THURSDAY, SEPTEMBER 2, 1897.

THE NECESSARY POSTULATES OF GEOMETRY.

An Essay on the Foundations of Geometry. By Bertrand A. W. Russell, M.A. Demy 8vo. Pp. xvi + 201. (Cambridge: at the University Press, 1897.)

THE title of this essay suggests a number of distinct problems. We may ask what the postulates of geometry are, or we may seek the source of our knowledge of them; in the latter inquiry, again, we may set out to discover how the fundamental geometrical notions grew up, or it may be our object to ascertain how we can have certainty concerning them. Mr. Russell's essay deals with the last of these questions. It is, on the one hand, a criticism of existing theories of geometry, and, on the other hand, it is constructive, and aims at formulating a new philosophical theory of the foundations of the science.

An abstract geometry, logically arranged, would start from a small number of definitions and postulates, and would proceed deductively. In the process there would occur places in the argument where a choice would be possible among different hypotheses, and at such places ambiguity would be removed by the introduction of fresh postulates. There would thus be different orders of postulates, some being required in order that there might be any geometry at all, and others being adapted to make geometry applicable to the formulation of experience. The problem of separating the postulates into such classes is the problem of transcendental geometry, or, as the author calls it, *Metageometry*.

Mr. Russell gives in his first chapter an outline of the history of metageometry. He shows how it began with attempts to deduce Euclid's parallel axiom from the remaining axioms, and how this attempt issued in the construction of logically consistent geometries which did not adopt the axiom; he describes how Riemann and Helmholtz attempted to classify geometrical axioms as successive determinations of space considered as a particular example of a more general class-conception—that of a manifold or numerical aggregate, and here he does not omit to summarise the extremely important results obtained by Lie in modifying and completing Helmholtz's investigation; lastly he explains how Cayley and Klein connected metageometry with projective geometry, and here he incidentally gives an account of what projective geometry is, and of its independence of the notion of measurement, a notion which was fundamental in Riemann and Helmholtz's methods. The chapter is partly historical and partly critical. It contains *inter alia* an answer to Cayley's challenge demanding that philosophy should either take account of the use of imaginaries in analytical geometry, or show that it has a right to disregard it (pp. 41–46).

The second chapter contains a criticism of philosophical theories of geometry propounded by Kant, Riemann, Helmholtz, Erdmann, Lotze, and others.

In the third chapter we have a discussion of the question what postulates are necessary in order that there may be a geometry at all. The same result is arrived at whether the subject is considered from the projective or the metrical point of view; it is that the necessary postulates are those of homogeneity, and continuity of space, and the existence of the straight line as a unique figure determined by two points. Thus the most general possible geometry includes Euclidean geometry, the hyperbolic geometry of Lobatschewsky, the spherical geometry of Riemann, and the elliptic geometry of Klein, but besides these there is no other. The postulates necessary to this general geometry are declared to be *à priori* axioms, while the parallel axiom and the axiom of three dimensions are found to be empirical.

The fourth chapter deals with some difficulties met with in the previous chapter, and traces some of the philosophical consequences of the theory proposed.

Mathematicians will turn with most interest to Chapter iii., to see what Mr. Russell lays down as the essential postulates of geometry, and how he establishes his conclusions. The chapter is divided into two sections, dealing respectively with the "Axioms of Projective Geometry," and the "Axioms of Metrical Geometry." In projective geometry, as the author points out, the notions of the point, straight line, and plane are presupposed. Technically, the subject starts from these notions, and determines by the methods of projection and section what figures are equivalent to a given figure. Philosophically, the subject has a wider aim, consisting in the determination of all figures which cannot be distinguished by their internal relations when quantity is excluded (p. 133). The kernel of the argument consists in the identification of projective equivalence with qualitative similarity. The author attempts to prove that a *form of externality* (a notion essential to the knowledge of a world of diverse and inter-related things) must possess precisely the properties attributed to space in projective geometry, these properties including homogeneity, and continuity, and the possibility of the straight line, or in other words of a unique figure determined by two points. He seeks, in fact, to deduce these properties of the form from the relativity of position. Without wishing to impugn the correctness of the deduction, or to deny the legitimacy of the conclusion, we cannot help thinking the argument obscure. This is especially the case in all that concerns the notion of the *point*. Thus, in speaking of the infinite divisibility of the form of externality (p. 138) he says:

> "The relation between any two things is infinitely divisible, and may be regarded, consequently, as made up of an infinite number of the would-be elements of our form, or again as the sum of two relations of externality."

He finds in the notion of the *point* "a self-contradictory result of hypostatizing the form of externality." This difficulty he recurs to again and again. Would it be presumptuous for a mere mathematician to suggest that this alleged contradiction may arise from the adoption of an antiquated mode of statement? We are told (p. 188) that the difficulty is extremely ancient. Is it not safe to say that the ancient philosophers had not firmly grasped and completely analysed the concept of the *mathematical continuum?* Mr. Russell says (p. 189):

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"Whatever can be divided, and has parts, possesses some thinghood, and must, therefore, contain two ultimate units, the whole namely, and the smallest element possessing thinghood."

The *mathematical continuum* contains no "smallest element," and there is, accordingly, no necessity for a thing which can be divided, and which has parts, to contain such an element. This remark may perhaps offer the key for the solution of the problem set by Mr. Russell, the problem namely of determining the properties of a *form of externality*. It is conceivable that, in arriving at the axioms of projective geometry as constituting a statement of these properties, he has assumed the solution of a problem in the *theory of manifolds* just as Helmholtz, in arriving at the axiom of constant *space-curvature* as necessary to congruence, assumed the solution of a problem in the *theory of groups*. In the latter case the weapon needed to attack the problem was forged at a much later date by Lie. In the case of Mr. Russell's problem the appropriate engine of discovery is still undeveloped, the mathematics of the manifold being at present limited to numerical aggregates. No one has yet done for the science of space what Dedekind did for the science of number.

Mr. Russell is happier in his treatment of the axioms of metrical geometry, and he has done real service to mathematics in pointing out the essential weakness of the Riemann-Helmholtz method. This method started from the consideration of space as a numerical aggregate, whose points are determined by coordinates, and then sought for the condition of the possibility of measurement. This condition was found in the uniformity of the measure of space-curvature, and it was shown, on the one hand, to imply the possibility of the straight line, and, on the other, to be equivalent to the statement that figures which can be brought to congruence are equal. The argument, as Mr. Russell shows, really involved a vicious circle. For space can be regarded as a numerical aggregate only if we have the means of assigning to points coordinates which have some spatial import, and coordinates which have such import presuppose measurement. The conclusion arrived at by Mr. Russell is that the essential postulate of metrical geometry is the *axiom of free mobility*, or the assertion of the possibility of equal figures in different places, and he has shown that the denial of this axiom would lead to logical and philosophical absurdities. In this connection it is only fair to Riemann to remember that his essay "Ueber die Hypothese, welche der Geometrie zu Grunde liegen" remained unpublished until after his death, a fact which points to the belief that he was not satisfied with it.

Leaving to philosophers by profession the task of appreciating and criticising Mr. Russell's philosophy of space, we may attempt to estimate the value of his book for mathematics. It has already been pointed out that in his criticism of Riemann and Helmholtz he has brought forward considerations which are mathematically important, and this is not the only place where he has had occasion to point to examples of the special philosophical vice of the mathematician, the tendency namely to mistake the sign for the thing signified (*cf.* Couturat "De l'Infini mathématique," p. 331). To mathematicians also his book should be interesting on account of its acute and novel treatment of familiar topics: thus—projective coordinates are numbers arbitrarily but systematically assigned to points of space "like the numbers of houses in a street" (p. 119). The ambiguity in the definition of distance, which is unavoidable on projective principles, does not show that distance is ambiguous, but that projective methods cannot adequately deal with distance (p. 35). The distinction between real and imaginary points is the distinction between quantities to which points correspond and quantities to which no points correspond (p. 44). The book is throughout well written, and is for the most part free from obscurity, and it may be recommended to all who wish to have clear ideas on matters of fundamental importance in mathematics.

A. E. H. L.

OUR BOOK SHELF.

A Bibliography of Gilbert White, the Natural Historian and Antiquarian of Selborne. Ey Edward A. Martin, F.G.S. Pp. xiii + 274. (Westminster: The Roxburghe Press, 1897.)

THERE are many places in England prettier than the little Hampshire village of Selborne, but none of them are so full of interest to the outdoor naturalist as the home of Gilbert White. Though more than a century has passed away since the simple student of nature's ways in the sleepy hollow of Selborne first gave the world the benefit of his observations and impressions, the book in which these notes are published is as fresh now as ever it was. The reason for this is, it seems to the writer, that Gilbert White was usually content to record facts as he found them, and he did not regard nature from the point of view of a pre-conceived theory. Accurate observations of natural objects and phenomena live for ever, but the explanation of such facts must alter from time to time as wider knowledge of the laws of nature is obtained.

The success of White's "Selborne" has had two unfortunate effects: it has made every country clergyman who can distinguish a martin from a swallow think that he is a Gilbert White, and it has caused the literary world to be deluged with so-called popular natural history works, which are often more remarkable for thoughts about nothing than for observations of something. We can, however, forgive the authors of such rhapsodies for inflicting their musings upon a busy world, because of the real naturalists which White's "Selborne" has created.

How large and widespread is the public to which the book appeals may be seen by the volume before us. Mr. Martin has found no less than seventy-three separate editions of our natural history classic; so the aggregate number of volumes published must be very great. The features of each of these editions are described in detail; hence Selbornites are now provided with interesting particulars of the various volumes which have refreshed the mind and administered to the intellectual enjoyment of thousands of nature-lovers the world over. Mr. Martin has not, however, confined his work to a mere list of editions of the "Natural History of Selborne"; he describes the naturalist himself and the main facts of his life, points out some of the chief observations and discoveries, gives a chapter on the village of Selborne, and devotes another to White's old house, "The Wakes." The work is thus more than a bibliography; it is a guide to the study of Gilbert White and his natural history, and as such will be prized by many of his disciples.

