he will also be appointed to the rank of full surgeon to the hospital. Two vacancies will therefore occur, that of assistant-surgeon to the hospital, and demonstrator of anatomy.

WE learn from *Van Nostrand's Eclectic Engineering Magazine* (New York) that the Darien Canal project is reviving. The United States steamer *Nipsic*, attached to the South Atlantic squadron, is under orders to proceed to the Isthmus of Darien to make surveys and explorations, with a view to determine the best location for an inter-oceanic canal. A similar survey on the Pacific shore of the Isthmus will be made at a future day.

M. FAVRE has recently detected evidences of the glacial period in the Caucasus, and M. Ed. Collomb finds traces, in the form of moraines and erratic blocks, of its having existed with great severity in the central plateau of France. This plateau forms an almost circular geological island 300 kilometres in diameter; its altitude increases progressively from north to south, and it is terminated on the south and west side by a barrier, the highest points of which, the Mézenc, the Plomb du Cantal, and the Mont d'Or rise to a height of from 1,750 to 1,900 metres (5,700 to 6,200 feet), above the level of the sea.

THE sense of taste has rarely been submitted to scientific examination, or at all events has attracted far less attention than its sister senses of sight and hearing, perhaps on account of the impossibility of treating it mathematically. That it differs to a remarkable extent in different individuals is, however, as every culinary artist would acknowledge, a matter of fact; and it is also well known that it is capable of extraordinary cultivation in some men, as shown by wine- and tea-tasters obtaining lucrative posts from the delicacy of their discrimination. Recently Dr. Keppler has published a paper in Pflüger's "Archives of Physiology," in which he gives the details of a number of experiments he performed with a view of determining the limits of gustatory discrimination for sapid substances in various degrees of concentration. In these experiments he first made a standard solution, and then successively employed weaker or stronger solutions, which were tasted with due precautions, sometimes before and sometimes after the standard solution, until no perception of flavour was distinguished. The substances he selected were common salt, quinine, phosphoric acid, and glycerine, all of them, be it observed, destitute of odour, which plays so important a part, often overlooked, in our ideas of the flavour of particular objects. In one series of experiments the solutions were taken freely into the mouth, rolled over all parts of the membrane lining it, and then discharged. In a second series the solutions, were more carefully applied to the surface of the tongue alone by means of a camel's hair brush. It was found in both cases that when a difference of 2·5 per cent. existed between the standard solution and the experimental one, the observers were able to form a correct judgment on the point that there *was* a difference in 53 per cent. of the trials, but when there was a difference between the two solutions amounting to 10 per cent., the answers were rightly given in 80 per cent. of all the trials. A more correct judgment was given when the standard solution was tasted before than after the experimental one with common salt and quinine, and the acuteness in the perception of a difference was greater when the trial solution was stronger than when weaker, but the opposite held good for the other substances.

WE learn from the *Gardener's Chronicle* that the Royal Horticultural Society has decided to retain a portion of the old Chiswick garden, comprising the ground occupied by the glass-houses, and extending sufficiently eastwards and southwards to include the large vinery and the fruit-room.

M. DUCLAUX has lately been experimenting on the effect of certain gases in retarding the incubation of silkworms' eggs. He has also been trying the effect of cold upon the same organisms, and finds that instead of retarding the period of incubation, it accelerated it: in fact, that eggs laid in autumn and left to themselves would only incubate in spring; but if subjected to the action of a freezing mixture for forty days, they would hatch into larvæ immediately afterwards, on being submitted to the action of a gentle heat. If these experiments are confirmed, M. Duclaux will have undoubtedly discovered an entirely new principle in physiology: that cold has a vivifying influence. Hitherto physiologists have always believed that its action was diametrically opposite.

THE journal of the Proceedings of the Asiatic Society of Bengal for January has an interesting article by Dr. F. Skoliczka on the Kjökenmöddings of the Andaman Islands.

THE *Journal of the Scottish Meteorological Society* has some interesting papers on the cold of last summer in Ireland, and upon the thunderstorms of Scotland. The part also contains a report on the Meteorology of Scotland and a minute of the meeting of the Council.

THE *American Gas Light Journal* reports that at a recent meeting of the Lyceum of Natural History of New York, Mr. Loew stated that ozone is produced copiously by blowing a strong current of air into the flame of a Bunsen's burner. He also communicated that he had observed the decomposition of sulphurous acid with production of sulphuric acid and deposition of sulphur, when an aqueous solution of the gas was exposed for two months to sunlight.

THE hardness of metals may now be ascertained by the aid of an instrument invented by a French engineer. It consists of a drill turned by a machine of a certain and uniform strength. The instrument indicates the number of revolutions made by the drill. From this, compared with the length of the bore-hole produced, the hardness of the metal is estimated. It is said that a great proportion of the rails now employed in France are tested by this instrument.

