the dorsal setæ, the exact converse of the condition which occurs in *Lumbricus*. Later investigations, however, which resulted in the discovery that the genital apertures and nephridiopores may coincide at the same setæ, led M. Perrier to abandon the hypothesis. My own discovery, first published in the Proceedings of this Society, that in *Acanthodrilus multiporus* there are more than a single pair of nephridiopores to each segment, removed the difficulties urged by Perrier. And as this discovery has been extended by myself and by others to many species and genera of earthworms, there can be no longer any intrinsic improbability in the hypothesis. The whole subject has been lately reviewed by Eisig in his treatise upon the anatomy and physiology of the Capitellidæ, which forms one of the series of monographs issued by the Zoological Station at Naples. Dr. Eisig decides that the genital ducts are probably modified nephridia in the Oligochæta; in the Capitellidæ they certainly are; but, as the Capitellidæ do not appear to me to be so nearly related to the Oligochæta as Dr. Eisig considers, I should regard this argument as only having the force that an argument from analogy can have. Since the appearance of Dr. Eisig's work, an important paper by Dr. Stolc, dealing with the generative organs of *Æolosoma*, has come into my hands; it appears that in this Annelid there are no special sperm ducts, but that the function of such ducts is performed by several pairs of nephridia. This fact, however, interesting though it is, is not a proof of the homology between sperm ducts and nephridia in other types.

I have lately had the opportunity of studying the development of the New Zealand species *Acanthodrilus multiporus*. The sum of money which the Government Grant Committee of the Royal Society were good enough to place at my disposal has enabled me to defray the expenses of this investigation.

In the young embryos of this worm each segment is furnished with a pair of nephridia, each opening by a ciliated funnel into the segment in front of that which carries the dorsally placed external pore. In later stages the funnels degenerate, and that portion of the tube which immediately follows the funnel becomes solid, losing its lumen; at the same time the nephridium branches, and communicates with the exterior by numerous pores. At a comparatively early stage, four pairs of gonads are developed in segments X.-XIII.; each of these is situated on the posterior wall of its segment, as in *Acanthodrilus annectens*, and not on the anterior wall, as in the majority of earthworms. When the gonads first appear, the nephridial funnels, with which they are in close contact, are still ciliated, and their lumen is prolonged into the nephridium for a short distance. Later the cilia are lost, and the funnels increase greatly in size, while those of neighbouring segments—in fact, all the remaining funnels—remain stationary for a time, and then become more and more degenerate. The large funnels of the genital segments become the funnels of the vasa differentia and oviducts; it will be observed that the number of ovaries and oviducal funnels (*two* pairs) at first corresponds to that of the testes and sperm duct funnels; subsequently the gonads and commencing oviducts of segment XII. atrophy. Each of these large funnels is continued into a solid rod which passes back through the septum, and then becomes continuous with a coiled tuft of tubules, in which there is an evident lumen, and which is a part of the nephridium of its segment. In the segments in front of and behind the genital segments, the rudimentary funnels communicate in the same way with a solid rod of cells which runs straight for a short distance and then becomes coiled and twisted upon itself and provided with a distinct lumen. In fact, apart from the relative size of the funnels and the presence of the gonads, it would be impossible to state from which segment a given section through the terminal portion of a nephridium had been taken. In a later stage the large funnels of the genital segments become ciliated; but this ciliation takes place before there is any marked change in the tube which is connected with the funnel.

In the young worm which has just escaped from the cocoon the funnels are ciliated, and they are each of them connected by a short tube, in which a lumen has been developed, but which ends blindly in close proximity to a coil of nephridia. No trace of any nephridial tube other than the sperm duct or oviduct could be observed, whereas in the preceding and succeeding segments the rudimentary nephridial funnel, and a straight tube leading from it direct to the body wall, was perfectly plain. Dr. Bergh has figured, in his account of the development of the generative organs of *Lumbricus*, a nephridial funnel in close contact with the funnel of the genital duct. It may be suggested that a corresponding funnel has been overlooked in the embryo *Acanthodrilus*; the continuity of a structure, identical (at first) with the nephridia of the segments in front and behind, with the genital funnels, seems to show that a search for a small nephridial funnel would be fruitless.

