but we may conclude that after it passed Mauritius it crossed Africa, the South Atlantic, and South America, whence we may expect to hear of it, as there are many competent observers in that part of the world; it then traversed the great South Pacific Ocean and North Australia, and after performing another such journey round the world, but in a higher latitude, was seen at Adelaide in South Australia about September 17. I conclude, as Mr. Todd, the Government Astronomer, there says in his report to NATURE, "that it was visible during the last fortnight of September." We next hear of it at the Cape of Good Hope on September 20. It again crossed the South Atlantic and South America about the latitude of Buenos Ayres, and a third time traversed the South Pacific, striking the coast of New Zealand on September 25, the date of my first seeing it; on which occasion the western sky at sunset presented all the colours seen in the pearl-shell. Since then the western and eastern skies have presented those beautiful crimson tints that have delighted the world, and on many occasions I have seen it almost in the zenith two hours after sunset. During some evenings it has quite illuminated the western face of buildings with a bright glare as from a fire, whilst on others it has been very faint and sometimes not discernible: giving to my mind the idea of its not being a continuous band but a series of dust clouds with clear spaces between.

From an investigation of the two tables it will be seen that the mean diurnal velocity in the Northern Hemisphere was, during the first revolution, about 2162 miles, and during the second it increased to 2192, or 30 miles per diem extra. And the same increased velocity is observed in the Southern Hemisphere, where we find the approximate velocity during the first two revolutions, viz. on its reaching Adelaide, to be 2041, whereas during the next revolution from Adelaide round to New Zealand it was 2120 miles, or an increase of 80 miles per day. It will be further noticed that in the Northern Hemisphere the time occupied in its first revolution was about eleven days, and the same rate is observed during the next revolution and three-quarters, or, in other words, within the tropics it encircled the world in eleven days. It is the same within the southern tropics, where it took 21¼ days to reach Adelaide in its second revolution, but it performed the next revolution in about 9¼ days, reaching New Zealand in 29¼ days after the eruption. Thus it performed 2¾ revolutions in the Northern Hemisphere in 29⅝ days, and in the Southern Hemisphere it performed 2⅝ revolutions in 29¼ days, showing that the initial velocity at starting has only very slightly fallen off in even latitude 45° S. So in the following discussion I will adopt a mean diurnal velocity for the dust cloud of 2083 miles, or 87 miles per hour to the westward.

As I showed at the beginning that, if the atmosphere be considered as part and parcel of the earth, a particle of it at a certain height will cover a greater distance in a certain time than that part of the earth immediately beneath would, so if we know the rate per hour that a certain thing *apparently* moves to the westward, or seems to lag behind the diurnal revolution, we can ascertain the height. We know that it lags behind at the rate of 2083 miles per day, which, added to the circumference of the world, gives a circle of 26,908 miles, and this divided by 3·1416 gives a diameter of 8565 miles, or 664 miles greater than that of the earth, or a height of 332 miles above the surface. Or, putting it this way, we may assume that at the latitude of Krakatoa the earth has an hourly velocity of 1034 miles, and that any matter ejected thence into the upper regions of the atmosphere, would retain the same rotary velocity as it had before, viz. 1034 per hour to the eastward; but we have material under our observation which cannot keep its zenithal position at starting, by 87 miles per hour, showing it to be at an elevation of 332 miles.

Now the spectroscope tells us that the red colour is produced through dust of almost ultra microscopic fineness, and in some specimens of this dust that have already fallen the microscope shows the existence of *salt* crystals, which fact in itself almost proves it to be of volcanic origin, and not meteoric or cosmic dust. Now Prof. Helmholtz states that "the reflecting medium, whatever it was, over Berlin on the last three nights of November, was about 40 miles above the earth;" and if we work on this data we have a circle whose diameter is 80 miles greater than that of the earth, or a circle of 7981 miles, which, multiplied by 3·1416 gives a circumference of 25,073, or 248 miles more than that of the earth, which, divided by 24, shows an excess of about 10⅓ miles per hour above the surface velocity of rotation. But we want to account for an excess of 87 miles per hour; so if we accept Prof. Helmholtz's statement we must only suppose that at the altitude of 40 miles there is an easterly current, or one moving to the westward, of 77 miles per hour; for, assuming as we do from the foregoing tables and calculations that the earth rolls from under the cloud at the rate of 87 miles per hour, unless we admit of an easterly current we cannot stop short of that enormous height of 332 miles unless we suppose that the power of gravitation has only a feeble hold on those most minute dust particles at the altitude of 40 miles, where the atmosphere has not the many thousandth part of the density it has on the surface of the globe.

Mr. W. H. Preece writes stating his opinion that the mass of matter ejected retained the same electric sign as that of the earth, and as long as that was the case the repulsion force would be sufficient to keep the matter afloat; and in reference to that theory Mr. Crookes writes to state that with a rarefaction of one-millionth of the atmosphere, two pieces of electrified gold leaf repelled each other at a considerable angle for thirteen months, and goes on to state that that rarefaction is attained at an altitude of 62 miles, and that the air there is a perfect non-conductor of statical electricity, without interfering with the mutual repulsion of similarly electrified particles; and when we bear in mind that the particles of minute dust are many thousands of times smaller and lighter than the gold leaves operated upon, there is every reason to believe that electrified dust, once projected 50 or 60 miles high, might remain there many years.

Before proceeding further I must draw your attention to the fact that at the time of the great eruption, and during September, the mean temperature at Batavia, and throughout Java generally, is at its maximum; consequently we may conclude that the equatorial belt of calms and uprushing air that encircle the globe was lying over that district at the time. This uprush is caused through the heated atmosphere rising, and the two trade winds, the north-east and south-east, feed it. When this heated air has attained its proper altitude, it flows off to the north and south, but the rotation of the earth causes it to flow towards the north-east in the Northern Hemisphere, and to the south-east in the Southern Hemisphere, and these winds are called by some the return trades, and by others the south-west and north-west upper currents respectively, and are of great altitude, probably ranging up to 50,000 feet.

