reference to Wüllner's investigation on the variability of spectra at different pressures and temperatures, that the results obtained must only be applied with the greatest care to the conditions of pressure of the sun's atmosphere, as the changes in the spectra are due far more to temperature than to pressure. But even under the assumption that this conjecture should become verified by special experiments, this circumstance would influence the results brought forward in this communication but in a slight degree. For the nature of the function (Formula 5) which served us in determining the temperature of the atmosphere is such that the pressure p_h under which the hydrogen spectrum becomes continuous may be varied within very wide limits without thereby causing any considerable alterations of the requisite temperature. Thus it was shown above that, by introducing the extremes of the pressure assumed which were in the proportion of 1 : 10, the temperature values resulting were only in the proportion of 1 : 1·5.

Nevertheless, the separation of the influences which pressure and temperature exercise on the nature of the spectrum of luminous gases must be regarded as a problem the solution of which is of the highest importance for astrophysics.

THE BRITISH ASSOCIATION

SECTIONAL PROCEEDINGS

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE

Rainfall: its Variation with Elevations of the Gauge.—Mr. Charles Chambers, F.R.S. The fact is well known to meteorologists that the quantities of rain received in gauges placed at different heights above the ground diminish as the elevation of the gauge increases. Several attempts have been made to explain this phenomenon, but none of them are so satisfactory as to discourage the search for other causes that may contribute substantially or mainly to its production. Hence the submission for the consideration of the British Association of this further attempt. One of the principal causes of rain is undoubtedly the transfer, effected by winds, of air charged with moisture in a warm damp district to a colder region, where the vapour it contains is partially condensed. The temperature of the lower as well as of the higher horizontal strata of the atmosphere being reduced by this transfer, it may fairly be inferred that condensation of vapour may also occur in the lower as well as in the higher horizontal strata. The rain caught by a gauge at any given elevation will therefore be the sum of the condensations in all the strata above it, and thus the lower a gauge be placed the greater will be the quantity of rain received by it. Again, it is known by observation, that there is at all times a greater or less difference of electrical tension between the atmosphere and the surface of the ground. If then—in accordance with the views of Prof. Andrews as to the continuity of the liquid and gaseous states of matter, from which it follows that the change of other physical properties must also be continuous—we regard the particles of vapour suspended in the electric bodies in relation to the dielectric principal constituents of the atmosphere, they will be polarised by induction from the ground. This polarisation will give rise to an attraction between every particle and the neighbouring particles above and below it; and being stronger in the particles near the ground than in those more remote, the tendency of the particles to coalesce—which will increase, by their mutual induction, as two neighbours approach each other—will be greatest near the ground. Thus it may be, each particle gathering to itself its neighbours in succession till their united density exceeds that of the atmosphere generally, some rain drops are formed, and that in greatest abundance near the ground. If this be the true cause of any substantial part of the phenomena in question, then, as the variation in intensity of electrical polarisation of the particles will vary with the height most rapidly near the ground, so the variation in the rainfall near the ground should be more rapid than at a greater elevation, and such is indeed the fact. Also, if the idea be correct, it will probably serve to explain other phenomena which it was not specially conceived to meet; and so it does. For, first, it requires that the rainfall over even ground, where the electrical tension is relatively weak, should be less than over similarly situated forest land, where at the tops of the trees, ends of branches, and edges of leaves, the tension is high, and this is in accordance with observation. And, secondly, the tension being relatively high at the tops of the elevations of a mountainous district, the rainfall should be greater there than in the neighbouring plains; this, again, is borne out by observation. Further, at the commencement of a passing thunderstorm, a sudden heavy shower of rain will often fall for a few moments and then suddenly cease. May not this arise from the approach, by the agency of opposite wind currents, of detached masses of differently charged clouds, the process just described of formation of rain drops going on rapidly in each mass as the two come near each other, and stopping when, by a flash of lightning between them, the two masses are brought into the same electrical condition? An experimental test of this idea would be to repeat Dalton's measures of the pressure of vapour in the vacuum space of a mercurial barometer tube—filling that space with air and a little water, and compare the values found when the mercury was charged with electricity and when not so charged. If in the former case a less pressure was found, we might conclude that the particles of vapour are really susceptible of electric induction, and the amount of difference existing would enable us to estimate whether the attractions of the particles upon each other were strong enough to cause the formation of rain-drops hypothetically attributed to them above.