Reference is made on p. 71 to a suggestion of White's that entomology required some "neat plates" for its advancement, and it is stated that the idea has been carried out by the Science and Art Department. Surely there is a mistake here.

British Rainfall, 1896. By G. J. Symons, F.R.S., and H. Sowerby Wallis. Pp. 221. (London: Edward Stanford, 1897.)

MR. SYMONS has now 3219 observers who send him rainfall statistics from different parts of the British Isles. On the average, there is one rainfall station in every 21 square miles in England, one in every 36 square miles in Wales, one in 74 square miles in Scotland, and one in 179 square miles in Ireland. The task of editing the records obtained at all these stations is thus a heavy one, and it becomes heavier every year on account of the increase in the number of observers. Unfortunately, the tendency is for observers to increase in districts already adequately supplied with rainfall stations, and to decrease in districts where stations are badly needed. In Scotland and in Ireland there are areas of several hundred square miles without a single observer, and in the county of Sutherland, which contains over two thousand square miles, there are only six stations, three of which are so close together that they may be regarded as one. It is to be hoped that next year the editors of "British Rainfall" will be able to report that Sutherland is giving more assistance than it does now to a knowledge of the rainfall of the county.

In addition to the usual discussion of the rainfall and meteorological observations of 1896, and general tables of total rainfall, the present volume contains short articles upon the rainfall in the vicinity of Seathwaite—the most rainy part of England—evaporation experiments, the Heberden family and meteorology, and a comparison of German and English rain gauges and of Mr. Sidebottom's snow gauge.

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 intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The late Earthquake in India.

MR. R. D. OLDHAM, Director of the Geological Survey of India, has written to me for particulars of the photographic record of the Calcutta earthquake of June 12, 1897, as shown by the horizontal pendulum of this observatory. As Mr. Oldham is preparing a full report on this earthquake, he has also asked me to let it be known that he would esteem it a favour if copies of all records of its effects, wherever it has left any traces, be sent to him at the "Geological Survey Office, Calcutta." RALPH COPELAND.

Royal Observatory, Edinburgh, August 24.

On Mimicry.

IN a letter on p. 197 of NATURE, which I saw only a few days ago, Mr. Walter F. H. Blandford, referring to my suggestion as to the scarcity of individuals of mimetic species of Lepidoptera, rightly insists, that it has first to be shown that there is correlation between the acquirement of mimetic resemblance and the production of small numbers of specimens, before my suggestion becomes acceptable, and adds, that the advantage which the imago state of Lepidoptera probably derives from the resemblance to an immune model may possibly be counteracted by increased destruction in other stages. Mr. Blandford has apparently not taken into account what I thought to be too well known to need fuller explanation, and hence touched only by stating that "so many mimetic species are scarce, in comparison with the non-mimetic allies," namely, that the number of rare forms amongst mimics is remarkably greater in proportion than the number of rarities among their non-mimetic allies. This excess of scarcity among mimics Mr. Blandford's assumption of increasing destruction in the larval states does not meet, unless we assume, further, that only rare species can become mimetic, or that the excess of rarity among the forms which have become mimetic is due to the acquirement of mimetic resemblance, *i.e.* that there is the kind of correlation which my suggestion (p. 153) requires. In support of the latter alternative—the former does not concern us here—I adduce the following statements, at which I arrived by a comparison of the mimetic and non-mimetic forms of those two groups of Eastern Papilios among which mimicry occurs (Haase's subgenera *Cosmodesmus* and *Papilio, s. str.*).

(1) According to a rough estimate the proportion of the number of rare mimetic forms to the number of more common mimetic forms of Eastern Papilios is approximately as 1 : 2, while the proportion of the number of rare non-mimetic forms to the number of more common non-mimetic forms is as 1 : 4; that is to say, the number of rarities is among mimics about twice as large proportionally as among their non-mimetic allies. These numbers are, of course, not quite correct, as our knowledge of the insects in question is far from being complete. I add, incidentally, that the proportion of the rare to the common forms is as 1 : 2 in that group of Eastern Papilios which feed as larvæ on *Aristolochiaceæ*, and partly serve as "models."

(2) The mimetic species which are mimetic only in one sex, or resemble the model only superficially, are generally common.

(3) The mimetic species which are very variable are common, at least commoner than their less variable allies.

(4) The mimetic forms which agree very closely with the model in both sexes are the rarest (*cf.* Haase, "Mimicry," ii. p. 116: Stuttgart, 1893).

These four points are decidedly in favour not only of there being a connection between the acquirement of mimetic resemblance and the scarcity of individuals, but also of the excess of scarcity among the mimics being a consequence of the development of the mimetic characters. It does not seem to me to be far-fetched to say—as others have said before me—that rigorous adjustment of a species in one special direction (by Neo-Darwinian and Neo-Lamarckian factors) tends to lessen the adjustability of the species to changed conditions of life. The factor which has brought about mimetic resemblance is, according to the theory of mimicry, selection; as it was in my letter on p. 153 not my intention to bring forth new facts, but to show that one of the arguments against the theory of mimicry was invalid, I had to accept selection as *the* factor, and accordingly explained the excess of rarity amongst mimetic species by assuming that rigorous one-sided selection makes the species physiologically one-sided, *i.e.* less fit to meet new conditions of life equally well as the non-mimetic, more variable, allied species, the result of which would be proportionally greater scarcity of individuals or even extinction. KARL JORDAN.

Zoological Museum, Tring, August 25.

INTERNATIONAL CONGRESS FOR THE UNIFICATION OF METHODS OF TESTING.

IN 1884 the late Prof. Bauschinger, of Munich, conceived the idea of bringing professional men engaged in testing materials into personal contact, with a view to initiating researches into the physical and chemical behaviour of structural materials. Congresses were held at Munich, Dresden, Berlin, Vienna, and Zürich; and at the last-named Congress it was decided to form a permanent International Association, which now numbers 1200 members; and under its auspices the sixth International Congress was held at Stockholm on August 23, 24 and 25. Prof. Tetmajer, of Zürich, presided, and 452 delegates from all parts of the world were present. One member of each nationality represented was elected an honorary president, the complete list being as follows: Mr. Ast (Austria), Mr. Greiner (Belgium), Prof. Hannover (Denmark), Mr. Peters (Germany), Mr. Bennett Brough (Great Britain), Mr. Baucke (Holland), Mr. Banowitz (Hungary), Mr. Fadda (Italy), Mr. Krag (Norway), Prof. Belelubsky (Russia), Mr. Nyberg (Finland), Mr. Akerman (Sweden), Mr. Schraft (Switzerland), Colonel Mayandia (Spain), and Mr. C. G. Henning (United States).

The list of papers presented comprised an account of the development of the iron, brick and cement industries of Sweden, by Mr. A. Wahlberg; a description of micro-metallography considered as a method of testing, by Mr.

F. Osmond; a plea for uniform international specifications for iron and steel, by Mr. Ast and Mr. Barba; and an account of the advantages to be derived from the formation of an international laboratory for investigating the methods of analysing iron and steel, by Dr. H. Wedding. In the last-mentioned paper it was pointed out that the relations of buyers and sellers in the iron and steel trades would be put on a much safer basis if standard methods were worked out so that any chemist of ordinary skill could be trusted to carry them out. This could best be done at a central laboratory, where the work done in various countries could be collated and reduced to a common standard. A competent director for such a laboratory had been found in Baron Jüptner, and ample accommodation had been granted at Zürich by the Swiss Government. Subscriptions towards the cost of maintenance for ten years had been promised by some of the large British and continental ironworks, and it was consequently decided to begin operations in January next.

In addition to the discussions bearing upon the testing of iron and steel, several important memoirs were discussed in the Section, dealing with artificial building materials, the principal ones being on the relation between the chemical composition of natural building stones and their resistance to weathering, by Mr. A. Buess (Hamburg); on the testing of earthenware pipes, by Mr. Gary (Berlin); on the hardening process of calcareous cements, by Mr. D. W. Michaelis (Berlin); and on the determination of the quality of hydraulic cements, by Mr. M. Meyer (Malstatt).

The governing body, consisting of Prof. Tetmajer, Prof. Martens (Berlin), Prof. Debray (Paris), Mr. Berger (Vienna), and Prof. Belelubsky (St. Petersburg), was re-elected; and, in view of the fact that the whole of the Council of the Iron and Steel Institute had joined the Association, it was decided to have representatives of the English-speaking countries on the governing body, Mr. R. A. Hadfield (Sheffield) and Captain Carter (U.S. Army) being those chosen. It was further decided that in future the proceedings of the Congress will be published in English, as well as in French and German.

THE RADIATION OF LIGHT IN THE MAGNETIC FIELD.

DURING the past few months some interesting experiments have been made regarding the partial polarisation of radiations emitted by certain luminous sources when they are placed under the influence of a magnetic field. Important investigations in this direction have been made by Dr. Zeeman, of the University of Leyden, who has shown that the perturbations experienced by the ions, under the influence of magnetic forces, produced new periods of luminous vibrations. Continuing this work, Messrs. Egoroff and Georgiewsky (*Comptes rendus*, April 5, 1897), with the aid of a Rowland grating and a Ruhmkorff coil, have observed a feeble broadening of the lines D_1 and D_2 in the spectra of both axial and equatorial radiations. In investigating the appearance of coloured flames of polarised rays by using the Savart analyser, it was observed that the partial rectilinear polarisation of rays directed towards the equator of the magnetic field was easily observed, not only in flames of sodium, lithium and potassium, but in induction sparks between magnesium electrodes. In the cases of carbon, aluminium, mercury, zinc, bismuth and iron, the Savart analyser showed no indication of rectilinear polarisation. In a second communication to the same journal (*Comptes rendus* for May 3), the results there enumerated may be summed up as follows. The relative quantity of equatorial radiations emitted by a sodium flame, and polarised rectilinearly, varies with the intensity of the magnetic field according to a particular curve. Under the influence of a magnetic field of given intensity, the quantity of the light polarised rectilinearly, and emitted equatorially by the sodium flame, varies with the temperature of the flame. In studying the change of spectra of metals in a field of considerable intensity, a modification of the method of procedure was adopted, and resulted in the discovery of the rectilinear polarisation of the equatorial radiations. Nearly all the metals employed—namely, Cu, Tl, Zn, Cd, In, Mg, Ca, Ba, &c.—showed polarisation exclusively for those rays that are easily reversed. The phenomenon, the authors state, "is observed in a very instructive manner for the copper in the green part of the spectrum (the change is very large for the ray 5105, most feeble for 5153, and zero for the long waves 5217 to 5292). For indium, the change only occurred for the violet ray at 4510, while the others (6193, 5230, 5900, 4680, 4616 and 4638) were not influenced by the field at all." In experiments with Geissler tubes containing hydrogen and helium, no definite results up to the present have been obtained.