I can only explain these facts by the supposition that *in Acanthodrilus multiporus the genital funnels and a portion at least of the ducts are formed out of nephridia.* This mode of development is a confirmation, to me unexpected, of Balfour's suggestion that in the Oligochæta the nephridium is broken up into a genital and an excretory portion.

In the comparison of the facts, briefly described here, with the apparently independent origin of the generative ducts in other Oligochæta, it must be borne in mind that in *Acanthodrilus* the segregation of the nephridium into several almost detached tracts communicating with the exterior by their own ducts precedes the formation of the genital ducts.

"The Patterns in Thumb and Finger Marks: on their Arrangement into naturally distinct Classes, the Permanence of the Papillary Ridges that make them, and the Resemblance of their Classes to ordinary Genera." By Francis Galton, F.R.S.

The memoir describes the results of a recent inquiry into the patterns formed by the papillary ridges upon the bulbs of the thumbs and fingers of different persons. The points especially dwelt upon in it are the natural classification of the patterns, their permanence throughout life, and the apt confirmation they afford of the opinion that the genera of plants and animals may be isolated from one another otherwise than through the influence of natural selection.

The origin of the patterns was shown to be due to the existence of the nail, which interfered with the horizontal course of the papillary ridges, and caused those near the tip to run in arches, leaving an interspace between them and the horizontal ridges below. This interspace was filled with various scrolls which formed the patterns. The points or point at which the ridges diverged to inclose the interspace were cardinal points in the classification. It was shown that there were in all only nine possible ways in which the main features of the inclosure of the interspace could be effected. In addition to the nine classes there was a primary form, occurring in about 3 per cent. of all the cases, in which the interspace was not clearly marked, and from this primary form all the other patterns were evolved. The forms of the patterns were easily traced in individual cases by following the two pair of divergent ridges, or the one pair if there was only one pair, to their terminations, pursuing the innermost branch whenever the ridge bifurcated, and continuing in an adjacent ridge whenever the one that was being followed happened to come to an end. Twenty-five of the principal patterns were submitted, and a few varieties of some of them, making a total of forty. They are by no means equally frequent.

The data as to the permanence of the patterns and of the ridges that compose them were supplied to the author by Sir W. J. Herschel, who, when in the Indian Civil Service, introduced in his district the practice of impressing finger marks as a check against personation. Impressions made by one or two fingers of four adults about thirty years ago, and of a boy nine years ago, are compared with their present impressions. There are eight pairs of impressions altogether, and it is shown that out of a total of 296 definite points of comparison which they afford, namely the places where ridges cease, not one failed to exist in both impressions of the same set. In making this comparison no regard was paid to the manner in which the several ridges appear to come to an end, whether abruptly or by junction with another ridge. The reason was partly because the neck where junction takes place is often low, and may fail to leave a mark in one of the impressions.

Lastly, the various patterns were shown to be central typical forms from which individual varieties departed to various degrees with a diminishing frequency in each more distant degree, whose rate was in fair accordance with the theoretical law of frequency of error. Consequently, wide departures were extremely rare, and the several patterns corresponded to the centres of isolated groups, whose isolation was not absolutely complete, nor was it due to any rounding off by defined boundaries, but to the great rarity of transitional cases. This condition was brought about by internal causes only, without the least help from natural selection, whether sexual or other. The distribution of individual varieties of the same patterns about their respective typical centres was precisely analogous in its form, say, to that of the shrimps about theirs, as described in a recent memoir by Mr. Weldon (Roy. Soc. Proc., No. 291, p. 445). It was argued from this, that natural selection has no monopoly of influence either in creating genera or in maintaining their purity.

"The Conditions of Chemical Change between Nitric Acid and certain Metals." By V. H. Veley, M.A.