Well, the most bulky masses cast upwards by the eruption of Krakatoa would immediately fall, and the less bulky would fall later according to their size, but the great portion of the dust and ash would be caught, on its downward course, in those upper currents just alluded to, and be carried by them to the north-east and south-east. Such we find to be the fact, for the ship *Meda*, when to the westward of Cape North-West, Australia, or about 1050 miles south-east of Krakatoa, experienced a fall of dust like fuller's earth, which covered the vessel, on the night of August 30-31, and Capt. Tierney, of the brig *Hazard*, on September 1, near New Ireland, a distance of 3850 miles due east of Krakatoa, saw the coloured suns, which was no doubt due to the presence of dust in the atmosphere, drifted eastward with the upper current.

Now, turning to the north-east quarter, or the direction in which the south-west upper current of the Northern Hemisphere proceeds, we find that in Japan during August 29, 30, and 31, the sun was of a copper colour, and had no brightness in it; at Yokohama, Mr. Hamilton states that on the 29th and 30th the sun was of a blood-red colour, and appeared to be obscured. This is at a distance of about 3000 miles from Krakatoa, which gives a velocity of the upper current, or return trade wind, of about 62 miles per hour; this is not excessive, as I have often measured the velocity of the north-west upper current at Adelaide as over 80 miles per hour.

You may remember that I did not continue the tracking of the dust cloud, from that position assigned to it by Capt. Penhallow, in lat. 24° N., long. 140½° W., on September 25, because the European and American reports are so peculiar. It was apparently seen in England *before* the rest of Europe, viz. on November 4 and 9, in California on the 20th, San Francisco on the 23rd, Italy on the 25th, New York on the 27th, and at Berlin on the 28th; so you see that the geographical arrangement is rather mixed in reference to the order of dates. This may be accounted for by the fact that there was a very severe volcanic eruption in the Alaska Group and Peninsula in October, I think; it was very intense, and quite capable of ejecting a dust cloud that would envelope the Polar and temperate regions of the Northern Hemisphere; of course it was not nearly so terrific as that of Krakatoa. So you will see that we must be careful before we assert that the brilliant sunsets of Europe are of Krakatoan origin.

The phenomena of coloured suns and brilliant sunsets, I may tell you, have been seen before, both in Europe and America, in connection with Vesuvian and Iceland outbursts; Mr. Somerville, the famous geographer, gives an instance of it which had been seen in Norway, and traced its origin to a severe eruption in Iceland. And H. C. Russell, B.A., F.R.A.S., F.R.Met.S., Government Astronomer, Sydney, in his book on the climate of New South Wales, pages 187, 188, gives some most interesting instances of historical accounts of darkened and coloured suns. I will quote them in their chronological order:—

"'At certain times the sun appears to be not of his wonted brightness, as it happened to be for a whole year when Cæsar was murdered, when it was so darkened that it could not ripen the fruits of the earth.'—Virgil, *Georg.*, lib. i., &c.

"In 1090 there was a darkening of the sun for three hours.

"In 1106, beginning of February, there was obscuration of the sun.

"In 1208 there was a darkening of the sun for six hours.

"In 1547, August 24 to 28, the sun was reddish, and so dark that several stars were visible at noonday.

"In 1706, May 12, about ten o'clock in the morning, it became so dark that bats commenced flying, and persons were obliged to light candles.

"In 1777, June 17, about noon, Messier states that he perceived an immense number of black globules pass over the sun's disk.

"In 1783 there was a *dry fog*, and many attributed it to volcanic action; and it is well known that in February that year fearful earthquakes in Calabria took place, followed by a long list of volcanic eruptions in other parts of the world.

"In 1831 was an extraordinary *dry fog*, which excited public attention throughout the world. It appeared on the

Coast of Africa	August	3
At Odessa	,,	9
In South France	,,	10
Paris	,,	10
New York	,,	15
Canton, China	,,	end of.

This fog was so thick that it was possible to observe the sun all day with the naked eye, and without a dark glass, and in some places the sun could not be seen till it was 15° or 20° high. At Algiers, United States, and Canton the sun's disk appeared of an azure blue or of a greenish colour. Where the fog was dense, the smallest print could be read even at midnight.

"In 1873, of the *dry fog* which came on suddenly in June, it is recorded that it extended from the northern coasts of Africa, over France to Sweden, and over great part of North America, and lasted more than a month. Travellers found it on the summit of the Alps. Abundant rains in June and July and most violent winds did not dissipate it; and in some places it was so dense that the sun could not be seen until it had attained an altitude of 12°, and throughout the daytime it was red, and so dull that it might be looked at with the naked eye. The fog diffused a disagreeable odour, and the humidity ranged from 57 to 68, while in ordinary fog it is 100. It had a phosphorescent appearance, and the light at midnight was compared to that of full moon."

Here was exhibited a diagram, drawn correctly to a scale of fifty miles to one inch, showing the arc (15°) of a circle whose radius was 6 feet 7 inches, or a diameter of 13 feet 2 inches. The Himalayas were shown in their correct proportion, so was the smoke from Cotopaxi, estimated by Whymper while on Chimborazo at 40,000 feet; he saw at 5.45 a.m. of July 30, 1880, a dense column of smoke shot up straight into the atmosphere with prodigious velocity, which in less than one minute had risen 20,000 feet above the crater, giving the total height of 40,000 feet above sea-level. The dust, he goes on to state, fell on Chimborazo after six hours, and he estimated that each particle did not weigh 1/25000 part of a grain, and the finest were still lighter.

Some people (and very rightly too) express wonder and unbelief at the possibility of *dust* being capable of having been shot up to such a height as that ascribed to it, as to cause the red sunsets,—but here I have quoted the fact of such, as seen by a man of known repute; the dust and ashes *were shot up* to that great height, and not only that, but as the dust cloud came between Mr. Whymper and the sun, he saw the phenomenon of the coloured suns. The same may be seen during any very heavy dust storm anywhere, when the cloud is between the observer and the sun.