In the experiments just referred to, it may be mentioned that all the observations were made with the eye. It would, however, be interesting to inquire whether the photographic plate would register these small variations, for then we should have a permanent record of a phenomenon which is not so very easy to observe, or which, at any rate, might be subject to "personal" error. The application of photography to show such effects has been accomplished by Mr. Alexander Anderson, assisted by Mr. Adeney. They employed a Rowland grating of 21·5 feet radius, and obtained photographs of the cadmium spectrum, the source of light being a spark between cadmium electrodes from the secondary of a large induction coil. Mr. Anderson's account of his experiments is briefly summarised as follows.

"Three lines are very distinct in all the photographs, namely, those of wave-lengths 5086, 4800, and 4678 tenth-metres. Photographs were taken, both without and with a magnetic field, the time of exposure being exactly the same in both cases. This field was produced by a large electro-magnet excited directly by a dynamo giving a pressure with open circuit of 70 volts, the flat poles of the electro-magnet being covered with ebonite, so that they could be brought very close to the cadmium electrodes without interfering with the sparking. The field thus produced was practically uniform, and its intensity was found to be about 17,000 C.G.S. units."

In the first photographs the slit width was about ·001 cm., but in the later photographs about twice this width was used. An examination of the photographs showed that there was no evidence of any effect of the magnetic field, though the definition of the lines was all that could be desired, namely, very clear and sharply defined. When it be remembered "that a length of one centimetre in the photograph corresponds to a change of wave-length of 26 tenth-metres, and since an increase of breadth of a line of one-tenth of a millimetre (and probably much less than this) could easily be seen on the photographs, there could not have been a change in the period of oscillation of as much as one part in 20,000."

To account for this negative result, Mr. Anderson suggests two possible reasons: viz. that perhaps the magnetic field was not of sufficient intensity, or that the exposure (thirty minutes for the narrow slit) was not long enough. He states, however, that with an eyepiece in place of the camera, he "saw (or fancied he saw) a widening of the lines."

The whole phenomenon of the widening of the lines in the spectra of metallic substances in a magnetic field is, however, of great interest to both physicists and astro-physicists, and it is important that both eye and photographic results should be obtained when possible.

SAMUEL EDWARD PEAL.

SAMUEL EDWARD PEAL, who died at Moran, Sibsagur, Assam, on July 29, was born December 31, 1834. Originally an artist, he went to India in 1862 as a tea planter, and it was while so engaged in 1873 that he discovered that the tea blight was due to the ravages of a kind of Aphis, "the tea bug of Assam," since named the *Helopelta theovora*, the life-history of which he worked out with suggestions for its extermination.

He was a Fellow of the Royal Geographical Society and of other Societies, and did good service in exploration among the Naga Hills, mainly with a view of showing the practicability of a direct route from India to China (the old Burmese route) over the Patkoi range, a work much appreciated by the Indian Government.

As a philologist his acquaintance with the various dialects of the hill men, and his great tact in dealing with them, made his presence acceptable where others had failed.

He devoted many years to the study of the grasses and trees of Assam and their life-histories, and had completed and profusely illustrated his work upon them, when the bungalow (during his absence) was destroyed by fire with all its contents, and his many years of labour wasted.

Astronomy of late years occupied his attention, and his theory of lunar surfacing as due to glaciation is gradually becoming accepted. He also wrote a paper "On a Possible Cause of Lunar Libration, &c." He was a frequent contributor to the Indian press, and also to the columns of NATURE, on various natural history subjects, and had recently traced the connection between the Dyaks of Borneo and some aboriginals of Assam. Having resided thirty-five years in Assam, he was considered the *doyen* of the Europeans of the province, and being held in high esteem, his loss will be severely felt.

NOTES.

THE concluding general meeting of the British Association at Toronto was held on Wednesday, August 25. Special thanks were accorded to Prof. Macallum, the leading local secretary, for the active share he had taken in making the meeting such a very successful one. The total attendance at the meeting was announced as 1362. The *Times* correspondent reports the following facts of interest:—Among the important new grants are 50*l*. towards the Meteorological Observatory in Montreal, 75*l*. for the biology of the lakes of Ontario, 125*l*. for the anthropology and natural history of Torres Straits, 100*l*. for the investigation of changes associated with the activity of nerve cells—total grants, 1350*l*. A new committee of great importance has been appointed. The Council was requested to consider the desirability of approaching the Government with a view to the establishment in Great Britain of experimental agricultural stations similar in character to those which are producing such satisfactory results in Canada. The committee is to report on the means by which in various countries agriculture is advanced by research, by special educational institutions, and by the dissemination of information and advice among agriculturists. The Association is to meet in Bristol next year, and in Dover in 1899.

THE Chancellor of the Exchequer has informed the executors of the late Sir Wollaston Franks that he will remit the estate duty on the bequest to the British Museum of the valuable collections and books which he left to it on that condition (see p. 275). The collection has therefore now been handed over.

IT is reported that the Duke of the Abruzzi (Prince Luigi of Savoy) and his party reached the summit of Mount St. Elias, at an altitude of 19,000 feet, on July 31. The expedition, which was the most successful that has ever undertaken the ascent of Mount St. Elias, passed fifty-one days on the ice and snow. It is stated that the explorers declare that they did not see the slightest indication that Mount St. Elias had been volcanic.

THE Committee on Indexing Chemical Literature presented its fifteenth annual report to the American Association for the Advancement of Science at the recent meeting. From the report we learn that a bibliography of the metals of the platinum group, 1748–1896, by Prof. James Lewis Howe, and a review and bibliography of metallic carbides, by Mr. J. A. Mathews, have been completed, and have been recommended to the Smithsonian Institution for publication. A bibliography of basic slags, technical, analytical and agricultural, has been completed by Karl T. McElroy. The channel of publication has not been determined. The second edition of the catalogue of scientific and technical periodicals, 1665–1895, by Dr. H. Carrington Bolton, is entirely printed, but has not yet been published. The new edition contains 8603 titles. A supplement to the select bibliography of chemistry, 1492–1896, has also been completed by Dr. Bolton, who has presented the MS. to the Smithsonian Institution. This supplement contains about 9000 titles, including many chemical dissertations, and is brought down to the end of the year 1896. Progress is also being made with an index to the literature of thorium; an index to the literature of tantalum; a bibliography of oxygen; and a bibliography of the constitution of morphine and related alkaloids. Letters for the Committee should be addressed to the Chairman, Dr. H. Carrington Bolton, at Cosmos Club, Washington, D.C.

MORE than seven thousand members attended the twelfth International Medical Congress held at Moscow on August 19–26. From a report in the *Lancet*, we learn that the Grand Duke Sergé Alexandrovitch officially opened the Congress on August 19, in the presence of a brilliant assembly; Count Delianof then delivered a short address of welcome in the Latin tongue. Prof. Sklifosovski, president of the organising committee, also delivered an address. Prof. Roth, the general secretary, then gave an account of the preliminary labours of the organising and executive committees. The recent Congress was larger than any of its predecessors, the number of members exceeding 7300, more than half of whom came from abroad. Prince Galitzin, the Mayor of Moscow, welcomed the members of the Congress in the name of the city of Moscow, and added that to commemorate the event the municipality had decided to offer a triennial prize for the best work on some selected medical subject. After brief addresses by the delegates of the different countries represented at the Congress, Prof. Virchow gave an address upon "The Continuity of Life as the Basis of Biological Science." The second address was by Prof. Lannelongue, who had for his subject "The Surgical Treatment of Tuberculosis." Dr. Lauder Brunton then read an address on "The Relations between Physiology, Pharmacology, Pathology, and Practical Medicine." This address is printed in the current number of the *Lancet* (August 28).

THE sixty-fifth annual meeting of the British Medical Association was opened at Montreal on Tuesday. This is the first occasion on which the Association has met outside the British Isles. About two thousand delegates from all parts of the British Empire are attending the meeting. The French Government sent Dr. Charles Richet as its official representative, and about four hundred leading American physicians are present. The opening meeting took place on Tuesday afternoon. The Mayor of Montreal welcomed the Association on behalf of the city; while Sir A. Chapleau, French Canadian Lieutenant-Governor, and Lord Aberdeen, expressed the welcome of the province and the Dominion respectively. Dr. T. G. Roddick, Professor of Surgery in the McGill University, and president of the Association, then delivered an address on the objects of the

Association, Canadian climatology, and the state of medical education in Canada. A vote of thanks for the address was proposed by Lord Lister, and seconded by Sir James Grant. Upon the evening of Tuesday Prof. Richet delivered a lecture upon Pasteur and his work.

THE annual general meeting of the Federated Institution of Mining Engineers will be held in Edinburgh on September 14–16. The following papers are among those to be read or taken as read:—"Submarine Coal-mining at Bridgeness," by Mr. Henry M. Cadell. "Alternating Multiphase Machinery for Electric-power Transmission," by Mr. Walter Dixon. "Observations on some Gold-bearing Veins on the Coolgardie, Yilgarn, and Murchison Gold-fields, Western Australia," by Mr. Edward Halse. "The South Rand Coal-field and its connection with the Witwatersrand Banket Formation," by Mr. A. R. Sawyer.