ON THE TEMPERATURE AND ANIMAL LIFE OF THE DEEP SEA*

III.

AN enormous addition has been made to the list of British *Echinodermata* by the discovery in our own seas of a number of species which had been previously known only as Norwegian or Arctic; and these often occurred in extraordinary abundance. One of the most interesting of these was the large and beautiful feather-star, the *Antedon* (*Comatula*) *Eschrichtii*, hitherto known only as inhabiting the shores of Greenland and Iceland, but now found over all parts of our cold area. On the other hand, the influence of temperature was marked not only by the absence of many of the characteristically southern types of this group, but by the dwarfing of others to such an extent that the dwarfed specimens might be regarded as specifically distinct, if it were not for their precise conformity in structure to those of the ordinary type. Thus the *Solaster papposa* was reduced from a diameter of six inches to two, and had never more than ten rays, instead of from twelve to fifteen; and *Asterocanthion violaceus* and *Cribella oculata* were reduced in like proportion. But, in addition, several echinoderms have been obtained which are altogether new to science, most of them of very considerable interest. The discovery, at the depth of 2,435 fathoms, of a living crinoid of the Apiocrinite type, closely allied to the little rhizocrinus (the discovery of which by the Norwegian naturalists was the starting-point of our own deep-sea explorations), but generically differing from it, cannot but be accounted a phenomenon of the greatest interest alike to the zoologist and the palæontologist. Another remarkable representative of a type supposed to have become extinct, occurred at depths of 440 and 550 fathoms in the warm area; being a large *echinidan* of the *diadema* kind, the "test" of which is composed of plates separated from one another by membrane, instead of being connected by suture, so as to resemble an armour of flexible chain-mail, instead of the inflexible cuirass with which the

* A Lecture delivered at the Royal Institution (continued from p. 540).

ordinary echinida are invested. This type bears a strong resemblance to the very singular fossil from the white chalk, described by the late Dr. S. P. Woodward, under the name of *Echinothuria floris*. Specimens were also obtained, both in the first and third cruises, of a most interesting *clypeastroid*, which is closely allied to the *infulaster*—specially characteristic of the later chalk.* These constitute only a sample of the interesting novelties belonging to this group, which our explorations brought to light.

Besides further additions to the remarkable group of vitreous sponges, which were made in the area over which the Globigerina-mud extends, a peculiar and novel form of sponge was found to be one of the most generally diffused inhabitants of the cold area. This sponge is distinguished by the possession of a firm branching axis, of a pale sea-green colour, rising from a spreading root, and extending itself like a shrub or a large branching gorgonia. The axis is loaded with siliceous spicules; and spicules of the same form are contained in the soft flesh which clothes it.

The foraminifera collected in the *Porcupine* expedition present features of no less interest, though their scale is so much smaller. The enormous mass of Globigerina-mud (sometimes almost pure, sometimes mixed with sand) that everywhere covers the deep-sea bottom in the region explored, save where its temperature is reduced nearly to the freezing-point, may be judged of from the fact that in one instance the dredge brought up half-a-ton of it from a depth of 767 fathoms. The resemblance of this deposit to chalk is greatly strengthened by the recognition of several characteristically cretaceous types among the foraminifera scattered through the mass of *Globigerinæ* of which it is principally composed; as also of the *Xanthidia*, frequently preserved in flints. Not many absolute novelties presented themselves among the foraminifera that form true calcareous shells; the chief point of interest being the occurrence of certain types of high organisation at great depths, and their attainment of a size that is only paralleled in much warmer latitudes, or in the Tertiary or yet older formations. This is especially the case with the Cristellarian group, which has a long geological range; and also with the Milioline, of which specimens of unprecedented size presented themselves. The most interesting novelty was a beautiful Orbitolite, which, when complete, must have had the diameter of a sixpence, but which, from its extreme tenuity, always broke in the process of collection. Of Arenaceous Foraminifera, however, which construct tests by cementing together sand-grains, instead of producing shells, the number of new types is such as seriously to task our power of inventing appropriate generic names. Many of these types have a remarkable resemblance to forms previously known in the chalk, the nature of which had not been recognsied. Some of them throw an important light on the structure of two gigantic Arenaceous types from the upper greensand, recently described by the speaker and Mr. H. B. Brady, an account of which will appear in the forthcoming part of the "Philosophical Transactions;" and there is one which can be certainly identified with a form lately discovered by Mr. H. B. Brady in a clay-bed of the carboniferous limestone.