* A perfect transparency of the gas mass to all rays emitted by itself is here assumed, a supposition which is the nearer the truth the smaller the weights compared.

SECTION C.—GEOLOGY

On the Mountain Limestone of Flintshire and part of Denbighshire.—Mr. G. H. Morton. Minute details of the physical structure of the region, and lists of the fossils, showed that these beds have been erroneously referred to the Millstone Grit, and that they were really Mountain Limestone, the shales and sandstones being intercalated among the typical rocks. The white limestone was an ancient coral reef, with the organisms exquisitely preserved. Mr. Hughes protested against co-relating with the Yorkshire beds, while Mr. Bailey supported the opinions of the author.

On the formation of Swallow-holes, or Pits with vertical Sides, in Mountain Limestone.—Mr. L. C. Miall. The author distinguished between cavities formed by direct excavation and those produced by subsidence of part of the roof of a cavern. The curious pits near the Buttertubs Pass at the head of Swaledale, were regarded as typical of the first kind, and their appearance and mode of formation were described, especially the vertical fluted sides and the isolated fluted pillars, which were ascribed to the action of dropping water, aided by pebbles. A basin is first formed upon a ledge of rock, and as the excavation proceeds it produces a semi-cylindrical scar, with sharp ridges upon the face of the limestone wall, as if cut by a gauge. The presence of a thick surface-covering of alluvium or drift was necessary to absorb and retain the rainfall, and to distribute it slowly and regularly. The limestone of a bare plateau furnishes fissures in great variety, but they are not true swallow-holes. Regular and well-marked joints were also necessary to the production of fissures, as they permitted the ready escape of the waters of erosion. The texture of mountain limestone, and its power of receiving and retaining sharp impressions, gave the peculiar features to the swallow-holes excavated in it. Some swallow-holes were due to the subsidence of an undermined crust. These frequently lie in a line, sometimes in a ring round a hill-side. A particular description of some near Ripon was given, and the testimony of eye-witnesses as to their sudden appearance was quoted. Swallow-holes are often disguised by surface accumulations. Many conical hollows in drift are probably due to concealed cavities of subsidence.

On the Stratigraphical Distribution of the British Fossil Gasteropoda.—Mr. J. L. Lobley. This was the third of a series of reports by the author on British fossil mollusca. By the help of diagrams were shown the distribution of the species, and the range, increment, decrement, and maximum development of the genera, families, and orders of the *Gasteropoda*. The cainozoic deposits contain the greatest number of genera and sub-genera, though they are numerous also in both the mesozoic and palæozoic rocks. A large number of genera and sub-genera are characteristic of single formations, and these are especially numerous in the carboniferous limestone, the lower lias, the middle Eocene, and the older and newer Pliocene. Details of the range and of the distribution of species of each of the

families of *Gasteropoda* were given, and the large groups or orders were similarly passed in review. The remarkable contrast between the distribution of the species of *Holostomata* and *Siphonostomata* was pointed out, the former being very largely developed in each of the three great divisions of the stratified rocks, while the other and more highly organised order is absent from the palæozoic, has only a few species in the Mesozoic, but is largely represented in the cainozoic formations. The distribution of the species without reference to generic family or ordinal divisions showed that the maximum number occurs in middle Eocene strata, from which beds 420 species have been described. The total number recorded in the paper exceeds 3000, but a great number of these are recurrent. The author insisted, in concluding, that as the recognised formations were of different values, as they had been unequally explored, as many formations were wanting in Britain, as the organic remains in the different formations had not been subjected to a uniformly rigid scrutiny, and as the British area, compared with the whole world, was so small, only the most general conclusions could be drawn from this investigation as to the progress of life on the globe.