IN the *Atti dei Lincei*, vi. 2 (July 18), Dr. Calandruccio and Signor Grassi give a brief account of their latest observations on the metamorphoses of the Murienoids. The authors have followed the transformation into the cæcal stage of several *Leptocephalus brevirostris* having their larval teeth still intact. This transformation takes place without the animal burying itself in sand. It is noteworthy, too, that the anterior and posterior extremities of the body have already acquired nearly all the characteristics of the cæcal stage when the remainder of the body is still far from possessing them. The Leptocephaloids of *Myrus vulgaris* are very similar to those of *Ophichthys hispanus* (= *O. remicaudus*). The Tiluroids may in all probability be referred to *Serrivomer*. Dr. Calandruccio and Signor Grassi have now observed the larval and semi-larval stages of all the Murenoids of the Mediterranean, with the exception of the very rare *Chlopsis bicolor* and the occasional *Murænesox savanna*.

A METHOD of determining the heights of clouds, and especially of the ill-defined stratus cloud, by means of the search light, was suggested by Prof. Cleveland Abbe many years ago. It was proposed to establish a search light, the beams of which should be vertical; the apparent altitude of the centre of the luminous spot of the cloud was to be observed from a station not far away, and the height was a matter of easy calculation. Prof. Abbe returns to the subject in the *Monthly Weather Review* (May), and points out that with the great increase in the power of the modern search light, further applications have become practicable; thus in harbours on the sea-coast, where one wishes to ascertain the presence and development of low-lying fogs, the search light which renders them visible is an invaluable assistant. A year ago some accounts were published relative to the cloud effects on Mount Low and Pasadena. According to these accounts Mount Low is about 15 miles north-north-east from Los Angeles, and about 6 miles in a straight line from Pasadena. When the beam of light fell upon the bodies of clouds they at once became luminous, so that all the details of motion were visible; when the beam fell upon the falling rain, the great cone of light glowed like molten metal. It seems, concludes Prof. Abbe, that the formation and motion of fog and cloud at night-time could be advantageously studied by means of the search light. The height at which fog first forms, and its gradual extension upwards and downwards during the night, would be a very interesting and profitable investigation.

THE disturbance of submarine cable working by electric tramways forms the subject of a paper by Mr. A. P. Trotter in the *Journal* of the Institution of Electrical Engineers. As soon as the electric tramway service was started at Cape Town, the working of the syphon recorder of the submarine cable of the Eastern and South African Telegraph Company was found to be seriously affected. When the tramcars were started and when they were stopped, "kicks" were recorded by the syphon recorder, and these being superimposed upon the received signals made it difficult and often impossible to read the message. The first mile of the cable was at a mean distance of about half a mile from the tramway. After a long series of experiments Mr. Trotter found that the only way to cancel the disturbances was to lay a new cable of about five miles long as nearly as possible over the old one, the cable terminating in an earth plate. As soon as this had been done the traffic was resumed, and no appreciable disturbances of the recorder took place. In the discussion upon the paper, Mr. W. H. Preece said that similar disturbances occurred wherever electrical tramways, and telegraphs, submarine or overland, existed together. Prof. Ayrton gave an account of observations of magnetic disturbances over the whole neighbourhood of the City and South London Electric Railway, which runs underground between London Bridge and Stockwell. The suspended magnet used in the investigation showed that disturbances of the earth's magnetic field occurred throughout the whole region of the line, and were caused either by magnets or masses of iron in the passing trains, or by currents passing through the earth.

AMONG many other papers in the *Proceedings* of the Indiana Academy of Science, dated 1894, but only just received, is one by Mr. D. T. MacDougal, showing that various species of Cypripedium have an irritant action upon the human skin. It was found that when the leaves of *C. spectabile* were rubbed lightly upon the skin of the wrist, arm, face, or ear, the person experimented upon was usually "poisoned" in a degree corresponding to the manner of application, and in a time varying from ten to twelve hours. There could be no doubt about the unpleasant effects produced by the leaves, for Mr. MacDougal soon found that he could not obtain subjects willing to sacrifice their feelings upon the altar of scientific knowledge. He was able to prove, however, that similar painful effects were produced by *C. pubiscens* and *C. parviflorum*. To ascertain whether the effect was due to the mechanical injury resulting from piercing the skin by the pointed hairs upon the leaves, or to the corrosive action of the secretion found on the outside of the globular tips of the glandular hairs, separate tests were made by material from *C. spectabile*. The hairs of each kind were taken from the leaf by means of a pair of fine forceps, and the tip pressed against the skin. Irritation was found to result from the contact of the glandular hair only. It was found, further, that the irritant action of the plant increased with the development of the plant, and reached its maximum with the formation of the seed-pod, from which it is inferred that this is a device for the protection of the reproductive bodies during the period from pollination to the maturity of the seeds.

THE *Sitzungsberichte der Physikalisch-medicineschen Societät in Erlangen* for 1896 contains a paper, by M. Willibald Hoftmann, on the forces exerted by an electric field on an incandescent electric lamp, through which a current is flowing. When a highly exhausted vacuum tube is placed in the neighbourhood of such a lamp, it is found that, with discharges of moderate frequency, the filament begins to oscillate; more rapid discharges, however, impart to the filament a certain rigidity of position, which causes it to tend to maintain a fixed distance from the discharge-tube when the lamp is moved about. The author investigates the cause of these phenomena.—The same volume contains papers by Alfred Bettinghaus, on the geology of the Rathsberg plateau; by Dr. Gotthold Fuchs, on certain aniline derivatives and their physiological action; by Dr. Fritz Glatzel, on the alkalimetry of the blood; and by Dr. Joseph Rosenthal, on Röntgen rays.

THOSE interested in the properties of kathodic and allied rays, will find quite a series of papers in the last five numbers of the *Atti della R. Accademia dei Lincei*. Among these we would call especial attention to the following:—On the action of electricity on the discharging property induced in air by *x*-rays, by Prof. E. Villari (vol. vi. part 1, p. 343).—On the penetrating power of the same rays, by A. Ròiti (*ibid.* p. 354).—On electric discharge in gases, and on certain phenomena of electrolysis, by Vito Volterra (*ibid.* p. 389), dealing with phenomena allied to those observed by Sella and Majorana, in connection with the action of Röntgen and ultra-violet rays on the electric spark.—On the electrostatic charges generated by kathodic rays, by Q. Majorana (vol. vi. part 2, p. 16), who finds that the emanation of kathodic rays depends to a certain extent on the position of the anode.—On the discharging action of air after being traversed by *x*-rays, by Dr. Adolfo Campetti (*ibid.* p. 43), who considers that the so-called effects of dispersion by air, modified either by *x*-rays or by combustion, depends on a temporary increase in the conductivity of the gas.—On the non-penetration of electric waves into the space enclosed by a metallic shell, by Prof. Augusto Righi (*ibid.* p. 59).—On the velocity of kathodic rays, by Q. Majorana (*ibid.* p. 66), who obtains values for the velocity ranging from 100 to 600 kilometres per second.—On the double refraction of wood for electro-magnetic waves, by Prof. Domenico Mazzotto (*ibid.* p. 73), who finds (*a*) that the index of refraction varies considerably in different woods, and increases with the density; (*b*) that in the same wood electric oscillations perpendicular to the fibres are propagated more rapidly than those parallel to the fibres, and, hence, the index of refraction is less for the former; (*c*) that the difference between the two indices is less for dense than for light woods.

THE action of light on various kinds of yeasts has lately been elaborately investigated by W. Lohmann. Kry has shown that the division of the cell in the case of *Sacch. cerevisiæ* takes place as vigorously in the presence of moderate light as in the dark, but the action of intense light upon this and other varieties of yeast has been studied by Lohmann. Exposure to the electric light, 11,590 candle-power, was found to exert a distinctly retarding action on the multiplication of these yeast cells. The sun's rays were, however, much more detrimental to their vitality, for after several hours' direct and uninterrupted insolation in the months of May and June, the rise in temperature being prevented by immersion of the agar-dishes containing the yeast cells in water, the latter were entirely destroyed. On the other hand, yeast cells kept in the dark during the same period of time, or only exposed intermittently to feeble sunshine, exhibited distinct multiplication. A microscopic examination revealed also a striking morphological difference between the cells kept in the dark and those which had been insolated. Whereas the former presented a perfectly normal appearance, the latter looked shrunken, exhibited irregular contours, and the plasma was drawn together in lumps, chiefly in the direction of the poles of the cells. Similar insolation experiments on other varieties of yeast exhibited the same lethal effect produced on these organisms by prolonged exposure to direct sunshine.

A NEW edition (the fourth) of Mr. Howard Collins' "Epitome of the Synthetic Philosophy of Herbert Spencer" (Williams and Norgate) has just been published. Mr. Spencer contributes a brief introduction to the volume, which is now a representation in miniature (if the word can be applied to a volume of nearly seven hundred pages) of the whole of his philosophy.—Dr. Max Verworn's "Allgemeine Physiologie" (Jena: Gustav Fischer), the first edition of which appeared early in 1895, has reached a second edition. Shortly after the original work appeared, its scope and many valuable qualities were described in these columns (vol li. p. 529). The volume has been thoroughly revised, and will doubtless pass through many more editions. English and Italian translations are being prepared. A Russian edition appeared some time ago, but Dr. Verworn states that it was published without his authority.

THE following are among the articles and other publications which have come under our notice within the past few days:—"On the Development and Structure of Dental Enamel," by Dr. J. Leon Williams, in the *Journal* of the Royal Microscopical Society (August). The paper is illustrated with several excellent photo-micrographs showing various phases of enamel development.—The Chemical Society has just issued the annual supplementary number of its *Journal*, containing title-pages, contents, and indexes of volumes lxix. and lxx. (1896). To chemists this record of contributions to chemistry must be invaluable.—Following other scientific instrument-makers, Messrs. Howard B. Little and Co. have prepared and issued an illustrated list of apparatus and accessories for work with Röntgen rays. Persons who require an efficient outfit at a reasonable price should see Messrs. Little's list.—A description of the various forms of Australian bullroarers, accompanied by illustrative drawings, is contributed to the *Journal* of the Anthropological Institute (August), by Mr. R. H. Mathews. The same publication contains papers on the Berbers of Morocco, by Mr. W. B. Harris; Káfiristan and its people, by Sir George Scott Robertson; and further discoveries of ancient stone implements in Somaliland, by Mr. H. W. Seton-Karr.—In the *Journal* of the Royal Horticultural Society (August) are papers on the study of microscopic organisms, and its importance to horticulturists, farmers, and foresters, by Prof. Marshall Ward, F.R.S.; diseases of plants, by Mr. George Massee; and the physiology of pitcher-plants, by Prof. Sydney H. Vines, F.R.S.—Dr. C. M. Aikman has sent us a pamphlet on "Sixty Years of Agricultural Science," reprinted from the *Agricultural Gazette*.—*The Quarterly Journal* of the Royal Meteorological Society (July), just issued, contains a report of a lecture by Mr. G. J. Symons, F.R.S., on "Meteorological Instruments in 1837 and in 1897," with plates illustrating the types of instruments employed sixty years ago and now in meteorological observations.