The question now arises, whether—as there must have been deep seas in all geological periods, and as the changes which modified the climate and depth of the sea-bottom were for the most part very gradual—we may not carry back the continuity of the accumulation of Globigerina-mud on some part or other of the ocean bed into geological epochs still more remote; and whether it has not had the same large share in the production of the earlier calcareous deposits, that it has undoubtedly had in that of the later. The foraminiferal origin of certain beds of the carboniferous limestone, for example, appears to be indicated by the presence of *Globigerinæ*, long since observed by Professor Phillips in sections of them, as well as by the fact just stated. The subcrystalline character of these rocks cannot be regarded as in any way antagonistic to such an idea of their origin, since it is perfectly well known that all traces of the organic origin of calcareous rocks may be completely removed by subsequent metamorphism, —as in the chalk of the Antrim coast.

What is the source of nutriment for the vast mass of animal life covering the abyssal sea-bed, is a question of the greatest biological interest. That animals have no power of themselves generating the organic compounds which serve as the materials of their bodies—and that the production of these materials from the carbonic acid, water, and ammonia of the inorganic world, under the influence of light, is the special attribute of vegetation —is a doctrine so generally accepted, that to call it in question would be esteemed a physiological heresy. There is no difficulty in accounting for the alimentation of the higher animal types, with such an unlimited supply of food as is afforded by the *Globigerinæ* and the sponges in the midst of which they live, and on which many of them are known to feed. Given the Protozoa, everything else is explicable. But the question returns,—on what do these Protozoa live?

The hypothesis has been advanced that the food of the abyssal Protozoa is derived from diatoms and other forms of minute plants, which, ordinarily living at or near the surface, may, by subsiding to the depths, carry down to the animals of the sea-bed the supplies they require. Our examination of the surface-waters, however, has afforded no evidence of the existence of such mycrophytic vegetation in quantity at all sufficient to supply the vast demand; and the most careful search in the Globigerina-mud has failed to bring to light more than a very small number of specimens of these siliceous envelopes of Diatoms, which would most assuredly have revealed themselves in abundance, had these Protophytes served as a principal component of the food of the Protozoa that have their dwelling-place on the sea-bed. Another hypothesis has been suggested, that these Protozoa which are so near the border of the vegetable kingdom, may be able, like plants, to generate organic compounds for themselves, manufacturing their own food, so to speak, from inorganic materials. But it is scarcely conceivable that they could do this without the agency of light; and as it is obviously the want of that agency which excludes the possibility of vegetation in the abysses of the ocean, the same deficiency would prevent animals from carrying on the like process.

A possible solution of this difficulty, offered by Professor Wyville Thomson in a lecture delivered last spring, has received so remarkable a confirmation from the researches made in the *Porcupine* expedition, that it may now be put forth with considerable confidence. It is, he remarked, the distinctive character of the Protozoa, that "they have no special organs of nutrition, but that they absorb water through the whole surface of their jelly-like bodies. Most of these animals secrete exquisitely-formed skeletons, sometimes of lime, sometimes of silica. There is no doubt that they extract both of these substances from the sea-water, although silica often exists there in quantity so small as to elude detection by chemical tests. All sea-water contains a certain amount of organic matter in solution. Its sources are obvious. All rivers contain a large quantity; every shore is surrounded by a fringe, which averages about a mile in width, of olive and red sea-weeds; in the middle of the Atlantic there is a marine meadow, the Sargosso Sea, extending over 3,000,000 of square miles; the sea is full of animals which are constantly dying and decaying; and the water of the Gulf Stream, especially, courses round coasts where the supply of organic matter is enormous. It is, therefore, quite intelligible that a world of animals should live in these dark abysses: but it is a necessary condition that they should chiefly belong to a class capable of being supported by absorption through the surface, of matter in solution; developing but little heat, and incurring a very small amount of waste by any manifestation of vital activity. According to this view, it seems highly probable that at all periods of the earth's history some form of the Protozoa—rhizopods, sponges, or both—predominated over all other forms of animal life in the depths of the sea; whether spreading, compact, and reef-like, as in the Laurentian and Palæozoic *Eozoon;* or in the form of myriads of separate organisms, as in the *Globigerinæ* and *Ventriculites* of the chalk."*

During each cruise of the *Porcupine*, samples of sea-water obtained from various depths, as well as from the surface, at stations far removed from land, were submitted to the Permanganate test, after the method of Prof. W. A. Miller, with an addition suggested by Dr. Angus Smith for the purpose of distinguishing the organic matter in a state of decomposition from that which is only decomposable; with the result of showing the uniform presence of an appreciable quantity of matter of the latter kind, which, not having passed into a state of decomposition, may be assimilable as food by animals, being, in fact, protoplasm in a state of extreme dilution. And the careful analyses of larger quantities collected during the third cruise, which have been since made by

* This was believed at the time to be an entirely new discovery; but since the return of the *Porcupine* we have learned that a type generically, if not specifically, the same, had been obtained by Count Pourtales during his most recent dredgings in the Gulf of Mexico, and had been described by Mr. Alex. Agassiz under the name *Pourtalesia miranda*.

* "The Depths of the Sea," a lecture delivered in the theatre of the Royal Dublin Society, April 10, 1869.