This paper is in continuation of a preliminary communication on the same subject. The main points contained in it are as follows:—

(1) The metals copper, mercury, and bismuth do not dissolve in nitric acid of about 30 per cent. concentration (the acid commonly employed for the preparation of nitric oxide gas) and heated to a temperature of 30° C., provided that nitrous acid is neither present initially nor formed subsequently. To prevent this, it is necessary in the cases of copper and bismuth to add a small quantity of some oxidizing substance, such as hydrogen peroxide or potassium chlorate, or, as less efficacious, potassium permanganate, or to pass a current of air, or, lastly, such a substance as urea, which destroys the nitrous acid by its interaction.

(2) If the conditions are such that these metals dissolve, then the amount of metal dissolved and the amount of nitrous acid present are concomitant variables, provided that the nitric acid is in considerable excess. Change of conditions, such as concentration of acid and variation of temperature, which increase the former increase also the latter.

(3) If the conditions are such that these metals dissolve, it would appear that the metallic nitrite is at first formed, together with nitric oxide; the former is decomposed by the excess of nitric acid to liberate nitrous acid, while the latter reduces the nitric acid to form a further quantity of nitrous acid.

Eventually the net result is the product of two reverse chemical changes represented by the equations:—

$$\text{(i.)}\ 2NO + HNO_3 + H_2O = 3HNO_2,$$
$$\text{(ii.)}\ 3HNO_2 = 2NO + HNO_3 + H_2O.$$

The nitrous acid is thus destroyed as fast as it is generated.

(4) If the conditions are such that metals dissolve in nitric acid, then nitrous acid is invariably the initial product of reduction.

(5) The metals copper, mercury, and bismuth dissolve very readily in a 1 per cent. solution of nitrous acid; under these conditions nitric acid present in slight excess interferes with, rather than promotes, the chemical change. This result is probably due to the greater stability of nitrous acid in the presence of nitric acid.

(6) Hydrogen gas reduces nitric to nitrous acid in presence of cupric or lead nitrate; it also converts mercuric into mercurous nitrate, but does not produce any change in solutions of bismuth and zinc nitrates dissolved in nitric acid.