THE additions to the Zoological Society's Gardens during the past week include a Mozambique Monkey (*Cercopithecus pygerythrus*) from South-east Africa, presented by Mrs. Charlesworth; five Australian Bush Rats (*Mus arboricola*) from New South Wales, presented by Mr. Edgar R. Waite; two Egyptian Kites (*Milvus ægyptius*) from South Africa, presented by Mr. G. A. Ogilvie; a Mountain Ka-Ka (*Nestor notabilis*) from New Zealand, presented by Mr. Arthur Hope; two Ravens (*Corvus corax*), British, presented by Mr. W. B. Bingham; a Turtle Dove (*Turtur communis*), British, presented by Miss Mallard; a Purple Sunbird (*Cinnyris asiaticus*) from India, presented by Mr. Frank Finn; a Tawny Owl (*Syrnium aluco*), British, presented by Mr. C. Hastings Bostock; two Ring-necked Parrakeets (*Palæornis torquatus*) from India, presented by Miss M. Parsons; a European Pond Tortoise (*Emys orbicularis*), European, presented by Mr. F. E. Bastian; a Goliath Beetle (*Goliathus druryi*) from the Gold Coast, presented by Mr. W. Durham Hall; a —— Spider (*Mygale*, sp. inc.) from South Africa, presented by Mr. Rowland Ward; a Feline Genet (*Genetta felina*), a Delalande's Lizard (*Nucos delalandii*), a Puff Adder (*Bitis arietans*), a Cape Bucephalus (*Dispholidus typus*), a Rough-keeled Snake (*Dasypeltis scabra*), two Rhomb-marked Snakes (*Trimerorhinus rhombeatus*), an Infernal Snake (*Boodon infernalis*), two Lineated Snakes (*Boodon lineatus*), a Rufescent

Snake (*Leptodira hotambœia*), three Crossed Snakes (*Psammophis crucifer*) from Port Elizabeth, South Africa, presented by Mr. J. E. Matcham; a Brown Capuchin (*Cebus fatuellus*) from Guiana, deposited; a Rough Fox (*Canis rudis*) from Guiana, two Black-throated Weaver Birds (*Ploceus atrigularis*), two Bengal Weaver Birds (*Ploceus bengalensis*) from India, purchased; a Barbary Wild Sheep (*Ovis tragelaphus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

RELATIONSHIP BETWEEN THE MASSES AND DISTANCES OF THE PLANETS.—In a previous number of NATURE (vol. lv. No. 1433) Mr. G. E. Sutcliffe, writing from Bombay, suggested a relationship between the masses and distances of the four superior planets. He found that when the masses and distance of each of the planets were multiplied together, the resulting numbers formed a series in geometrical progression having a common ratio of 1·8391, this latter number being nearly equal to the mean distance of Saturn (1·8338) when the mean distance of Jupiter is taken as unity. In a recent communication to us he has worked out the case of the inferior planets, with the result that the relationship of these planets to one another is not the same as obtained in the previous investigation. The ratios are still, however, in powers of the same value of R (the common ratio), namely 1·8391; and for this reason Mr. Sutcliffe suggests that this number is perhaps one of the constants of the solar system. In the same communication he gives a formula which expresses the mass of the sun in terms of the masses and distances of Venus, the earth and the moon, and from this he investigates the question of whether there is a planet which bears the same relationship to Jupiter that the earth and moon do to Venus. The mass, distance, and period of this hypothetical planet are given, but we doubt considerably its actual existence.

THE MADRAS OBSERVATORY.—Mr. C. Michie-Smith, the Government astronomer at Madras, tells us in his report for the year ending March 31, that, as regards the staff, the Government has sanctioned the revival of the appointment of a chief assistant. The past year has been conspicuous by the great amount of heavy rain, and both the director's and assistants' houses have suffered considerably. Observations for time have, as usual, been carried on, and the investigation for the determination of the divisions error of the Meridian Circle has been completed, no less than 72,192 micrometer readings being employed. The Madras Catalogue has further advanced, and the mean places for the first sixteen hours have been deduced. Proposals have been sanctioned for observing the total eclipse of the sun next January, and Karad has been fixed upon as the most suitable station.

STATIONS FOR OBSERVING THE TOTAL ECLIPSE OF THE SUN IN JANUARY 1898.

THE land path of the line of the total eclipse of the sun commences from a little south of Ratnagiri, on the Bombay coast, and runs in a north-easterly direction to Nepal, passing nearly over Mount Everest, and then disappears in Thibet. The shadow of the moon will therefore pass through parts of the Bombay Presidency, through Hyderabad, Berars, Central Provinces, and parts of Central India, Bengal, and North-west Provinces. The length of the path through India is about a thousand miles, and the width of the shadow roughly fifty miles. Hence the area from which observations *could* be taken is enormous. In India, however, facilities for travelling simply do not exist at all over by far the greater part of the country; and as accommodation for European travellers is even more scanty than the means of transport, the number of stations from which observations of the forthcoming eclipse are likely to be made is much smaller than would be expected. As the duration of the total phase of the eclipse on the central line decreases from about two minutes ten seconds on the Bombay coast, to about one minute forty seconds in parts of Bengal and the North-west Provinces, the natural tendency will be for observers to prefer the western stations. In addition, too, it would appear that the meteorological conditions are more favourable at the western than at the eastern or central stations on the line of totality.

The majority of travellers visiting India for the purpose of observing or seeing the total eclipse will land either at Bombay or Calcutta, probably at the former station. From Bombay several parts of the line of totality can be comfortably visited. The stations on the Bombay coast can be very easily reached by the local steamers of the Bombay Steam Navigation Company. As at present arranged, there is a daily passenger steamer to and from Bombay, calling at such ports as Ratnagiri and Viziadurg, which are close to the central line, and at Jaygad, which is close to the north limit of the line of totality, and at Dewgad, which if just within the southern limit. Combined passenger and cargo steamers also leave Bombay for some of these ports twice or three times weekly. The journey only takes from twelve to eighteen hours each way. The fares are cheap, the first-class fare from Bombay to Ratnagiri being seven rupees; the second, two rupees; and the third, one rupee four annas. It should be remembered that these fares do not include food; also that the steamers are small, even the combined passenger and cargo steamers having only about five cabins. Hence passengers should take their own bedding and food, and, for comfort's sake, should travel with their own servants.

Several other points on the line of totality can be reached by the railway from Bombay. Commencing with the lines of communication from the west side of India, the train can be taken *viâ* Kalyan Junction to Poona, passing through the Ghats. From Poona two lines diverge, one to Satara, which is a little north of the central line of totality and well within the northern limit, and from thence to Koregaon, &c., while the second line passes through Sholapur to Hyderabad, &c.; but on this second line there are no considerable stations within the line of totality, nor are there any towns within reasonable distance of the railway, though the smaller stations of Indapur and Kumbhargaon may be easily reached.

Another section of the line of totality can be visited from Bombay by the Great Indian Peninsular Railway *viâ* Kalyan Junction to Bhusawal Junction, proceeding thence to Amraoti, Pulgaon, Warda, and Nagpore. Pulgaon and Nagpore are said to be good stations for the purpose of observation. It should also be stated that Nagpore can be easily reached from Calcutta by the East Indian and Bengal Nagpore lines of railway, the latter railway being joined at Assensole Junction on the East Indian Railway.

Another section of the line of totality can be reached by continuing the journey by the Great Indian Peninsular Railway from Bhusawal Junction to Jubbalpore, where the East Indian Railway is joined, and then passing southwards from Katni by the Bilaspur branch. Again, this railway line crosses the path of the moon's shadow at a point where there are no towns of any importance.

The other parts of the line of totality which are crossed by the lines of railway could be reached either from Bombay by continuing the journey from Bombay to Allahabad, and then turning southwards on the East Indian main line, or more easily by making Calcutta the starting point, and proceeding northwards from there. The main line of the East Indian Railway crosses the line of totality from a little south of Benares to a little north of Arrah, the considerable station of Buxar being almost on the central line. There is also a small branch line leading to Ghazipur, which is said to be a good place for observations, and is also a fair-sized station. Again, leaving the East Indian Railway at Bankipore by means of the Bengal and North-western Railway, the path of the shadow can be easily visited, the considerable station of Chupra being near the southern limit. Again, by leaving the East Indian Railway at Mokameh, two sections of the shadow path can be reached by the Bengal and North-western and Tirhoot Railway, and the most considerable station on these two lines is Motiharee.

There are, therefore, eight sections of the path of the eclipse which are cut by various railways, in addition to the coast line which can be reached by the line of steamers: so that nine sections, or stations on the central line, could be easily occupied if necessary.

A considerable amount of local information as to sites suitable for observing parties has been collected by a committee of the Asiatic Society of Bengal at Calcutta,[1] and in connection with

[1] Copies of the information collected could probably be obtained by application to the Honorary Secretary, Bengal Asiatic Society, 57 Park Street, Calcutta.

the inquiries made, the various railway companies on which observing parties would have to travel have very liberally promised to make considerable reductions from their usual rates of fares, and for carriage of luggage, instruments, camp furniture, &c., to all *bonâ fide* observers and observing parties. Thus the Southern Mahratta Railway, running in the West of India, offer to give free passes to all observers; the Great Indian Peninsular Railway will allow all parties of observers to travel at half rates on ordinary trains; and the East Indian, Bengal and North-western and Bengal Nagpore Railways will make a reduction of 25 per cent. from their fares, &c., to observers and observing parties.