Dr. Frankland, have fully confirmed these results, by demonstrating the highly azotized character of this organic matter, which presents itself in samples of sea-water taken up at from 500 to 750 fathoms' depth, in such a proportion that its universal diffusion through the oceanic waters may be safely predicted.

Until, therefore, any other more probable hypothesis shall have been proposed, the sustenance of animal life on the ocean-bottom at any depth may be fairly accounted for on the supposition of Prof. Wyville Thomson, that the protozoic portion of that fauna is nourished by direct absorption from the dilute protoplasm diffused through the whole mass of oceanic waters, just as it draws from the same mass the mineral ingredients of the skeletons it forms. This diffused protoplasm, however, must be continually undergoing decomposition, and must be as continually renewed; and the source of that renewal must lie in the surface-life of plants and animals, by which (as pointed out by Prof. Wyville Thomson) fresh supplies of organic matter must be continually imparted to the oceanic waters, being carried down even to their greatest depths by that liquid diffusion which was so admirably investigated by the late Professor Graham.

Not only, however, has the nutrition of the abyssal fauna to be explained; its respiration also has to be accounted for; and on this process also the results of the analyses of the gases of the sea-water made during the *Porcupine* expedition throw very important light. Samples were collected not only at the surface, under a great variety of circumstances, but also from great depths; and the gases expelled by boiling were subjected to analysis according to the method of Prof. W. A. Miller—the adaptation of his apparatus to the exigencies of ship-board having been successfully accomplished during the first cruise bv Mr. W. L. Carpenter. The general average of thirty analyses of surface-water gives the following as the percentage proportions:—25·1 oxygen, 54·2 nitrogen, 20·7 carbonic acid. This proportion, however, was subject to great variations, as will be presently shown. As a general rule, the proportion of oxygen was found to diminish, and that of carbonic acid to increase, with the depth; the results of analyses of intermediate waters giving a percentage of 20·0 oxygen, 52·8 nitrogen, and 26·2 carbonic acid; whilst the results of analyses of bottom-waters gave 19·5 oxygen, 52·6 nitrogen, and 27·9 carbonic acid. But bottom-water at a comparatively small depth often contained as much carbonic acid and as little oxygen as intermediate water at much greater depths; and the proportion of carbonic acid to oxygen in bottom-water was found to bear a much closer relation to the abundance of animal life (especially of the more elevated types), as shown by the dredge, than to its depth. This was very strikingly shown in an instance in which analyses were made of the gases contained in samples of water collected at every fifty fathoms, from 400 fathoms to the bottom at 862 fathoms, the percentage results being as follows:—

	750 fath.	800 fath.	Bottom 862 fath.
Oxygen	18·8	17·8	17·2
Nitrogen	49·3	48·5	34·5
Carbonic Acid	31·9	33·7	48·3

The extraordinarily augmented percentage of carbonic acid in the stratum of water here immediately overlying the sea-bed was accompanied by a great abundance of animal life. On the other hand, the lowest percentage of carbonic acid found in bottom-water, viz. 7·9, was accompanied by a "very bad haul." In several cases in which the depths were nearly the same, the analyst ventured a prediction as to the abundance, or otherwise, of animal life, from the proportion of carbonic acid in the bottom-water; and his prediction proved in every instance correct.

It would appear, therefore, that the increase in the proportion of carbonic acid and the diminution in that of the oxygen, in the abyssal waters of the ocean, is due to the respiratory process, which is no less a necessary condition of the existence of animal life on the sea-bed, than is the presence of food-material for its sustenance. And it is further obvious that the continued consumption of oxygen and liberation of carbonic acid would soon render the stratum of water immediately above the bottom completely irrespirable—in the absence of any antagonistic process of vegetation—were it not for the upward diffusion of the carbonic acid through the intermediate waters to the surface, and the downward diffusion of oxygen from the surface to the depths below. A continual interchange will take place at the surface between the gases of the sea-water and those of the atmosphere; and thus the respiration of the abyssal fauna is provided for by a process of diffusion, which may have to operate through three miles or more of intervening water.

The varying proportions of carbonic acid and oxygen in the surface-waters are doubtless to be accounted for in part by the differences in the amount and character of the animal life existing beneath; but a comparison of the results of the analyses made during the agitation of the surface by wind, with those made in calm weather, showed so decided a reduction in the proportion of carbonic acid, with an increase in that of oxygen, under the former condition, as almost unequivocally to indicate that superficial disturbance of the sea by atmospheric movement is absolutely necessary for its purification from the noxious effects of animal decomposition. Of this view a most unexpected and remarkable confirmation has been afforded by the following circumstance:—In one of the analyses of surface-water made during the second cruise, the percentage of carbonic acid fell as low as 3·3, while that of oxygen rose as high as 37·1; and in a like analysis made during the third cruise, the percentage of carbonic acid was 5·6, while that of oxygen was 45·3. As the results of every other analysis of surface-water were in marked contrast to these, it became a question whether they should not be thrown out as erroneous; until it was recollected that, whilst the samples of surface-water had been generally taken from the bow of the vessel, they had been drawn in these two instances from abaft the paddles, and had thus been subjected to such a violent agitation in contact with the atmosphere, as would pre-eminently favour their thorough aëration.