In this description given by Whymper, we have a good illustration of the tremendous force Nature uses in these convulsions; a force that could throw the finest dust to a *height* of 20,000 feet is almost inconceivable to the human mind, and in that phenomenon we have, I may say, only an everyday occurrence when compared with that giant eruption of Krakatoa. Let us draw a comparison. At the destruction of Pompeii, situated at the *foot* of Vesuvius, the city was enveloped with darkness from the density of the dust and ash cloud that enshrouded it, and that ultimately buried it; but now contemplate the tremendous power that ejected from a mountain a sufficiency of dust and ash envelop a city in total darkness for thirty-six hours, *eighty miles distant*. On that diagram I have sketched an imaginary picture of the eruption, and eighty miles distant is represented by a little over an inch and a half, where you see the letter B, showing to your mind the relative distance of Batavia from Krakatoa. You can form in your imagination some idea of the great height that the dust cloud ascended: to my mind twice forty would not be too great. Then again we have the ship *Charles Bal*, when *thirty miles distant*, was enveloped at noon-day in pitch darkness through the mud-fall. Furthermore, as Lockyer says, the sound, the least part of the affair, was heard over an area of 4000 miles in diameter, viz. in Ceylon to the north-west, at Saigon to the north, and throughout North Australia to the south-east. In the last quarter the reports were at intervals of fifteen minutes, and sounded like ship-guns, but as the hearers were from 150 to 200 miles from the coast, such cause could not be assigned. All that can be said is that it is beyond the human mind to conceive of such gigantic forces, and therefore absurd to throw doubt on the result; by which I mean that if the laws of refraction show that the substance, whatever it may be, that causes the red glow, is at an altitude of forty or sixty miles, it is ridiculous to doubt that result, when we cannot conceive the magnitude of the power that operated.

It was not only one eruption that took place, but several, during the 26th, the following night, and up to 11.15 a.m. of the 27th, about which time the grand finale is supposed to have taken place. These eruptions followed each other in rapid succession, and are thought to have been caused by the rapid conversion into steam of vast quantities of water that found admittance into the bowels of the earth. Later on the influx of water was too much, and the result was that a tremendous power was generated, so much so as to cause the north part of the island to be blown away, and fall eight miles to the north, forming what is now called Steers Island. This was followed by a still greater eruption, when it is thought that the north-east portion was blown clean away, passing over Long Island, and fell at a distance of seven miles, forming what is now known as Calmeyer Island. These suppositions are almost proved to be facts, from the Marine Survey of the Straits just concluded, from which it will be seen that the bottom surrounding these new islands has not risen, which would most naturally have been the case had they been caused by upheaval, but if anything the bottom shows a slightly increased depth in the direction of the great pit that now occupies the position that the peak of Krakatoa did the day before. These incidents are cited to show you the awful nature and magnitude of the forces brought into play, as you can the more readily satisfy your minds as to the great height the dust and ash were thrown to.

As I said before, this dust cloud may probably be denser in some places than others, owing that fact to the relative period of time that elapsed between each eruption; where it is dense we may assume that they followed each other rapidly, and where it is less dense the interval of time was greater. For you must remember that it was shown to you that the cloud apparently moves to the westward, or that the earth moves from beneath the cloud, at the rate of 87 miles per hour, so that during each hour of the eruption there was a long streak of smoke and dust being formed. These densest parts were no doubt the cause of the coloured suns, and as some observers state, "the sun appeared to shine with diminished strength," others "that it was rayless and giving no heat," so we may look upon that dust cloud as playing the part of a great screen, shutting off some of the heat of the sun from us. In these southern latitudes we have experienced those brilliant sunsets for over seven months, and I have no hesitation in expressing my opinion that the remarkably cool and wet summer just passed in New Zealand was due to that dust cloud shutting off the sun's heat in a great degree. And I see from the Adelaide report that the mean temperature there during January was over 4½ degrees cooler than the average of the previous twenty-five years, and on only one occasion during that period was it so low, viz. in 1869. At Melbourne also the weather was more like winter than summer, whereas in North and Central Australia, or I may say down to lat. 30° on that continent, the weather was fine, clear, and hot, without rain, giving me the idea that the sun had less power than usual; consequently the north-west monsoon was very feeble, not penetrating far inland, the result being that the interior of Australia has undergone one of the most disastrous droughts on record. But now that, as we may suppose, the equatorial regions of the atmosphere have parted with the greater part of their dust, if not all, the sun has regained his usual power, and the north-west monsoon its usual strength, penetrating the heart of Australia with refreshing rains and thunderstorms. So we have here an instance of a most terrific phenomenon that not only brought death and destruction to thousands at the time, but that indirectly caused the death of thousands and thousands of cattle and sheep through drought, and it would be most interesting and instructive to learn whether or not such consequences were experienced in other parts of the Southern Hemisphere at least.

It would be beyond the province of this paper, and in fact too late to-night, to enter on a history of the tidal and atmospheric waves that resulted from this eruption, but I will state two facts to finally clinch your mind of its magnitude. When the earth opened her mouth and swallowed that vast quantity of water, the down-rush that accompanied the closing-in of the surrounding crust was so much as to produce a tidal wave that passed and repassed twice, I believe, round the globe. The other fact is, that the tremendous explosion that accompanied the final eruption produced such a vacuum as to cause atmospheric waves to start, and which traversed and retraversed the earth to the antipodes of Krakatoa no less than four times.

Some astronomers have thought that the whole phenomenon may be accounted for by supposing the earth to be passing through a dense meteoric track. To my mind, however, the greatest difficulties brought to bear against the volcanic theory are child's play when compared with the possibility of about 10,000,000,000 to one of a meteoric track so formed as to have its path, either at aphelion or perihelion, so remarkably coincident with that of the earth as to keep company with her for seven or eight months. Besides, were it either meteoric or cosmic dust, it would be seen all over the earth at the same time, and would be visible all night.

No; the only extra-terrestrial argument that would bear any investigation is that of its belonging to the phenomenon of the zodiacal light, which argument, I believe, was adopted at first by my friend Charles Todd of Adelaide; but, as time goes on and more information is gathered, the volcanic theory, I believe, will be finally adopted.

THE THEORY OF THE WINTER RAINS OF NORTHERN INDIA [1]

At first sight, the occurrence of rain in Northern India at the season when the north-east or winter monsoon is at its height seems to present a meteorological paradox. The well-known theory of the winter monsoon is that at that season the barometer stands highest in North-Western India where the air is cold and dry, and lowest in the neighbourhood of the equator where it is warm and moist; and therefore, in accordance with elementary mechanical laws, the wind blows from the former to the latter. But the precipitation of rain requires that the air should have an ascending movement, and this can take place only over a region of low barometer, towards which, therefore, the winds are pouring in. Hitherto no one has attempted the reconciliation of these apparently discrepant conditions.

Since the establishment of a Meteorological Department under the Government of India has rendered it possible to study the weather of India as a whole from day to day, it has been my practice to investigate every case of cold weather rainfall in Northern India, amounting generally to three or four in each year, and although many important points still remain for elucidation, it is now at least possible to clear up many of the difficulties of the problem, and to reconcile the apparent inconsistencies.