It must not, however, be thought that the conditions in India for parties travelling are the same as in England or Europe generally. Food can be had at the various refreshment rooms on all the main lines of railway, but on the branch lines the passenger has frequently to carry his own food. Again, all first and second class passengers travelling at night in Indian railways are entitled to a sleeping berth without extra charge; but each passenger must provide his own pillows, rugs, &c., if he wishes to be comfortable.

Again, in the matter of accommodation for visitors, conditions in Indian towns and villages are very different from those in Europe. At such towns as Calcutta, Bombay and Benares hotel accommodation is fairly plentiful; but even here at certain seasons of the year the demand is larger than the supply, and rooms should be engaged beforehand.

Except at such large towns as those mentioned, or at places on the usual route of tourists, hotels are not to be found, and in the great majority of cases travellers in India have to make their own arrangements for living and accommodation. At the headquarters stations in the various districts into which India is divided, it is true that Government keeps up small houses called district or travellers' bungalows, or in Bengal called dák bungalows. Travellers' bungalows are to found at Ratnagiri, also at Indapur and Kumbhargaon in the Sholapur district, Satara (probably), Nagpore, Ghazipur (empty bungalows), Robertsganj (near Mirzapur), Ballia (near Buxar), Chupra, &c. Such bungalows usually contain three or four rooms and are provided with necessary, but not luxurious furniture, and a few servants are in attendance. A small fee is charged for residence; but in the event of a stay of more than twenty-four hours being made, a new arrival has a prior claim to be accommodated over the older residents. The servants at these bungalows can usually provide plain food. Small waiting rooms are to be found at most of the stations on the various lines of railway crossing the path of the eclipse; and the railway companies would probably allow observers to occupy these, but in such cases travellers would have to make their own arrangements for living and sleeping. Failing travellers' bungalows or the waiting rooms at stations, the only plan would be to camp out, and this will probably have to be done in the great majority of cases. Tents and camp furniture can be purchased, and in some cases hired at large towns in India; and in addition the Government of India in the Military Department have promised to lend tents and the ordinary articles of camp furniture *as far as they may be available* for the use of *bonâ fide* scientific observers who may come out to India for the purpose of witnessing the total eclipse of the sun. Probably, also, tents could be procured in some instances from the Magistrates and Collectors and other officials of districts who would be certain to give every assistance in their power to observing parties. Here, again, arrangements would have to be made by each party or person as to servants, commissariat, &c. If any station were selected at a distance from large towns or headquarters of districts, arrangements for food would have to be made beforehand, for only things like fowls, eggs, milk, rice, &c., can be purchased at the smaller stations. Indian servants can, however, always be procured who are accustomed to camp life, and who can take the greater part of the responsibility in making such arrangements.

In a few cases the easily accessible sites near to lines of railway communication are situated in districts where there are European Indigo and other factories. This is especially the case in Bengal, where the line of totality actually passes through Tirhoot, &c. The managers and other European gentlemen in charge of such factories have a well-deserved reputation for almost boundless hospitality, and an observing party stationed in such a district would be certain of a warm and hearty welcome. The districts, however, in which European planters reside in India are, unfortunately for travellers, comparatively few.

THE BRITISH ASSOCIATION.

TORONTO, *August* 18.

WE are now at the opening day of the meeting, and the various parties of members have converged upon Toronto from different directions. The President, the President-elect, and a number of others, including most of the sectional officers, crossed in the *Parisian*, leaving Liverpool on August 5. During the voyage an Anthropometrical Laboratory was opened, and the heads of the *Parisians* were duly measured and recorded. Townets were worked continuously day and night from the Irish Sea to the St. Lawrence, so as to obtain a section across the plankton of the North Atlantic.

Lord Lister, Sir John Evans, and the other members of the party from the *Parisian* visited Montreal on Monday, and met with a most cordial reception from the Governors, Principal and Fellows of the McGill University. After an address of welcome the party was taken round the splendidly equipped College laboratories, was entertained to luncheon, and was then taken for a drive round the town. Ottawa, with its Government experimental farm, its important Geological Museum, and its extensive timber-yards and saw-mills, was visited yesterday, when Prof. Robertson of the Agricultural Department, Prof. Bovey of McGill University, the Mayor of Ottawa, and some other citizens kindly enabled the visitors to see as much as possible in the time.

Toronto, we have been told, owes its name to the Indians, who originally called it "a place of meetings." To us it seems excellently suited for a place of meeting at the present day. The convenient system of electric tram-cars, the ample accommodation for sectional and other meetings, the natural objects of interest around, the enthusiasm and hospitality of the inhabitants, combine to give all the necessary local elements for a successful meeting.

The meeting, of course, will not be a very large one. The number is now about 1100, which may be regarded as satisfactory. The Massey Hall, in which the presidential address and the evening lectures will be delivered, is a splendid building—probably unnecessarily large for the audience. The reception room and the sectional meeting rooms are located in the various buildings of the University, surrounded by fine grounds. The Secretarium, in the same park, occupies the Wycliffe College, where Prof. and Mrs. Macallum act as hosts. In addition to private hospitality, there is a full list of garden-parties and excursions. The local authorities and the railway, steamboat and telegraph companies have with great liberality given abundant facilities for travel and intercommunication to their visitors from Europe.

This afternoon a formal welcome will be given to the Association by his Excellency the Governor-General, and by the Mayor and Council of Toronto. We find that the presidential address to-night, and the sectional addresses to-morrow, are being looked forward to by our hosts with keen interest. In order to enable those members who take a general rather than a special interest to hear as many of the presidential addresses as possible, the Sectional Committees have wisely, by re-arrangement of programmes, dovetailed the addresses so as to have less clashing than usual. For example, in the Biological Sections the address in I will take place at 10.30, that in D at 11.30, while those of H and K have been postponed till the following forenoon.

One hears in every section that the prospect of papers and interesting matter for discussion is good; a fair number of papers are contributed by Canadians and Americans, and the work in several of the sections has distinct reference to the country in which we are meeting. W. A. HERDMAN.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY PROF. SIR WILLIAM TURNER, M.B., LL.D, D.C.L., D.Sc., F.R.SS., L. AND E., PRESIDENT OF THE SECTION.

Some Distinctive Characters of Human Structure.

WHEN the British Association for the Advancement of Science held its first Canadian meeting at Montreal in 1884, the subject of Anthropology, or the Science of Man, attained on that occasion for the first time the rank of an independent Section.

It was presided over by the accomplished writer and learned anthropologist, Dr. E. B. Tylor, who selected as the subject-matter of his opening address several prominent questions in Anthropology, with special reference to their American aspects. For example, the question of the presence of a stone age in America; whether the aborigines are descendants and representatives of man of the post-glacial period; the question of the Asiatic origin of the American Indians, and the arguments derived from anatomical structure, language, and social framework, bearing upon this theory. The traces of Asiatic influence in the picture writings of the Aztecs, correspondences in the calendar cycles of Mexico and Central America with those of Eastern Asia, and the common use of certain games of chance were also referred to.

It is not my intention, even had I possessed the requisite knowledge, to enlarge on the topics so ably discussed by my eminent predecessor. As my own studies have been more especially directed to the physical side of Anthropology, rather than to its archæological, historical, philological, moral and social departments, I naturally prefer to call your attention to those aspects of the subject which have from time to time come within the range of my personal cognisance. I have selected as the subject of my address "Some Distinctive Characters of Human Structure."

When we look at man and contrast his form and appearance with other vertebrate creatures, the first thing probably to strike us is his capability of assuming an attitude, which we distinguish by the distinctive term, the erect attitude. In this position the head is balanced on the summit of the spine, the lower limbs are elongated into two columns of support for standing on two feet, or for walking, so that man's body is perpendicular to the surface on which he stands or moves, and his mode of progression is bipedal. As a consequence of this, two of his limbs, the arms, are liberated from locomotor functions; they acquire great freedom and range of movement at the shoulder-joint, as well as considerable movement at the elbow and between the two bones of the forearm; the hands also are modified to serve as organs of prehension, which minister to the purposes of his higher intelligence. The erect position constitutes a striking contrast to the attitude assumed by fish, amphibia, and reptiles when at rest or moving, in which vertebrates the body is horizontal and more or less parallel to the surface on which they move. Birds, although far removed from the erect attitude, yet show a closer approximation to it than the lower vertebrates or even the quadrupedal mammals. But of all vertebrates, those which most nearly approximate to man in the position assumed by the body when standing and walking are the higher apes.

The various adaptations of structure in the trunk, limbs, head, and brain which conduce to give man this characteristic attitude are essential parts of his bodily organisation, and constitute the structural test which one employs in answering the question whether a particular organism is or is not human.

These adaptations of parts are not mere random arrangements, made at haphazard and without a common purpose; but are correlated and harmonised so as to produce a being capable of taking a distinctive position in the universe, superior to that which any other organism can possibly assume. If we could imagine a fish, a reptile, or a quadruped to be provided with as highly developed a brain as man possesses, the horizontal attitude of these animals would effectually impede its full and proper use, so that it would be of but little advantage to them. It is essential, therefore, for the discharge of the higher faculties of man, that the human brain should be conjoined with the erect attitude of the body. The passage of a vertebrate organism from the horizontal position, say of a fish, in which the back, with its contained spinal column, is uppermost, and the head is in front, to the vertical or erect position of a man, in which the back, with its contained spinal column, is behind, and the head is uppermost, may be taken as expressing the full range and limit of evolution, so far as the attitude is concerned, of which such an organism is capable. Any further revolution of the body, as in the backward direction, would throw the back downwards, the head backwards, and would constitute a degradation. It would not be an advance in the adaptation of structure to the duties to be discharged, but rather an approach to the relation of parts existing so generally in invertebrate organisms.