Hence, then, it may be affirmed that every disturbance of the ocean-surface by atmospheric movement, from the gentlest ripple to the most tremendous storm-wave, contributes, in proportion to its amount, to the maintenance of animal life in its abyssal depths—doing, in fact, for the aëration of the fluids of their inhabitants, just what is done by the heaving and falling of the walls of our own chest for the aëration of the blood which courses through our lungs. A perpetual calm would be as fatal to their continued existence as the forcible stoppage of all respiratory movement would be to our own. And thus universal stagnation would become universal death.

Thus it has been shown that the bed of the deep sea, even in the immediate neighbourhood of our own shores, is an area of which the conditions have until lately been as completely unknown us those of the ice-bound regions of the poles, or of the densest forests, the most arid deserts, the most inaccessible mountain-summits, that lie between the tropics; and further, that by the systematic employment of the sounding-apparatus, the thermometer, and the dredge, almost as complete a knowledge can be gained of those conditions, as if the explorer could himself visit the abyssal depths he desires to examine. Of the important discoveries in almost every department of science, but more particularly in what Mr. Kingsley has well termed Bio-Geology, which may be anticipated from the continuation and extension of an inquiry of which the mere commencement has yielded such an abundant harvest, the speaker felt it scarcely possible to form too high an expectation. And, in conclusion, he referred to the systematic and energetic prosecution of deep-sea explorations by the United States Coast Survey and by the Swedish Government—the results of which prove to be singularly accordant with those now briefly expounded—as showing that other maritime powers are strongly interested in the subject; and expressed the earnest hope that the liberal assistance of Her Majesty's Government, which has already enabled British naturalists to obtain the lead in this inquiry, would be so continued as to enable them to keep it in the future. In particular, he called attention to the suggestion lately thrown out by M. Alex. Agassiz, that an arrangement might be made by our own Admiralty with the naval authorities of the United States, by which a thorough survey, physical and biological, of the North Atlantic should be divided between the two countries; so that British and American explorers, prosecuting in a spirit of generous rivalry labours most important to the science of the future, might meet and shake hands on the Mid-Ocean.

W. B. CARPENTER

NOTE.—Tables I. and II. on the following page give the Temperature of the Sea at different Depths—(I.) in the Channel between the North of Scotland, the Shetland Isles, and the Faroe Islands (the Roman Numericals indicate the *Lightning* Temperature-Soundings, corrected for pressure); and (II.) near the Western margin of the North Atlantic Basin, as ascertained by *Serial* and by *Bottom* Soundings.

TABLE I.

Warm Area. Series 87. Depth.	Series 87. Temperature.	Station No.	Depth.	Surface Temperature.	Bottom Temperature.	Cold Area. Series 64. Depth.	Series 64. Temperature.	Ser. 52. Temperature.	Station No.	Depth.	Surface Temperature.	Bottom Temperature.
f.h.	°		fths.	°	°	fths.	°	°		fths.	°	°
0	52·6					0	49·7	52·1				
50	48·1	73	84	52·7	48·8	50	45 5	48·5	70	66	53·4	45·2
		80	92	53·2	49·4				69	67	53·5	43·8
100	47·3					100	45·0	47·3	68	75	52·5	44·0
		71	103	53·0	48·6				61	114	50·4	45·0
		81	142	53·3	49·1				62	125	49 6	44·6
150	47·0	84	155	54·3	49·2	150	43·3	46·5	60	167	49·5	44·3
		85	190	53·9	48·7				IX.	170	52·0	41·0
200	46·8					200	39·6	45·6				
		74	203	52·5	47·7							
						250	34·3	38·4				
300	46·6					300	32·4	30·8				
									63	317	49·0	30·3
									65	345	52·0	29·9
									76	344	50·3	29·7
		50	355	52·6	46·2	350	31·4	..	54	363	52·5	31·4
		46	374	53·9	46·0	384	..	30·6				
400	46·1					400	31·0	..	86	445	53·6	30·1
		89	445	53·1	45·6	450	30·6	..				
		90	458	53·1	45·2				56	480	52·6	30·7
		49	475	53·6	45·4				53	490	52·1	30·0
500	45·1					500	30·1	..	X.	500	51·0	30·8
		VI.	530	52·5	44·8				58	540	51·5	30·8
·		47	542	54·0	43·8				VIII.	550	53·0	29·8
		XV.	570	52·0	43·5	550	30·1	..	77	560	50·9	29·8
									59	580	52·7	29·7
600	43·0					600	29·9	..				
		XVII	620	52·0	43·5				55	605	52·6	29·8
·		XIV.	650	53·0	42·5				57	632	52·0	30·5
						640	29·6	..				
700												
		88	705	53·5	42·7							
767	41·4											

TABLE II.