The charts which accompany the paper show the distribution of atmospheric pressure and the prevalent winds in the four months of the cold weather. They exhibit many features in common. The region of highest barometer is in the Punjab and the Indus Valley, and from this an axis or ridge of high pressure extends across Rajputana and Central India, having a trough of slightly lower pressure in the Gangetic plain and the Northern Punjab on the one hand, and a much lower pressure in the peninsula on the other. The winter monsoon blows around this region of high pressure in an anticyclonic curve, *i.e.* in the direction of the watch-hands, but in the Punjab and the Gangetic plain there is but little movement of the air, the average rate

[1] Abstract of a paper read before the Asiatic Society of Bengal on March 5, 1884, by H. F. Blanford, F.R.S., President of the Society.

being less than two miles an hour, and calms constitute about one-third of the observations. Also it is shown, by the barometric registers of the Himalayan hill-stations, that that distribution of pressure which, on the plains, causes the north-east monsoon, does not exist and is even slightly reversed at an elevation of 7000 feet.

Hence, in Northern India, the state of things which produces the winter monsoon is restricted to a small height, and is then only an average and not a permanent condition; and that which chiefly characterises the atmosphere is its stillness, a condition in which any local action, small and feeble as it may be at first, may eventually set up a disturbance such as to revolutionise the existing conditions.

The cold weather rainfall is always the result of a local fall of the barometer, the formation of a barometric depression, which generally appears first in the Punjab or Western Rajputana, and then moves eastwards. Towards and around this depression the winds blow cyclonically (*i.e.* against the direction of the clock-hands), and the winds from the south, coming up charged with vapour which they have collected from the warmer land surface of the peninsula and sometimes from the sea, discharge this as rain chiefly to the east and north of the barometric minimum, where they form an ascending current.

Thus in the cold weather, rain generally begins in the Punjab and later on extends to the North-Western Provinces, Behar, and sometimes to Bengal. As the disturbance travels eastwards, it is followed up by a wave of high barometric pressure, and cool north-west winds, which usually last for a few days after the rain has cleared off.

The crucial point of the problem of the cold weather rains is, then, how to account for the formation of these occasional barometric depressions in a region where the barometer is generally high at this season. It has been suggested by one writer that they travel to us from the west across Afghanistan. This, however, can be only a guess in the dark, for, at the time it was made, there were no observatories to the west of India nearer than Bushire, at the top of the Persian Gulf. There is one now at Quetta, and I have examined the registers of this observatory to see if they give any support to the idea, and find that, with the exception of two doubtful instances, they do not. I conclude therefore that in most cases, if not in all, these disturbances originate in India, and their cause is to be sought for in the meteorological conditions of Northern India itself. In some instances they make their first appearance in Rajputana or Central India, and there can then be no question whatever of their purely local origin.

Now the region over which the winter rains are more or less regularly recurrent coincides with that in which the relative humidity of the air at this season, instead of diminishing towards the interior of the country, increases with the increasing distance from the coast. In any month between March and December, as we proceed from the coast of Bengal towards the Upper Provinces, the air becomes drier and drier, not only as containing an absolutely smaller quantity of water vapour, but also, in most months, in virtue of its increased capacity for taking up vapour, owing to its higher temperature. But from December to March the dryness increases inland only as far as Behar. Beyond this, although the quantity of vapour in the air remains very nearly the same or even undergoes a slight diminution, in virtue of the increasing cold there is an approach to that temperature at which this small quantity of vapour would begin to condense, forming cloud or fog; and it is in the Punjab that, in this sense, the air is most damp. The result is that which our registers show to be the case, viz. that from December to March it is also the most cloudy province. This seems to depend very much on the stillness of the air. The vapour that is always being given off from the earth's surface diffuses gradually upwards in the still atmosphere, and soon reaches such an elevation that it begins to condense as cloud. When once a moderately thick bank of cloud is thus formed, the equilibrium of the atmosphere is speedily disturbed. It is well known as a fact from Glaisher's balloon observations, and is also a consequence of the dynamic theory of heat, that the vertical decrease of temperature in a cloud-laden atmosphere is much slower (about one-third) than that in a clear atmosphere. This initial disturbance will suffice then to cause an indraught of air from around, an ascending current is set up, the barometer falls; warm, vapour-laden winds pour in from the south, and we have all the conditions of the winter rains.

If this view be just, the stillness of the atmosphere combined with the presence of a moderate evaporation must be accepted as the condition which primarily determines the formation of barometric minima and the winter rains of Northern India. And this stillness is obviously due to the existence of the lofty mountain ranges which surround Northern India, leaving free access to the plains open only to the south.

Were the Himalayan chain absent and replaced by an unbroken plain stretching up to the Gobi Desert, it is probable that the winter rains of Northern India would cease; any local evaporation in the Punjab and Gangetic valley would be swept away by strong, dry, north-east winds blowing from the seat of high pressure, which, in the winter months, lies in Central Asia, and instead of the mild weather and gentle breezes which now prevail at that season on the Arabian Sea, it would be the theatre of a boisterous and even stormy monsoon, such as is its local equivalent of the China Seas.