At an early period in the evolution of the human mind and intelligence an anthropomorphic conception of the Deity arose, to whom were ascribed the possession of the bodily form and attitude of man, and even human affections and passions. This idea took so firm possession of the imagination that, in the course of time, it obtained objective expression in the statues of ancient Greece and Rome and in the masterpieces of Christian art. In one of the most ancient of all books, in which is embodied the conception entertained by the Jewish writers of the Genesis of the world, and of all creatures that have life, we read that "God created man in His own image, in the image of God created He him, male and female created He them." By the association, therefore, of the human form with the idea of Deity, there was naturally present in the minds of these writers, although not expressed in precise anatomical language, a full recognition of the dignity of the human body, of its superiority to that of all other creatures, and that the human form was the crown and glory of all organic nature.

This conception of the dignity of man in nature is not confined to those writings which we are accustomed to call sacred. The immortal Greek philosopher and naturalist, Aristotle, in his treatise "On the Parts of Animals," composed at least three hundred years B.C., refers more than once to the erect attitude of man, and associates it with his "God-like nature and God-like essence." In the second century of our present era lived another Greek author, Claudius Galen, whose writings exercised for many centuries a dominating influence in medicine and anatomy, comparable to that wielded by Aristotle in philosophy. Although Galen, as has been shown by Vesalius and other subsequent anatomists, was often incorrect in his descriptions of the internal parts of the human body, doubtless because his opportunities of dissection were so scanty, he had attained a correct conception of the perfection of its external form, and he thoroughly understood that in its construction it was admirably fitted for the sentient and intelligent principle which animated it, and of which it was merely the organ. In his treatise on the use of the various parts of the body he associates the hand with the exercise of the gift of reason in man, and he speaks of it as an instrument applicable to every art and occasion, as well of peace as of war. It is, he says, the best constructed of all prehensile organs, and he gives a careful description of how both the hand as a whole and the individual digits, more especially the thumb, are brought into use in the act of grasping.[1] Galen does not indeed enter into the minute anatomical details which have been emphasised by more recent writers on the subject, but by none of these has the use of the hand and its associations with man's higher intelligence been more clearly and more eloquently expressed than by the Greek physician and philosopher seventeen centuries ago.

By the publication in 1859 of Charles Darwin's ever-memorable treatise "On the Origin of Species," an enormous impulse was given to the study of the anatomy of man in comparison with the lower animals, more especially with the apes. By many anatomists the study was pursued with the view of pointing out the resemblances in structure between men and apes; by a more limited number to show wherein they did not correspond. I well remember a course of lectures on the comparative characters of man delivered thirty-five years ago by my old master, Prof. John Goodsir, in which, when speaking of the hand of man and apes, he dwelt upon sundry features of difference between them.[2] The human hand, he said, is the only one which possesses a thumb capable of a free and complete movement of opposition. It may be hollowed into a cup and it can grasp a sphere. It is an instrument of manipulation co-extensive with human activity. The ape's hand again is an imperfect hand, with a short and feeble thumb, and with other clearly defined points of difference and inferiority to that of man. It can embrace a cylinder, as the branch of a tree, and is principally subservient to the arboreal habits of the animal. Its fingers grasp the cylinder in a series of spirals.

Here then is an important difference in the manipulative arrangements of the two hands, the advantage being with the hand of man, in regard to the greater variety of movement and adaptability, to co-ordinate it with his reasoning faculties. As showing the acuteness of perception of Galen and his complete recognition of a fundamental feature of the human hand, he also dwells on the hand being able to form a circle around a sphere, so as to grasp it on every side, and to touch it with every part of itself, whilst it can also securely hold objects that possess plane or concave surfaces. So impressed was the old Greek writer with the fitness of the hand to discharge the duties imposed on

[1] See passages translated in Dr. Kidd's "Bridgewater Treatise," 1833, and Dr. J. Finlayson's "Essay on Galen." Glasgow, 1895.

[2] "On the Dignity of the Human Body," in "Anatomical Memoirs," by John Goodsir, vol. i. p. 238, Edinburgh, 1868.

it by the higher intelligence of man that, pagan though he was, he regarded its construction as evidence of design in nature, and as a sincere hymn to the praise and honour of the Deity.

It is not my intention to dwell upon the multitudinous details of those features of structure which distinguish man from other vertebrates, for these have been considered and described by numerous writers. The leading structural differentiæ constitute the merest commonplaces of the human anatomist, and are already sufficiently imprinted on the popular mind. But it may not be out of place to refer to certain aspects of the subject which are not so generally known, and the significance of which has been brought into greater prominence by recent researches.

If we compare the new-born infant with the young of vertebrates generally, we find a striking difference in its capability of immediately assuming the characteristic attitude of the species. A fish takes its natural posture and moves freely in its element as soon as it is hatched. A chicken can stand and walk when it is liberated from the egg, though, from its wings not being developed, it is not at once able to fly. A lamb or calf can assume the quadrupedal position a few minutes after its birth. But, as we all know, the infant is the most helpless of all young vertebrates, and is months before it can stand on two feet and move freely on them. During the period of transition, from the stage of absolute dependence on others to the acquisition of the power of bipedal progression, important modifications in the structural arrangements both of the spine and lower limbs have to take place. At the time of birth the infant's spinal column exhibits only two curves; one, corresponding to the true vertebræ, extends from the upper end of the neck to the lowest lumbar vertebra, and the concavity of its curve is directed forwards; the other and shorter corresponds to the sacro-coccygeal region, and also has its concavity directed forwards. In the number and character of the curves, the new-born infant differs materially from the adult man, in whose spine, instead of one continuous curve from the neck to the sacrum, there are alternating curves, one convex forwards in the region of the neck, succeeded by one concave forwards in the region of the chest vertebræ, which again is succeeded by a marked convexity forwards in the vertebræ of the loins. The sacro-coccygeal region continues to retain the forward concavity of the new-born child. The formation and preservation of this alternating series of curves is associated with the assumption of the erect attitude, and the development of the lumbar convexity is correlated with the straightening of the lower limbs when the child begins to walk.[1]

When the child is born, the curvature of its spine in the dorso-lumbar region approximates to that of an ordinary quadruped in which there is no lumbar convexity, so that the spine in that region presents one continuous curve concave forwards. For some time after its birth the infant retains the quadrupedal character of the spinal curve in the dorso-lumbar region, and, as it acquires nervous and muscular power and capability of independent movement, its mode of progression in the early months by creeping on hands and knees approximates to that of the quadruped. It is only after it has attained the age of from a year to sixteen months that it can erect its trunk, completely extend the hip and knee joints, and draw the leg into line with the thigh, so as to form a column of support, which enables it to stand or move about on two feet. Hence there is this great difference between the young of a quadruped and that of a man, that whilst the former is born with the dorso-lumbar curve proper to its attitude, and which it retains throughout life, the child does not possess, either when born, or for some months after its birth, the characteristic spinal curves of the man. These curves are therefore secondary in their production; they are acquired after birth, and are not imprinted on the human spine from the beginning, though the capability of acquiring them at the proper time is a fundamental attribute of the human organism.[2]

It has sometimes been assumed that the acquisition of the erect attitude by the young child is due to the fostering care of the mother or nurse; that it is a matter of training, encouragement and education, without which the child would not raise itself upon its feet. I cannot, however, agree with this opinion. If one could conceive an infant so circumstanced that, though duly provided with food fitted for its nutrition and growth, it should never receive any aid or instruction in its mode of progression,

[1] Prof. Cleland, in Reports of British Association, 1863, p. 112.

[2] In his work on the "Origin and Progress of Language" (vol. i. p. 173, Edinburgh, 1773), Lord Monboddo held that the erect position in man is an acquired habit, and, like speech, is acquired with difficulty and as the result of training.

there can, I think, be little doubt that when it had gained sufficient strength it would of itself acquire the erect attitude. The greater growth in length of the lower limbs, as compared with the upper, would render it inconvenient to retain the creeping or the quadrupedal position.

We cannot lose sight of the important influence which, altogether independent of education, is exercised by parents on their offspring. The transmission of hereditary qualities, through the germ from which each individual organism is derived, is one of the fundamental and most striking properties of the germ plasm. Characters and peculiarities which appertain not only to the family of which the individual is a member, but also to the species to which he belongs, are conveyed through it from one generation to another. Hence, as the capability of assuming the erect attitude and of thus standing and moving on two feet have been attributes of the human form from its beginning, there can be little doubt that this power is potential in the human organism at the time of birth, and only requires a further development of the nervous and muscular systems to become a reality, without the aid of any special training.

The spinal column in the region of the true vertebræ consists of numerous bones joined together, and with discs of soft fibro-cartilage interposed between and connecting the bodies of adjoining vertebræ with each other. It is to their presence that the spinal column owes its flexibility and elasticity. These discs are larger and thicker in the region of the loins, where the lumbar convexity is situated, than in any other parts of the column, and there can be no doubt that the acquisition of this convexity is intimately associated with the presence of these discs.

It is a matter for observation and consideration to what extent the bodies of the vertebræ contribute to the production of this curve. A few years ago Prof. Cunningham, of Dublin,[1] and I[2] undertook much about the same time researches into the form and dimensions of the bodies of these bones. Our observations were made independently of each other and on two different series of skeletons, and as we arrived at practically the same conclusions, we may, I think, infer that, in their main features at least, these conclusions are correct.

The method followed in the investigation was to measure the diameter from above downwards of the body of each of the five lumbar vertebræ, both in front and behind. If the upper and lower surfaces of the bodies of the vertebræ were parallel to each other, it is obvious that, so far as they are concerned, the column formed by them would be straight, as is the case of a column built of hewn stones possessing similar parallel surfaces. But if the surfaces are not parallel, the body of the vertebræ is wedge-shaped; should the front of the collective series of bones have a greater vertical diameter than the back, it is equally obvious that the column would not be straight, but curved, and with the convexity forwards. From the examination of a considerable number of spinal columns of Europeans, we found that, although the vertical diameter of the bodies of the two highest vertebræ was greater behind than in front, in the two lowest the anterior vertical diameter so greatly preponderated over the posterior that the anterior vertical diameter of the bodies of the entire series of lumbar vertebræ in each spine was collectively greater than the corresponding diameter of the posterior surface. In twelve European skeletons I observed that the mean difference was between 5 and 6 mm. in favour of the anterior surface. If we are to regard the collective vertical diameter anteriorly of the five bones as equal to 100, the same diameter posteriorly is only equal to 96, which may be regarded as the lumbar index in Europeans. Dr. Cunningham obtained a similar index from the examination of a much larger number of European skeletons, and he further showed that in women the lumbar convexity forwards is more pronounced than in men. It follows, therefore, from these observations, that when the broad end of the wedge-shaped bodies is in front the bones themselves would by their form give a forward convexity to the spine in the lumbar region. But a similar wedge-shaped form is also possessed by the lower intervertebral discs in this region, and especially by that interposed between the last lumbar vertebræ and the sacrum. Hence it follows that both vertebral bodies and intervertebral discs contribute in the white races to the production of the lumbar convexity.