Serial Soundings. Depth.	Temperature. Ser. 23.	Temperature. Ser. 42.	Temperature. Ser. 22.	Temperature. Ser. 19.	Temperature. Ser. 20.	Temperature. Ser. 21.	Temperature. Ser. 38.	Bottom Soundings. Statn. No.	Depth.	Surface Temperature.	Bottom Temperature.
fths.	°	°	°	°	°	°	°		faths.	°	°
0	57·3	62·6	56·9	54·8	55·5	56·2	64·0				
50	..	53·2						27	54	55·6	48·3
								34	75	66·0	49·7
								6	90	54·0	50·0
								35	96	63·4	51·3
100	48·5	51·1						8	106	54·2	51·2
								24	109	57·7	46·5
150	..	50·9						7	159	53·2	50·4
								14	173	53·2	49 6
								18	183	53·2	49·4
200	48·0	50·5						13	208	53·6	49·6
250	..	50·2	48·5	48·0	48·5	48·3	50·5	4	251	53·5	49·5
300	47 8	49·6									
350	..	49·1						1	370	54·0	49·0
400	47·5	48·5									
450	..	47·6						15	422	52·2	47·0
								45	458	60·7	48·1
500	45·8	47·4	46·7	46·7	46·9	47·5	47·8				
								40	517	63·4	47·7
550	..	46·4									
600	44·5	45·5						41	584	63·4	46·5
630	43·4										
650	..	44·3									
700	..	43·6						12	670	52·2	42·6
								3	723	54·5	43·0
								36	725	63·9	43·9
750	..	42·5	42·0	41·2	41·6	42·4	41·3				
800	..	42·0									
								2	808	54·1	41·4
862	..	39·7						16	816	53·0	39·5
900								44	865	61·2	39·4
1000	..	..	38·8	38·5	38·8	38·5	38·3				
1200								43	1207	61·7	37·7
1263	..	..	37·3								
								28	1215	57·7	37·1
1250	..	..	..	..	37·7	37·9	37·7	17	1230	53·2	37·8
1300								29	1264	56·9	36·9
1360	..	..	..	37·4							
1400											
1443	..	..	..	..	37·0			32	1320	55·9	37·4
1450								30	1380	56·0	37·1
1476	..	..	..	..	..	36·9					
1500	..	..	..	..	..	..	37·2				
1750	..	..	..	..	..	..	36·7				
2090	..	..	..	..	..	..	36·3	37	2435	65·6	36·5

PHYSICS

Mechanical Theory of Heat

WE translate the following passages from a paper by Dr. Meyer, of Heilbronn :—

It has been inferred from the meteorite theory, which supposes the sun to derive its heat from the impact of planeto-kosmic masses, that the entire machine of creation must eventually come to a standstill. I gladly seize the opportunity which now offers itself, to state that I do not share this view. The doctrine of the development of heat by the collision of spatially separate masses, has but just arisen, has therefore advanced but little, and cannot yet serve as an appropriate foundation for so comprehensive a consequence. I will briefly state what may be said, from my own point of view, as to the stability of the universe. Its final cessation will occur, when all the ponderable matter it contains is combined in a single mass; whereupon, as we may readily perceive, the whole of its existing *vis viva* would be uniformly distributed in the form of heat throughout the mass, which would thus attain an eternal equilibrium.

But how could such a combination happen? Five years have passed since Brayley, of London (and Reuschle just recently in a number of the German quarterly journal), stated, that if masses of the magnitude of our sun, or only half as great, were to come into collision, so enormous would be the effect, that all cohesion would be at an end, and the molecules would fly off into infinite space. Now we have every reason to suppose that, in the ceaseless course of time, and in an unlimited expanse, this kind of destruction or partial ruin of worlds has taken place, and is actually in progress. We have a striking proof of it in the observation of meteorites with a hyperbolic path. On this point I would refer to the important memoir of Prof. Heis, of Münster. "The large fire-ball which was seen on the evening of March 4, 1863, in Holland, Germany, Belgium, and England (Halle, 1863)." The true heliocentric motion of this meteorite amounted to 9.145 geographical miles per second. A body lying between the earth's orbit and the sun, and owing its motion solely to the attraction of the latter, cannot have a greater rate than 5·8 geographical miles; so that the fire-ball above referred to must have entered the sphere of attraction of our sun with an initial velocity of 7 geographical miles per second. Now, whence could it have derived such a motion?