SCIENTIFIC SERIALS

Bulletin de l'Académie des Sciences de St. Pétersbourg, vol. xxix. No. 2.—On a new comet, by O. Struve. Its elements, calculated by Herr Seyboth, are:—T = 1884, January 23·225 average time of Pulkowa; $\pi = 92° 19' 39''$; ☊ $= 253° 22' 52''$; $i = 74° 21' 56''$; $\omega = 198° 56' 47''$; $q = 9·87922$. Dr. Struve considers it as identical with the comet of 1812, calculated by Encke, and adds a note, by Herm. Struve, about the sudden increase of its light on September 19 to 22.—A report on M. Backlund's memoir on the motion of the comet of Encke from 1871 to 1881, by O. Struve.—On petrified wood from Ryazan, by Prof. Mercklin; it is like *Cupressinoxylon erraticum*.—Observations on some propositions relative to the numerical function $E(x)$, by V. Bouniakovsky (third paper).—Remarks on Ginakîrti's "Kampakakathanâkaka," translated by A. Weber, by Otto Böhtlingk.—On the contact of inverse figures with the polar reciprocals of the directing figures, by J. S. and M. N. Vanecek.—Note on wollastonite, by N. Kokscharow.—Telephonic phenomena in the heart produced by the irritation of *nervus vagus*, by N. Wedenski.—On the use of the telephone for the measurement of temperature, by R. Lenz.—On terrestrial currents compared with magnetic variations, by H. Wild.—On the variability of the light of Y Cygni, by Ed. Lindemann. The observations were made in 1881 to 1883, and the magnitude varied from 6·8 to 10·4, showing an annual periodicity. The star changed its colour, as also its shape, becoming sometimes more nebulous, and the changes could scarcely be explained by mere conditions of observations.—Determination of the parallax of α Tauri, by Otto Struve. Its value, deduced from observations made in 1850 to 1857, is $0''·516$, with a probable error of $0''·057$.—On some arithmetical consequences of the formulæ for the theory of elliptical functions, by Ch. Hermite.—Note on the discovery of kalait in Russia, by N. Kokscharow.—Studies on milk (second and third papers), by Heinrich Struve; being a series of analyses of cows' and human milk, which bring the author to the conclusion that there are two kinds of caseine, the α-caseine and the β-caseine.—On the atmospheric waves produced by the Krakatoa eruption, by M. Rykatcheff.

Verhandlungen des Naturhistorischen Vereins der preussischen Rheinlande und Westfalens, fortieth year, 1883.—Contributions to the knowledge of the igneous rocks in the Carboniferous hills and New Red Conglomerates between the Saar and the Rhine, by H. Laspeyres.—On the trachyte of Hohenburg near Bonn, by the same author.—A study of the Devonian formations between the Roer and Vicht Rivers, by E. Holzappel.—Remarks on the loess of the Lahn Valley, by F. F. von Dücker.—Tertiary shingles of marine origin on the slate hills of Nassau and Ems, by the same author.—An account of some living American reptiles, spiders, and insects found at Uerdingen amongst the dye-woods imported for the Crefeld silk dyeworks, by F. Stollwerck.—Report on the prehistoric remains of the Sieg Valley, by Dr. M. Schenck.—On the development of the mining and smelting industries in the Sieg district, by H. Gerlach.—Remarks on some monstrosities and aberrations in the colour of the mammals of Westphalia, by Dr. H. Landois.—On the greenstone of the Upper Ruhr Valley and its association with the slates of the Lenne district, by A. Schenck, jun.—A description of some archæological remains from the Vlotho district, Weser Valley, by H. D'Oench.—A contribution to the study of the flora of the Rhenish Province, by M. Melsheimer.—A survey of the geological relations in the French Ardennes, by Prof. von

Lasaulx.—On the granites of the Watawa district, Bohemia, by Dr. J. Lehmann.—On the progress of electrical appliances, by H. Coerper.—Memoir on Anoplophora (*Uniona pohlig*), by Prof. von Koenen.—Obituary notice of Dr. Hermann Müller of Lippstadt, by Ernst Krause.—On the crystals of oxalate of lime present in the foliage and stem of *Iris florentina* (four illustrations), by Prof. von Lasaulx.—Remarks on a human skull and other human remains recently discovered in the loess of the Mosel near Metternich, by Prof. Schaffhausen.—Report of a geological excursion to the island of Corsica, by Prof. von Rath.—On the bacillus of tuberculosis and its presence in the human tissues, by Dr. H. Menche.—Remarks on some small crystals of leucite of unusual formation, by Prof. von Rath.—On ten small mammoth teeth from the Schipka Cave, Moravia (one illustration), by Prof. Schaffhausen.—On the action of bromide of aluminium on the dibromide of acetyl and on benzine, by Dr. Anschütz.—On a new synthesis of anthracene, by the same author.—Note on pyrites from the Gommern and Ploetzky sandstone, near Magdeburg, by Prof. von Lasaulx.—On the treatment of bites by venomous snakes, by Prof. Binz.—On a manganese and copper alloy, by H. Heusler.—Report of a scientific excursion in the island of Sardinia, by Prof. von Rath.—On the Tertiary formations of the Bonn district, by Dr. Pohlig.—On the naphtha and petroleum regions of Caucasia, by Dr. O. Schneider.—On the fossiliferous diluvium of the North German lowlands, by Dr. A. Remelé.—Microscopic examination of a series of Norwegian rocks from the Tromsoe district and the Lofoten Islands, by A. Philippson.—Effects of heat on the optical bearing of crystals, by W. Klein.—On the properties of racemic acid and of the inactive pyrotartaric acid of calcium, by Dr. Anschütz.—Geological and palæontological researches in the Bonn district, by Dr. Pohlig.—Microscopic examination of some specimens of volcanic matter from Krakatoa, by Prof. von Lasaulx.—Remarks on a new variety of glaukoppan from the island of Groix, on the west coast of Brittany, by the same author.

Rendiconti del R. Istituto Lombardo, May 29 and June 5.—Etruscan notes, by Prof. Elia Lattes.—Remarks on the laws affecting contract labour, by U. Gobbi.—On the colouring substances of putrefaction, and on some methods of discharging colours, by Dr. Paolo Pellacani.—On the supposed disposition to cretinism in patients operated on for affections of the parotid glands, by Dr. G. Fiorani.—A new determination of the latitude of the Brera Observatory, Milan, effected in the months of February and March of the present year, by L. Struve.—On a problem connected with the theory of stationary electric currents, by Prof. E. Beltrami.—On the nature of the colouring substance found in the urn of St. Ambrose, dating from the ninth century, by Prof. G. Carnellutti.—On the relation between the elasticity of some metallic wires and their electric conductibility, by Dr. G. Poloni.