On the Glacial and Post-Glacial Beds in the Neighbourhood of Llandudno.—Mr. H. F. Hall. The necessity for a more exact definition of boulder clay, and for discarding a name which is made to include a series of beds formed under very different conditions, was insisted upon. The section at Llandudno exhibited a base bed formed by the action of an ice-cap covering the whole land down to the sea level, which ground together the different materials of the bed. The overlying beds lie unconformably on this base bed, and show land and water conditions connected with a much more genial climate. From the section, the author concluded that colour is no criterion for deciding as to the base bed, as it varies in each district with the underlying rock; that the materials of the base bed are obtained from the rocks of the neighbourhood; that this bed was the result of the pressure and passage of land-ice disintegrating the surface of the land which it capped; that to this bed, which is invariably denuded and has the superposed beds lying unconformably upon it, the name "Boulder-clay" should be restricted; and that the red clay, over the sands and gravels which overlie the base bed, is variable in colour and constituents, showing a change which produced extensive denudation in more northern regions, the materials being spread over the sea bottom mixed with pebbles and boulders, which fell from melting or stranded icebergs and ice-flows. The author said there was a hope of being able to co-relate the beds of the eastern districts with those he had described.

Remarks on the Fossils from the Railway Cutting at Huyton.—Mr. W. Carruthers. The great value of this collection, made by the Rev. H. Higgins, depended as much upon the comparatively limited number of species met with as on the fine state of preservation in which they occurred. It was possible to arrive at considerable—in some cases absolute—certainty as to the different parts of the same species. Of the four species of *Calamites*, the materials existed in the specimens from Huyton for reconstructing the entire plant of at least one. The roots, long considered to be a distinct plant under the name *Pinnularia*, were present in great abundance. It had a delicate fistular stem of the type described by Professor Williamson at a previous meeting of the section, but of great size. The scars of the fallen branches were shown in several specimens as well as the foliage, which was preserved in the early bud condition, as well as in its fully developed state. Several fruits showing the structure of the cone, described by the author under the name *Volkmannia binneyi*, but with differences that were at least of specific value. A cone having the structure of that described by Professor Williamson probably belonged to *Calamites longifolius*, with the foliage of which it was associated in these beds. Specimens of *Sphenophyllum* were exhibited and referred to *Calamites*. The light thrown on the structure of *Lepidodendron* by the specimens was then dwelt on, and especially two undescribed cones—one long and slender, with a single sporangium on each scale, the other short and having two sporangia on each scale. The stem and foliage of *Flabellaria*—a palm-like lycopodiaceous genus—occurred among the fossils, as well as several species of beautifully-preserved ferns. Two specimens of insect remains had also been found—the one by Messrs. Clementshaw and Smith, young gentlemen whose interest in natural science was due to the revival of those studies in our great schools, and whose personal efforts had greatly contributed to its advancement at Rugby. Professor Williamson contended that the interpretation he had given on a former occasion of the structure of the stems of *Calamites* was more in accordance with the hundreds of specimens he had examined than those just expressed; but, in reply, Mr. Carruthers maintained, on structural grounds, the correctness of the views he had expounded.

Section D.—Biology

Department of Zoology and Botany

The Secretary read a paper by Dr. J. E. Gray, F.R.S., *On the Whalebone Whales of the Southern Hemisphere.* The author remarked that formerly the number of Cetacea was believed to be very limited, and that each species was supposed to have a very extensive geographical distribution. At one time, even, the hunchback of the Cape of Good Hope was supposed to be the same species as the whale of the North Sea. The author gave a list of the true whales, or Balænidæ, the hump-backed whales; and the Physalidæ. Five species of the first group were described, three of the second, and one of the last group. Reference was also made to three apparently different forms of Finne whales, known only from having been seen swimming.

Dr. Cunningham read a paper *On the Terrestrial and Marine Fauna of the Strait of Magellan and Western Patagonia.*

Professor Van Beneden read some notes "*Sur les Parasites*"—One frequently finds described under the title of "Parasites" animals which do not demand more than a place to live on, and do not live at the expense of their neighbour, such, for example, as the Adamsia by the side of the Pagurus. Some of these do not completely enjoy their liberty, as the Coronula on the whale. This type I would designate under the name of Oikasitæ, whereas those which are perfectly free I would designate as Coinositæ. The true Parasites may also be divided into groups: those that have no communication with the exterior are the Xenositæ, these, like the Cysticercus, are possibly only transitory forms: others, having arrived at the end of their journey, live in the open passages of organs, occupying themselves with reproduction, and these I would designate Nostocitæ; and lastly, those which appear to stray by the way, without a hope of arriving at the end of their journey, and indeed only by chance returning to the good road, such as the vesicular and agamic worms which frequent the flesh of carnivores, I would call Planositæ.