In order to throw light on this question, we might imagine a peculiar progressive movement of the whole solar system in space, or have recourse to a movement round a so-called central sun. But we cannot suppose any such accumulation exists sufficiently large to confer an appreciable velocity on our sun at the distance of the fixed stars. Moreover, if our earth possessed a distant motion towards space in addition to its centripetal motion towards the sun, the light which reaches it from the fixed stars would present phenomena of aberration different from those actually observed. Were this proved, meteors with a hyperbolic path would be so many fiery couriers, living witnesses of a conflict somewhere and sometime happening in strength sufficient to explode and scatter the molecules in every direction. If we also consider that the radiating power of the sun's body, as of all the fixed stars, is connected with the consumption of collided masses, yet that consumption has not therefore ceased, since throughout the disturbance, large masses of debris continually reach our world.

All the phenomena of terrestrial motion, except volcanic action and the ebb and flow of the tides, are eventually derived from the sun. One of these, which we are about to consider more particularly, is an electric current on the surface of the earth. That it actually exists is evident from the direction of the magnetic needle, as also from the immediate observations of Lamont. But as there can be no action without corresponding cause, it follows that this remarkable expenditure of electric effort must be attended with as large a compensation. We have, then, to consider our earth as being, in this respect, a huge and permanently efficient electric machine. I do not here refer to the local phenomenon of thunderstorms.

For a constant source of the constant disturbance of electrical equilibrium in the earth's body, we can only have recourse to the unceasing flow of air between the tropics, known under the name of the trade-winds. The lowest layer of the trade-wind assumes, by friction on the surface of the sea, an opposite electrical condition. This air, however, heated by the sun, and dislodged by the colder current setting beneath it, rises and directs its course to the poles, where its high electric tension originates the beautiful phenomenon of the aurora. It must now be observed that, on account of the physical condition of the earth's surface, the electromotor activity of the southern hemisphere must be throughout much stronger than in the northern; whence it happens, that not only on both hemispheres between pole and equator, but also between the north and south poles themselves, a continual disturbance of electric equilibrium occurs; and it is this by which the direction of the needle is determined. The narrow belt between the north and south-east trades—called by Dove the zone of calms—may be termed, for present purposes, the meteorological equator. This is known not to coincide with the geographical equator, but to oscillate slowly about a limit of 1 to $1\frac{1}{2}$ degrees north of it. The *experimentum crucis* for the theory—or, as we will only term it at present the hypothesis—here adduced of the trade-winds as the source of terrestrial magnetism, would consist in establishing that the known alterations which the magnetic pole, as well as declination, gradually undergo, are accompanied by parallel changes of our magnetic equator. But work of this description cannot be accomplished by a single private individual, and I must content myself with having brought the subject forward.

Amagat on the law of Mariotte

PROFESSOR E. H. AMAGAT has published the results of some experiments, still in progress, on the influence of temperature on departures from the law of Mariotte. The researches of Regnault have shown that this law is not rigorously obeyed by any gas excepting hydrogen; in all other cases compressibility increases with pressure, that is, when the gas approaches its temperature of ebullition. This phenomenon has received various explanations. It has been considered as resulting from reciprocal molecular attraction; it has also been elucidated by a theory which was first enunciated by Daniel Bernouilli, but has received successive additions at the hands of Joule, Krœnig, and Clausius. The theory in question takes into account not only the movements of translation of molecules, but their rotatory and internal movements, as well as the possible movements of imponderable fluids. If we admit the first explanation, then, as attraction only depends on the mean distance of the molecules, the departure from the law in any single case must be the same at any temperature, provided the initial and final volumes are the same. In other words, let V be a given volume of gas at the temperature t and pressure p. Reduce this volume to V′ by a pressure p', the temperature remaining unchanged. On heating the gas to t, it will expand; let P be the pressure necessary to restore the volume to V, and P′ the corresponding pressure. If the departure be only a function of the volume, it is clear that we must have

$$\frac{pV}{p'V'} = \frac{PV}{P'V'}.$$

As $\frac{V}{V'}$ is common to both sides of this equation, it is only necessary to compare $\frac{p}{p'}$ with $\frac{P}{P'}$. The author has done this in the case of sulphur dioxide, ammonia, and carbon dioxide. In the instance of sulphur dioxide—

$$\left.\begin{array}{l}\text{at } 14^\circ,\ \frac{p}{p'} = 0{\cdot}50838 \\ \text{at } 98^\circ,\ \frac{P}{P'} = 0{\cdot}50277\end{array}\right\}\ \text{difference, } 0{\cdot}00561.$$

(This difference corresponds to an observed height of more than one centimetre of mercury.) For ammonia—

$$\left.\begin{array}{l}\text{at } 13^\circ,\ \frac{p}{p'} = 0{\cdot}50731 \\ \text{at } 97^\circ,\ \frac{P}{P'} = 0{\cdot}50402\end{array}\right\}\ \text{difference, } 0{\cdot}00329.$$