Physical Society, November 14.—Prof. W. E. Ayrton, F.R.S., President, in the chair.—The following communications were made:—On certain relations existing among the refractive indices of the chemical elements, by the Rev. T. Pelham Dale. The first part of the paper corroborates the results announced in a communication made in May 1889 on the same subject, and says that as far as experimental data are forthcoming the refraction $(\mu - 1)$ divided by the vapour density (d) is equal to a constant multiplied by some integer. Several metals whose refractions have since been determined conform to this law. On examining the relation between molecular weight (M) and refraction, similar conclusions are arrived at; for to a fair degree of approximation the ratio $M/(\mu - 1)$ is a constant, or a simple multiple of this constant. The question as to how far the relation $(\mu - 1)/d = c$ holds good for the same element in the three states of vapour, liquid, and solid, has been examined as far as data exist for this purpose. The resulting numbers are not identical, but some of the data themselves are doubtful. Another relation is between the molecular distances (h) (see Proc. Phys. Soc., vol. ix. p. 167) and the atomic weight (a) of the elements, h being nearly proportional to $\sqrt{a}$. In the case of selenium, sulphur, and phosphorus, the agreement is close, but for bromine, chlorine, and carbon, not so good. A fifth relation appears to exist between the upper limit of refraction and the line spectra of elements. For example, the upper limit of refraction for selenium occurs at wave-length 5295·7, whilst its spectrum exhibits a remarkable series of strong lines about this wave-length. A similar relation apparently holds with sulphur, phosphorus, and bromine. Gold also shows a series of strong lines about c, in the vicinity of which the metal has the greatest reflective power. The author finds that selenium polarizes and reflects nearly all the light that falls on it at a large angle, and suggests that it may be used in polariscopes. He has also endeavoured to connect together the phenomena of a limit of refraction and anomalous dispersion. In the case of fuchsin the dark space coincides with the limit of refraction, and the same is probably true of cyanin. If one of the anomalous indices be given the other can be found. He also believes that bodies of high molecular weight give anomalous dispersion, and thinks solutions of iodine will exhibit the phenomenon. The mathematical investigation of the whole subject involved difficulties arising from the want of trustworthy data, and the author hopes that some member will take up the necessary experimental determinations. Dr. Gladstone thought the author under-estimated the amount of work done and in progress on the subject, for the question whether $(\mu - 1)/d$ is constant or not is being investigated by many. The French physicists, he said, had found the quantity nearly constant, but Lorenz's expression $(\mu^2 - 1)/(\mu^2 + 2)$ is slightly better when applied to compounds in the liquid and gaseous states. Metals were difficult to deal with, especially as, according to the recent paper of Du Bois and Reubens, their refractions do not follow the law of sines. Mr. Dale here suggested that they might be related to hyperbolic sines. Dr. Gladstone, continuing, said that, by taking solutions of metals, it was found that their specific refractive energies were nearly inversely as the square roots of their combining weights, but at present the known cases were not sufficient to establish a law. Prof. Rücker said that of the two expressions, $(\mu - 1)/d$ and $(\mu^2 - 1)/(\mu^2 + 2)$, the latter seemed preferable, for it could be converted into electrical quantities by writing K for μ^2. The expression then becomes $(K - 1)/(K + 2)$, and if this can be shown to be constant by electrical work, this would be an argument in its favour. On the subject of anomalous dispersion he directed Mr. Dale's attention to Mr. Glazebrook's Report on Optical Theory made to the British Association. Mr. Dale, in reply, pointed out that, from the nature of the two formulæ, any inaccuracy or variation in μ would affect theirs more than Lorenz's. He also thought that $(\mu - 1)/d$ was a limit towards which the numbers tend.—Tables of spherical harmonics, with examples of their practical use, by Prof. J. Perry, F.R.S. The author defined a spherical harmonic as a homogeneous function of x, y, z, satisfying the equation—

$$\frac{d^2V}{dx^2} + \frac{d^2V}{dy^2} + \frac{d^2V}{dz^2} = 0,$$

stated the fundamental properties of such functions, and pointed out their importance in problems on heat, electricity, and hydrodynamics. Referring to zonal harmonics (homogeneous functions of $(x^2 + y^2)^{\frac{1}{2}}$ and z), he showed that these harmonics are symmetrical with respect to the axis of z, and might be expressed as functions of the angle (θ) which the line joining the point (x, y, z) to the origin makes with the axis of z, multiplied by r^i; where r is the radius-vector and i the degree of the homogeneous function. These functions of θ are called zonal surface harmonics, and are designated by $P_0, P_1, P_2, \ldots P_i$, according to the degree of the function, and it was the values of these quantities which form the tables brought before the Society. The tables comprise the values of P_1 to P_8, and are calculated to 4 places of decimals and for every 1° between 0° and 90°. As an example of the use of such tables, the case of a spherical surface covered with attracting matter whose density varied as the square of its distance from a diametral plane was taken. It was required to find the potential both outside and inside the sphere, and to determine the equipotential surfaces and lines of force. The potentials inside (A) and outside (B) were shown to be given by

$$\frac{A}{\pi} = 8 + \frac{16}{5}r^2P_2 \quad \text{and} \quad \frac{B}{\pi} = \frac{8}{r} + \frac{16}{5}\frac{1}{r^3}P_2$$

respectively. By giving A and B definite values, and choosing values of r, the corresponding P_2's can be calculated, and the value of θ determined from the tables. Hence any equipotential surface can be easily determined, and lines drawn to cut these surfaces orthogonally are lines of force. Another problem which had been tried consisted in finding the directions of the lines of force near a circular coil of rectangular cross-section when an electric current circulates in the coil. This was treated