Professor Van Beneden exhibited a specimen of a species of Echinorhynchus, apparently new, lent to him for exhibition by Dr. John Barker of Dublin.

On Brackish-water Foraminifera.—Mr. H. B. Brady. The author described a form of Foraminifera from a fresh-water pond, some five or six miles from the sea, and while describing in addition a large number of new species from brackish water, he also alluded to the fact that he had met with some Foraminifera whose tests had withstood the action of acids. Without wishing positively to assert the absolute presence of chlorophyll granules, as occurring in some species, he might yet mention that he had found traces of it in the test of some of the forms he had examined.

On a stock-form of the parasitic Flat-worms.—Mr. E. Ray Lankester. This worm was found parasitic in *Tubifex rivulorum* from the Thames. It had the form of a fluke with very mobile head, no alimentary tube, a very elaborate vascular system, and simple generative organs. A small mobile tail was attached to one end of the worm at the opening of the vascular system. This tail was only paralleled by that of the *Cercariæ* or larvæ of Flukes. A worm known as Caryophyllœus, which lives in carp and tench, was stated to be exactly like the new worm in respect of its mobile head, wrongly held to be the tail by Emile Blanchard. The tailed form *Uroscolex*, Mr. Lankester considered to be the larva of *Caryophyllœus*, and hence we have in this simple worm a representative of the common ancestors of all the Trematods and Cestoids. Mr. Lankester said he was informed by Professor Van Beneden, that last year Caryophyllœus had been shown to have a six-hooked embryo.

On Worms from Thames mud.—Mr. E. Ray Lankester. The author showed that the tons of red worms which are the only non-microscopic tenants of the foul parts of the Thames at London, consist of three distinct species, and a natural hybrid between two also occurs, as he demon-

strated from minute study of their characters. The species are *Tubifex rivulorum*, *T. umbellatus* and *Limnodrilus*, sp. *incert.*; the last very abundant. Mr. Lankester then mentioned the gregarinæ of these worms, and the discovery of their pseudonaviculæ having long stiff processes, so that they run into the worms like pins, and in this way penetrate into previously uninfested worms. The formation of the spermatophors of this group of Annelids (the Oligochæta) discovered by Mr. Lankester—Professor Claparède having mistaken them for Opalinoid parasites—was also detailed.

Department of Anatomy and Physiology

On the Embryonal Development of the Hæmatozöon (Bilharzia).—Dr. Cobbold. After commencing with a general description of this remarkable parasite, Dr. Cobbold proceeded to notice the manner in which the larvæ escaped from the eggs; and also their subsequent activity and remarkable alterations of form and structure. He had obtained ample evidence of the existence of a complicated water-vascular system, similar to that described by Dr. Guido Wagener, as occurring in the larva of *Diplodiscus*. The prevalence of the Bilharzia disorder in Egypt and at the Cape was well known; and it had recently been suggested by Dr. Aitkin, that these parasites had some connection with the so-called Delhi boils. He refrained from entering into professional details in this matter: but stated that he had performed a large number of feeding experiments on small fishes, crustaceæ, and molluscs, with the view of putting the question of injection beyond the region of mere conjecture. Dr. Cobbold added that he had obtained for a month past about 10,000 eggs of Bilharzia daily, from a case under his care.

Dr. Cobbold exhibited the heart of a dog filled with Hæmatozoa causing the animal's death. He had received the specimen from Mr. Robert Swinhoe, H.B.M. Consul at Amoy, China, accompanied by a note from the donor, stating that the dog "died on the 18th of April, 1869, at Shanghai, after three days of great suffering." Hitherto, following the authority of M. Bohe-Moorea Diesing and other systematists, he had been accustomed to regard this form of entozoon as the species called *Spiroptera sanguinolenta;* but, in the author's opinion, this view would have to be changed. He hoped, before long, to be able, by further investigation, to set this point at rest. The presence of entozoa in the heart and blood-vessels of animals and man is much more common than is supposed. Thus, MM. Grube and Delafond, who examined 480 dogs, found Filariæ present in nearly 5 per cent. Most of these parasites, however, were of microscopic size; being probably the brood of the species marked *Filaria sanguinis* in Dr. Cobbold's list. They estimated that these verminiferous dogs severally harboured from 11,000 to 224,000 of these larval hæmatozoa.