SOCIETIES AND ACADEMIES

London

Geological Society, June 25.—Prof. T. G. Bonney, D.Sc., F.R.S., President, in the chair.—James Campbell Christie was elected a Fellow, and Baron C. von Ettingshausen, of Graz, a Foreign Correspondent of the Society.—The following communications were read:—Additional notes on the Jurassic rocks which underlie London, by Prof. John W. Judd, F.R.S. Since the reading of the former paper on the subject (February 6, 1884) the well-boring at Richmond has been carried to a depth of more than 1360 feet. The point reached is, reckoning from Ordnance-datum line, 220 feet lower than that attained by any other boring in the London basin. A temporary cessation of the work has permitted Mr. Collett Homersham to make a more exact determination of the underground temperature at Richmond. At a depth of 1337 feet from the surface this was found to be 75½° F., corresponding to a rise of temperature of 1° F. for every 52·43 feet of descent. The boring is still being carried on in the same red sandstones and "marls," exhibiting much false-bedding, which were described in the previous communication. The Rev. H. H. Winwood, of Bath, has had the good fortune to find the original fossils obtained by the late Mr. C. Moore from the oolitic limestone in the boring at Meux's Brewery in 1878. A careful study of these proves that, though less numerous and in a far less perfect state of preservation than the fossils from the Richmond well, they in many cases belong to the same species, and demonstrate the Great Oolite age of the strata in which they occur.—On some fossil Calcisponges from the well-boring at Richmond, Surrey, by Dr. G. J. Hinde, F.G.S.—On the Foraminifera and Ostracoda from the deep boring at Richmond, by Prof. T. Rupert Jones, F.R.S.—Polyzoa (Bryozoa) found in the boring at Richmond, Surrey, referred to by Prof. J. W. Judd, F.R.S., by G. R. Vine, communicated by Prof. Judd, F.R.S.—On a new species of *Conoceras* from the Llanvirn beds, Abereiddy, Pembrokeshire, by T. Roberts, B.A. Only five species of *Conoceras* have as yet been described; the author compared the Llanvirn species with these, and also with a fossil from the Devonian of Nassau, which Kayser referred to *Gomphoceras*, but which possesses several characters in common with *Conoceras*. The horizon from which this new species was obtained is that of the Llanvirn beds, some typical Llanvirn fossils having been found with it. The author named the species *Conoceras llanvirnensis*.—Fossil Cyclostomatous Bryozoa from Australia, by A. W. Waters, F.G.S. In the present paper the Cyclostomata from Curdies Creek, Mount Gambier, Bairnsdale, Muddy Creek, &c., Aldinga and River Murray Cliffs were described, bringing the total number of fossil Bryozoa from Australia, dealt with in this series of papers, up to 195, of which 85 are known living. Of the 32 Clyclostomata now dealt with, 12 at least are known living, and one cannot be distinguished from a Palæozoic form; 9 are apparently identical with European Cretaceous fossils. Although so many remind us of European Chalk and Miocene species, great stress was laid upon the imperfect data available for such comparisons, the Cyclostomata furnishing but few characters which are available for classification, which, so far, has, almost entirely been based upon the mode of growth, which, in the Chilostomata, has been shown to be of secondary value. In consequence of the few available characters, the Cyclostomata do not seem likely to be ever as useful palæontologically as the Chilostomata, and as they are less highly differentiated, it is not surprising to find that they are more persistent through various periods. In order to see how far other characters might be available, the author has examined Cyclostomata, both recent and fossil, from many localities and strata, and pointed out that the size of the zoœcia should always be noticed, as also the position of the closure of this tube. The arrangement of the interzoœcial pores may frequently give great assistance, and these are considered the equivalents of the rosette-plates; but the most useful character of all is no doubt the ovicell, which varies specifically in position and structure; but this unfortunately occurs on but few specimens, and has rarely been described fossil, although greater attention to this will no doubt lead to its being frequently found and noticed.—Observations on certain Tertiary formations at the south base of the Alps, in North Italy, by Lieut.-Col. H. H. Godwin-Austen, F.R.S.—On the geological position of the Weka-Pass stone, by Capt. F. W. Hutton, F.G.S. The beds described in this paper are of older-Tertiary and newer Secondary age, and occur in the northern part of Ashley county, in the province of Canterbury, between the Hurinui and Waipara Rivers. All of the beds are met with at Weka Pass, on the railway and road between Christchurch and Nelson, and the following is the section in descending order:—(1) Mount-Brown beds; pale yellowish sandstone with bands of shells and coral limestone, considered by all New Zealand geologists upper Eocene or Oligocene; (2) gray sandy marl; (3) Weka-Pass stone, yellowish with arenaceous limestone, usually with small green grains; (4) Amori limestone, white, flaggy, and argillaceous; (5) green sandstone with remains of marine Saurians. The last rests conformably on beds of coal and shale, with leaves of dicotyledonous Angiosperms, forming the base of the Waipara system. To this system Nos. 4 and 5 of the above section have also been referred by Dr. von Haast and the writer. The upper beds are the Oamara system of the same authors. The question to be decided is the limit between the two. The green sandstone (No. 5) and the coal shales are generally admitted to be Cretaceous. The geographical distribution of the beds enumerated was briefly described, the gray sandy marl (No. 1), the Amori limestone (No. 4), and the green sandstone having a northerly extension to Cook's Straits, whilst the other beds have been traced to the south only. An examination of the stratigraphical evidence shows that at Weka Pass, and also on the Waipara, the Weka-Pass stone rests on a water-worn surface of the Amori limestone, and near the Pass the former overlaps the latter. The gray marl (No. 2) is evidently unconformable to the lower beds of the Waipara system, whilst at Waipara and Weka Pass it passes down conformably into the Weka-Pass stone. The gray marl also passes up conformably into the Mount-Brown beds. The author concludes that the break in succession is between the Weka-Pass stone and the Amori limestone. The geological evidence is in accordance with the palæontological data. The fossils hitherto found in the Weka-Pass stone (*Voluta elongata*, *Scalaria rotundata*, *Struthiolaria senex*, *Pecten hochstetteri*, *Meomi crawfurdi*, *Schizaster rotundatus*, and *Flabellum circulare*) are found in other parts of New Zealand in Upper Eocene beds. None of them are known from the Cretaceous Waipara system. The fossils from the gray marl are also in some cases identical with those found in the Mount-Brown beds. The author concluded by giving reasons for not agreeing with Dr. Hector, who classes all the beds mentioned as belonging to one system of Cretaceo-Tertiary age.—On the chemical and microscopical characters of the Whin Sill, by J. J. H. Teall, F.G.S.—A critical and descriptive list of the Oolitic Madreporaria of the Boulonnais, by R. F. Tomes, F.G.S.—On the structure and affinities of the family Receptaculitidæ, including therein the genera *Ischadites*, Murch., (= *Tetragonis*, Eichw.), *Sphærospongia*, Pengelly, *Acanthochonia*, g.n., and *Receptaculites*, Defr., by Dr. G. J. Hinde, F.G.S.—On the Pliocene mammalian fauna of the Val d'Arno, by Dr. C. J. Forsyth Major, communicated by Prof. W. Boyd Dawkins, F.R.S., F.G.S.—Notes on the geology and mineralogy of Madagascar, by Dr. G. W. Parker., communicated by F. W. Rudler, F.G.S. This paper commenced with a sketch of the physical geography of the island of Madagascar. A central plateau from 4000 to 5000 feet high occupies about half the island, rising above the lowlands that skirt the coast, and from this plateau rise a number of volcanic cones, the highest, Ankaratra, being 8950 feet above the sea. With the exception of certain legends, there is no record of a period when the volcanoes were active: two such legends were given. The known volcanic cones were enumerated. They extend from the northern extremity of the island to the 20th parallel of south latitude. Beyond this, granite and other primitive rocks occur as far as lat. 22°, south of which the central parts of Madagascar are practically unknown to Europeans. Some crater-lakes and numerous hot and mineral springs occur. Earthquakes are occasionally felt in the island, most frequently in the months of September and October. The shocks are generally slight. Only a single trap-dyke is known near Antananarivo. The hills around this city are of varieties of granite (? granitoid gneiss). The general direction of the strata is parallel to the long axis of the island. Marine fossils have been found by Rev. J. Richardson and Mons. Grandidier in the south-west part of the central plateau. These fossils are referred by the last-named traveller to the Jurassic system. Remains of *Hippopotami*, gigantic tortoises, and an extinct ostrich-like bird have also been recorded. North and north-west of the fossiliferous rocks, between them and the volcanic district of Ankaratra, sandstone and slate occur. North of this volcanic district again is a tract of country in which silver-lead (mixed with zinc) and copper are found. Near the north-western edge of the central plateau are granitic escarpments facing northwards and about 500 feet high. Some details were also given of valleys through the central plateau, and of lagoons within the coral-reefs on the coasts. To these remarks succeeded some details of the physical features exhibited by the province of Imerina as seen from Antananarivo.—Notes on some Cretaceous Lichenoporidæ, by G. R. Vine, communicated by Prof. P. Martin Duncan, F.R.S.