For carbonic dioxide—

$$\left.\begin{array}{l}\text{at } 13^\circ,\ \frac{p}{p'} = 0{\cdot}50981 \\ \text{at } 97^\circ,\ \frac{P}{P'} = 0{\cdot}50402^*\end{array}\right\}\ \text{difference, } 0{\cdot}00210.$$

It appears from the preceding numbers that the departure is not only a function of the volume, but also of the temperature at which the experiment is performed. This result agrees, however, with the second theory. In fact, the *vis viva* of the molecules being greater as the temperature rises, it may be readily conceived that the loss due to their collision is relatively smaller than the augmentation of pressure on the walls of the enclosing vessel, due to the augmentation of *vis viva*, this being true even when, as the rate is accelerated, the molecular collisions become more numerous.

* This number is obviously a misprint.

In a new series of experiments, M. Amagat kept the initial and final pressures as nearly as possible the same in each case, thus obtaining the influence of temperature alone. He then arrived at the following general results :—

1. That near 100°, sulphur dioxide and ammonia depart but little from Mariotte's law, yet more so than air at the ordinary temperature.
2. That near 100°, carbon dioxide is almost a perfect gas.
3. That near 100°, air exactly follows the law.

The author is convinced that the higher the temperature of liquefaction of a gas is found to be (under the same pressure), the less does it depart from the law of Mariotte at the same distance from its point of liquefaction. *—[Archives des Sciences physiques et naturelles, 139, p. 169.]

* With the above results compare those obtained by Andrews (Proceedings of the Royal Society, xviii. 42).

SOCIETIES AND ACADEMIES

LONDON

Linnean Society, March 17.—Mr. Carruthers exhibited a section of a fossil *Osmunda* from the eocene beds of Herne Bay, in which not only the forms of the cells were preserved, but the contents of the cells, and even the starch-granules. Before its conservation it had been attacked by a parasitic fungus, the mycelium of which is preserved, in precisely the same condition as it would be in a recent specimen.—Dr. Hooker read a further communication from Sir Henry Barkly on the Flora and Fauna of Round Island. The highest point of the island is 1,049 feet above the level of the sea; the summit is smooth, with three large and remarkable blocks of granite. It is entirely composed of tufa, mixed with volcanic sand in perfectly preserved strata. The deeper ravines are crowded with lofty palms. Of the twenty-six flowering plants gathered, the greater number belong to the orders *Gramineæ*, *Pandanaceæ*, *Palmaceæ*, *Ebenaceæ*, *Cinchonaceæ*, *Compositæ*, and *Asclepiadeæ*. The proportion of Endogens to Exogens is very large, namely, twelve to fourteen; but this proportion by no means represents the enormous preponderance of the former in individuals, probably amounting to 99 per cent. Some of the Exogens are specifically identical with those of the Mauritius, but few of the Endogens; those of the former class which are common to the two islands have probably been introduced at some remote period. Of the three cryptogamic plants observed, one was a moss, probably a *Sphagnum*, one a *Selaginella*, certainly a new species, and one a widely-spread fern, *Adiantum caudatum*. Of the five grasses the most abundant is identical with the Indian Lemon-grass. The *Cyperaceæ* are represented by one species, *Scirpus maritimus*. The *Pandanaceæ* are very remarkable; *Pandanus utilis* occurs, but in one spot only, rare, and no doubt introduced, whilst the other, an allied species (*P. Vandermeerckii*, is quite peculiar to the islet). Of Palms there are no less than three species, probably all peculiar, the most remarkable being the bottle-stemmed species (a *Hyophorbe*) already described as peculiar to the island. The only other Endogen belongs to the order *Liliaceæ*, and is an aloe, growing on the summit, and probably a new species. Of *Ebenaceæ* there are three species, and two Asclepiads with trailing stems; one species of *Myrsineæ*, new; two *Compositæ*, one of them a *Sonchus*, both probably introduced; one species of *Combretaceæ* and one of *Myrtaceæ;* two *Cinchoneæ*, and a small tree about twelve feet high, resembling the *Blackwellia* of Mauritius. It will be seen that while the genera of the Round Island Flora are Mauritian, the species are mostly peculiar. It is probable that the whole group of islands—Mauritius, Bourbon, Round Island, Ile de Serpents, Rodriguez, with the smaller islets, and probably Madagascar—are fragments of a vast continent. As regards the Fauna, there are no indigenous mammalia, although goats and rabbits have been introduced and have multiplied exceedingly, and no land birds, not even the Mauritian pigeons. The island seems, on the other hand—perhaps from the absence of mammalia and birds—very favourable to reptile life. Of Chelonians, a female land-tortoise had previously been captured on the island. Four distinct Saurians were found, the largest exceeding a foot in length, a native of