Note on Methæmoglobin.—Mr. E. Ray Lankester. It was shown that carbonic acid, when passed through a solution of oxyhæmoglobin, gave rise to two new bands in addition to those of the oxyhæmoglobin itself. This was the nitrite-hæmoglobin of Dr. Gamgee, and the brown cruorine of Mr. Sorby, also identical with methæmoglobin as described by Preyer. Addition of a minute quantity of acetic acid to this solution caused the disappearance of the oxyhæmoglobin bands and intensification of the two new bands, which are those of what really was originally called methæmoglobin by Hoppe Seyler. It can be formed by the passage of CO_2 alone if a weak solution of hæmoglobin is used, as was done by Heynsius, who mistook this product for hæmatin. Its band in red is not identical with that of hæmatin as supposed by Hoppe Seyler and Heynsius, and all previous observers, including Hoppe Seyler, Preyer, Gamgee, and Sorby have missed the second band in blue (the fourth of the mixture of oxyhæmoglobin and methæmoglobin) now figured and described. It was shown that no separation of an albumen accompanies the change of hæmoglobin into methæmoglobin, whilst hæmatin results solely from a splitting up of the hæmoglobin into it and an albumen.

The action of certain Vapours and Gases on the red Blood Corpuscles.—Mr. E. Ray Lankester. These experiments were made with Stricker's gas chamber, which enables the observer to study gradual changes, caused by gaseous reagents, as to the change of form caused by atmospheric air in the red corpuscle of the frog, which had been acted on first by CO_2 as observed by Stricker, was shown to be equally produced by hydrogen, or by carbonic oxide, or by diminution of pressure, hence it was simply to be ascribed to the diffusion of the carbonic acid. The action of cyanogen gas, carbonic oxide, alcohol vapour, chloroform vapour, and especially of ammonia vapour, was described. A distinction was insisted on between mere definition of the nucleus—as caused by some agents—and granulation of the nucleus. The normal living frog's red corpuscles was inferred to be *usually* free from any appearance of definition of the nucleus, and to be devoid of an envelope or æcoid, though owing its form to a remarkable condition of tension, which was readily destroyed by physical agents.

On the Relations of Fins of Fishes to one another.—Professor Humphry.

Department of Ethnology and Anthropology

The Pre-Turkish Frontagers of Persia.—Mr. H. Howorth. In continuation of the previous paper the author showed with the assistance of Vivien St. Martin, Thomas, Prinsep, &c., that after the first century, the Indo-Scyths were called Kouschauk by the Armenians, Koneichang by the Chinese, that their great king Kanichka who was a convert to Buddhism, and introduced that religion into China and Thibet, was, with his people, previously a fire-worshipper, and that the form of Mithraism, which was introduced at Rome by Pompey and derived by him, in the first instance, from the Parthians, was the original religion of the Massagetæ and the Indo-Scyths.

On the decay of the power of the Indo-Scyths, the remains of the nation were conquered by the Avares or White Huns, and are called by Procopius, Priscu, and Cosmas, White Huns, and Ephtalitæ, and by the Persians Hainthelah. The etymology of these names shows they were the Yuetchi or Massagetæ, led and governed by a caste of Huns.

In latter days these White Huns are to be identified with the Khazars, the ancestors of the Circassians. Thus the Circassians are proved to be lineal descendants of the Massagetæ. That the Circassians are allied to the Thibetans was long ago showed by Mr. Hodgson in the Journal of the Asiatic Society. This is the first time their genealogy as a race has been clearly traced out, and it opens up a new light on Asiatic Ethnography.

On the Manx of the Isle of Man.—Dr. King.

SECTION G.—MECHANICAL SCIENCE

On Ashton and Storey's Steam-Power Meter.—Mr. Ashton. The apparatus described in this paper, as its name implies, shows at all times the measure of the power developed by the steam engine to which it is applied, and registers the aggregate of that power during any required period of time. The mechanism is very like that of a well-balanced chronometer. The whole of the indicating mechanism is very light, and mounted so as to move with great freedom; and the power required to work it is exceedingly small. Its indications would be especially valuable in the case of steamships. The apparatus has been in practical use about a year.

In the discussion which followed this paper the invention was very highly praised.

CONTENTS

ERRATA.—Page 464, second column, line 30, for "monodont" read "homodont"; line 35, for "but its analogue in front has" read "but, unlike its analogue in front, has."