Edinburgh

Royal Society, July 7.—Robert Gray, Vice-President, in the chair.—Prof. James Thomson gave a geometrical solution of the problem: Given a number of points moving Galilei-wise, from their relative positions to determine a reference-frame such that the motions relatively to it may satisfy the condition.—Prof. Tait gave a quaternion solution of the same problem.—Prof. Geikie read a paper on the occurrence of drifted trees in beds of sand and gravel at Musselburgh.—Prof. Tait gave a solution of the problem: To determine the number of different ways in which a given number may be divided, no part being less than 2 or greater than one-half the given number.—Prof. C. Michie Smith gave a communication on the green sun and associated phenomena.—Mr. P. Geddes read the 5th part (psychological) of his paper on analysis of the principles of economics.

Sydney

Linnean Society of New South Wales, May 28.—Prof. W. J. Stephens, M.A., F.G.S., in the chair.—The following papers were read:—New Australian fishes in the Queensland Museum, by Charles W. De Vis, M.A. This, the first of a series of papers descriptive of rare and new fishes in the Queensland Museum, is confined to the *Percidæ* only. Twenty-three species are described and four new genera, viz. *Herops*, allied to *Priacanthus*; *Homodemus*, a fresh-water fish approaching *Dules*; *Auristhes*, of doubtful affinity; and *Hephestus*, a fresh-dusæ vegetable-feeding fish resembling *Lobotes*.—The Hydrome-water of Australia, part iii., by R. von Lendenfeld, Ph.D. The Australian Hydromedusæ are here described which belong to the author's family *Blastopolypidæ*. To the species described by former authors, which are enumerated with references, several new ones are added, some of which are of greater morphological interest, particularly *Diphosia symmetrica*, nov. sp., which produces perfectly bilateral symmetrical female Gonangia. The number of species is exceedingly great. As far as some of the sub-families of this group are concerned, no other shore is inhabited by anything like such a number and diversity of forms as ours.—On the geographical distribution of the Australian Medusæ, by R. von Lendenfeld, Ph.D. The distribution of the Medusæ, or at all events of the large Rhizostomes, is shown in this paper to be entirely controlled by the ocean currents. Consequently, where the currents are permanent the range of a species can only extend in one direction.—The digestion of sponges, ectodermal or entodermal?, by R. von Lendenfeld, Ph.D. The earlier experiments, which were made to ascertain where the digestive organ of the sponge is situated, showed such different results, that the author made a series of experiments on the subject two years ago in Melbourne, and was by the help of these enabled not only to show with a large degree of probability where and how the digestion was effected in the sponge which he experimented on, but he was also enabled by these experiments to find out the cause of the great difference in the results attained by former observers. The experiments were carried on with carmine powder mixed with the water of the aquarium in which the sponge was kept. The results the author arrived at were taken up by the recent authors on sponges at home; and the second part of the question, viz. to which embryonic layer the epithelia belonged which, according to the author's researches, absorbed the food, was extensively discussed. The present paper gives an abstract of this interesting discussion, and there are also a few additions to the author's former statements.—Remarks on the coincidence of the eruption in the Straits Settlements and the red sunsets, by R. von Lendenfeld, Ph.D.

Paris

Academy of Sciences, July 15.—M. Rolland, President, in the chair.—On Newton's rule for finding the number of imaginary roots in numerical algebraic equations, by M. de Jonquières.—On the equation in matrices $px = xq$, by Prof. Sylvester.—Second memoir on the treatment of wheaten flour, by M. Balland.—Observations of the solar protuberances made at the Royal Observatory of the Collegio Romano during the year 1883, by M. P. Tacchini.—On a lunar halo observed at Rome on the night of July 4, by M. P. Tacchini.—On a theorem in mathematical analysis of M. Fuchs, by M. H. Poincaré.—On the electrical conductivity of distilled water and of ice, by M. G. Foussereau. The author infers that under certain conditions the observation of electric resistance may supply a delicate means of testing the purity of water, and determining the slow chemical phenomena produced in liquids.—On the purification of methylic alcohol, by MM. J. Regnauld and Villejean.—Account of a deposit of saltpetre in the neighbourhood of Cochabamba, Bolivia, by M. Sacc. An analysis of this vast deposit, which is large enough to supply the whole of the world with nitrate of potash, yields the following results:—

Nitrate of potash	60·70
Borax, with traces of salt and water	30·70
Organic substances	8·60
	100·00

The author concludes that the saltpetre is the result of the decomposition of an enormous deposit of fossil animal remains.—On the action of coffee on the composition of the blood and the digestive functions, by MM. Couty, Guimaraes, and Niobey. From their experiments the authors conclude that coffee acts beneficially in stimulating the consumption and digestion of the nitrogenous elements in the food.—Note on the perception of the successive chromatic differences on luminous surfaces, by M. Aug. Charpentier.—Note on the topographic distribution of the secondary processes of decay following on destructive lesions of the cerebral hemispheres in man and some other animals, by M. A. Pitres.—Report on the chief results of the Finnish Polar Expedition of 1883-84, by M. Selim Lemström.

BERLIN

Physical Society, June 13.—Prof. Lampe spoke on the subject of a hypothesis respecting the formation of the solar system set up by M. Faye in place of Laplace's hypothesis. According to M. Faye's theory, in the original uniform nebular mass, vortices were formed which gave rise to the existence, first of the middle planets, and then, ultimately, of the outer planets. This hypothesis was advanced as an explanation of the fact that the moons of Uranus and Neptune revolved in a direction opposite to that of the sun, the planets, and the other moons, a fact which was not accounted for by Laplace's theory. Only a brief communication, however, had yet been published of M. Faye's hypothesis, which, too, appeared to betray a number of lacunæ. —Dr. König called attention to the investigations that had hitherto been prosecuted on the subject of complementary colours, that is of those pairs of homogeneous spectral colours which, being blended together, produced a white appearance. Regarding the number of such pairs contained in the spectrum there had in all been three distinct experiments made—one by Herr von Helmholtz about the beginning of the '50's, another by Herr Schelske, and a third by Herren von Kries and von Frey. Having described the methods which had been followed in these different experiments, Dr. König proceeded to the results that had been severally arrived at, dismissing, however, without further consideration those attained by Herr Schelske as being all too defective in precision. Herr von Helmholtz had found in the spectrum seven pairs of complementary colours for his eye, Herr von Kries thirteen, and Herr von Frey, who had made use of the same apparatus as that adopted by Herr von Kries, likewise thirteen. The results represented in an arbitrary scale by the two last observers Herr König had converted into undulatory lengths, and, as in the case also of the results attained by Herr von Helmholtz, had exhibited them graphically. By drawing up the undulatory lengths of one spectrum as abscissæ, and those of the other as ordinates, he obtained for the complementary colours of the three observers certain points which, being connected together, yielded a curve of the complementary colours. While now the complementary colours were peculiar for each eye, the three curves of the complementary colours were, on the other hand, very approximate and similar to each other. Herr König then brought forward a few more considerations on complementary colours for monochromatic, bichromatic, trichromatic, and tetrachromatic eyes, demonstrating how, in the case of monochromatic eyes, there could be no question whatever of complementary colours. In the case of bichromatic eyes, on the other hand—eyes, that is, distinguishing only two ground colours, "colour-blind" eyes, as they were usually denominated—the complementary colours on their graphic representation formed quadratic surfaces lying outwardly from the neutral point. In the case of trichromatic eyes, again, they formed two curves, as was deduced from the observations, while, finally, in the case of the tetrachromatic eye, the complementary colours likewise formed curves, the curves marking the perception of the separate ground colours ranging over the whole spectrum. If, however, this last phenomenon was wanting, then complementary colours appeared only when the sectional point of the first and second curve corresponded with a shorter undulatory length than the region of the fourth curve, and the sectional point of the third and fourth curve corresponded with a longer undulation than the end of the first curve. If this condition were not fulfilled, complementary colours could not appear, a fact which would seem to militate against the possibility of a tetrachromism, that is of the existence of four ground colours.

Physiological Society, July 4.—Prof. Munk spoke on the extirpation of the cerebrum in rabbits. After a short historical survey of Prof. Christiani's and his own publications on the functions of the cerebrum, the speaker summed up the difference between his results and those of Prof. Christiani in the statement that in his most successful experiments, after removing the cerebrum, he observed in rabbits, just as in other vertebrates, birds and frogs, a state of depression lasting for a longer or shorter period, to as long as several hours, a state in which they lay apathetically, taking and keeping whatever position might be imposed on them. From this state they recovered to go through, first of all, interrupted and apparently spontaneous movements, which yet, however, on closer inspection proved to be reflex movements. These, again, were followed by a quickened reflex excitability, which finally was succeeded by compulsory movements, a kind of running stage, which, twenty-four to fifty hours after the operation, issued in the death of the animal. Prof. Christiani, on the other hand, after removing the cerebrum, in no case observed a state of depression such as that above referred to, but his excerebrated rabbits all acted like normal ones: they moved about, sprang, ran, &c., during the first twelve hours at least after the operation, which he exclusively observed. Prof. Munk then scrutinised the methods of the operation, pointing out certain minute differences between them, which he subsequently turned to account in explaining how the results deviated so widely from each other. These differences in the execution of the same operation consisted in the fact that he (Prof. Munk) made the section at a somewhat further distance (from about 1 to 2 mm.) from the optic thalami than did Prof. Christiani, and that he had made use of a knife while Prof. Christiani used the handle of a knife to separate the crus cerebri. In explanation of the phenomena observed, Prof. Munk, by means of sections and searching examinations of the brains operated on, established that the depression which at first ensued was the direct effect of the removal of the cerebrum, and that the succeeding reflex irritability and compulsory movements, the latter of which lasted till death, were due to an inflammation which extended from the surface of the incision to the cerebral ganglia, and, quite in accordance with the occurrence of the running stage, appeared sooner or later, progressed with more or less rapidity, and ultimately caused death. Prof. Christiani in his experiments did not observe the first stage, that of the exhaustion of the animal, which resulted from the extirpation of the cerebrum, but only the second or running stage following immediately on the operation, because in his procedure the severer irritation of the surface of the incision, together with the bleeding, led at once to inflammation of the cerebral ganglia, that in the case of Prof. Christiani's experiments lay so much nearer the surface of the incision.—Prof. Christiani in replying to Prof. Munk's address, rebutted the latter's interpretation, maintained in all points the validity of the results he had arrived at, and referred to a more complete publication, which was shortly to appear, in which he would prove his assertions, as well as refute the objections that had been raised.

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