When we pass to the examination of the corresponding region in the spines of those races of men that we are accustomed to call

[1] "The Lumbar Curve in Man and the Apes," Cunningham, *Memoirs of the Royal Academy*, Dublin, 1886.

[2] "Report on Human Skeletons," "*Challenger* Reports," Part xlvii., 1886.

lower races, we find a remarkable and important difference. Let us take as a characteristic example of a lower race the aborigines of Australia. In their skeletons our observations have proved, that the vertical diameter of the bodies of the five lumbar vertebræ was collectively deeper behind than in front. In my series of skeletons the mean difference was between 6 and 7 mm. in favour of the posterior surface, so that they possessed the opposite condition to that which prevails in Europeans. Hence if the spine had been constructed of vertebræ only, instead of a lumbar convexity, the column would have possessed a forward concavity in that region. For this character, as shown in the skeleton only, I have suggested the descriptive term "Koilorachic."

We know, however, that elastic discs are intercalated between the bodies of the osseous vertebræ in the black races as well as in Europeans. It is necessary, therefore, to examine their spinal columns, when the intervertebral discs are in position, in order to obtain a proper conception of the character of the curve in the living man.

A few years ago Prof. Cunningham had the opportunity of studying the spinal column of an aboriginal Australian,[1] in which the intervertebral discs had been preserved in their proper position, in relation to the bones, without losing their flexibility, or their natural shape and thickness. He found that, whilst the bodies of the lumbar vertebræ were longer than in Europeans, the proportion of intervertebral disc to vertebral body was distinctly less, so that the disc appeared to be reduced in depth, in relation to the greater vertical diameter of the vertebral body. Notwithstanding this difference, as compared with the white man, the Australian spine had a marked lumbar convexity which showed no material difference from that seen in Europeans. As the lumbar curve was not due to the wedge-shaped form of the bodies of the vertebræ, it was therefore produced solely by the strong wedge-shape of the intervertebral discs, and was not, as in Europeans, a product of a combination of both these factors. The spinal column, when complete, is not therefore koilorachic in the lumbar region.

The greater vertical diameter of the bodies of the lumbar vertebræ behind them in front, as compared with Europeans, is not limited to the Australians, but is participated in by other black races, as the now extinct Tasmanians, the Bushmen, Andaman Islanders, and Negroes, which, if tested solely by the measurements of the skeleton, would also be koilorachic. But in these races intervertebral discs are also present, and there can be no doubt that through the compensating influence of the wedge-shaped discs, with their deeper ends in front, the lumbar curve is in them also convex forwards. It is clear, therefore, that in the black races the intervertebral discs play relatively a more important part in the production of the lumbar curve than in Europeans.

One of the acquirements of civilisation is the wearing of clothes, and fashion frequently prescribes that they should be tight-fitting and calculated to restrict motion in and about the spinal column. In savage races, on the other hand, clothing is often reduced to a minimum, and when worn is so loose and easy as in no way to hamper the movements of the body. The spinal column retains therefore in them much more flexibility, and permits the greater measure of freedom in the movements of the trunk, which is found in savage man, and has often been referred to by travellers.

It used to be considered that the possession of a lumbar convexity in the spinal column was the exclusive privilege of man, and was shared in by no other vertebrate. There can be no doubt that it attains a marked development in the human spine, and as such is associated with the erect posture. But the observations of Cunningham on the spinal column of apes, more especially the anthropoid group, made in fresh specimens, in which the intervertebral discs were in place, have proved that in the Chimpanzee the lumbar convexity is probably as strongly pronounced as in the adult man. In a Chimpanzee, two years old, the development is more advanced than in a child of the same age. The lumbar convexity is established at an earlier age than in the child, for it would seem as if the Chimpanzee attained its maturity at a younger period of life than the human being. In the Orang the lumbar curve is more feeble than in Man and the Chimpanzee, and in the specimen described by Cunningham resembled that of a boy six years old. In a fresh specimen of the Gibbon, examined by the same anatomist, the lumbar curve was intermediate between the Chimpanzee and the Orang.

In 1888, I purchased the bones of an adult male Gorilla, in which the vertebræ were in position and connected together by the dried intervertebral discs. This condition is of course not so satisfactory, for the study of the spinal curves, as if the specimen had been fresh, and with the discs retaining their natural flexibility and elasticity. But it was quite obvious that the spine possessed an alternating series of convex-concave curves from above downwards. The cervical and lumbar convexities, more especially the latter, did not project so far forwards as in man, and the dorsal concavity was not so deep. The most projecting part of the lumbar convexity was at the junction of the bodies of the third and fourth lumbar vertebræ and their intermediate disc. A vertical line drawn downwards from the most prominent part of this convexity fell in front of the coccyx. When prolonged upwards it passed in front of the bodies of the dorsal vertebræ, and intersected the body of the sixth cervical vertebra, so that the bodies of the vertebræ, higher than the sixth, were directed obliquely from below upwards and forwards in front of the vertical line.

The dried state of the discs did not enable one to determine precisely the proportion in which they entered into the formation of the length of the column, but the vertical diameter of the interlumbar and lumbo-sacral discs was obviously not as great as in the human spine. On the other hand, the vertical diameter of the bodies of the lumbar vertebræ was greater than in man, so that the length of the lumbar spine, and possibly its degree of convexity, were due more to the bodies of the vertebræ than to the elastic discs interposed between them. The Gorilla corresponds with the Chimpanzee in having longer vertebral bodies and shorter intervertebral discs than in man.

Without going into the question whether a lumbar convexity exists in the tailed monkeys, the determination of which with precision is a matter of some difficulty, it must be obvious that the presence of this convexity can no longer be regarded as the exclusive prerogative of man. It undoubtedly forms an important factor in the study of the erect attitude; but in order that man should acquire and be able to retain his distinctive posture, something more is necessary than the possession of a spinal column with a curve in the lumbar region convex forwards.

Our attention should now be directed to the lower limbs, more especially to the two segments of the shaft, which we call thigh and leg.

If we look at a quadruped we see that the thigh is bent on the trunk at the hip joint, and that the leg is bent on the thigh at the knee joint; whilst the foot forms more or less of an angle with the leg, and the animal walks either on the soles of its feet or on its toes. In the Anthropoid apes there is also distinct flexure both of the hip and knee joints, so that the leg and thigh are set at an angle to each other, and the foot is modified, through a special development of the great toe, into an organ of prehension as well as of support. When we turn to the human body we find that in standing erect the leg and thigh are not set at an angle to each other, but that the leg is in line with and immediately below the thigh, that both hip and knee joints are fully extended, so that the axis of the shaft of the lower limb is practically continuous with the axis of the spine. The foot is set at right angles to the leg, and the sole is in relation to the ground. The vertical axis of the shaft of the lower limb, the extended condition of the hip and knee joints, and the rectangular position of the foot to the leg are therefore fundamental to the attainment of the erect attitude of man.

In narratives of travel by those who have studied the Penguins in their native habitats, you may read that these birds may be seen standing on the rocks on the coasts which they frequent, in rows, like regiments of soldiers, and the idea has become implanted in the minds of many that they can stand erect. Even so accomplished a writer and acute a critic as the late Mr. G. H. Lewes thought that the Penguins had the vertical attitude when standing, and that some mammals, as the Jerboa and Kangaroo, very closely approached to it. The attitude of man was, he considered, merely a question of degree, and did not express a cardinal distinction.[1]

In arriving at this conclusion, however, only the external appearance of the birds and mammals referred to by him can have been looked at. If the skin and flesh be removed, and

[1] *Proc. Roy. Soc. London*, January 24, 1889, vol. xlv.; also see *Journal of Anatomy and Physiology*, vol. xxiv. 1890.

[1] Aristotle, "A Chapter from the History of Science," p. 309, London 1864.

the arrangement of the constituent parts of the skeleton be studied, it will be seen that the axis of the spine in them, instead of being vertical, is oblique, and that there is no proper lumbar convexity; that the hip and knee joints, so far from being extended, are bent; that the thigh is not in the axis of the spine, and that the leg, instead of being in a vertical line with the thigh, is set at an acute angle to it. The so-called vertical attitude therefore in these animals is altogether deceptive. It does not approximate to, and can in no sense be looked upon as equivalent to, the erect attitude in man.

We may now consider what agents come into operation in changing the curve of the spine from the concavity forwards, found in the new-born infant, to the alternating series of curves so characteristic of the adult. The production of the lumbar convexity is, without doubt, due to structures associated with the spine, the pelvis and the lower limbs, whilst the cervical convexity is due to structures acting on the spine and the head.

There can, I think, be little doubt that muscular action plays a large part in the production of the cervical and lumbar convexities. The study of the muscles, associated with and connected to the spinal column, shows that large symmetrically arranged muscles, many of which are attached to the neural arches and transverse processes of the vertebræ, extend longitudinally along the back of the spine, and some of them reach the head. On the other hand, those muscles which lie in front of the spine, and are attached to the vertebræ, are few in number, and are practically limited to the cervical and lumbar regions, in which the spine acquires a convexity forwards.

It has already been pointed out that the formation of the lumbar convexity is correlated with the power of extending the hip joints and straightening the lower limbs. When these joints are in the position of extension, an important pair of muscles called the "psoæ," which reach from the small trochanter of the femur to the bodies and transverse processes of the lumbar vertebræ, are in a state of tension. In the act of extending the hip joints so as to raise the body to the erect position, the opposite ends of these muscles are drawn asunder, and the muscles are stretched and elongated, so that they necessarily exercise traction upon the lumbar spine. Owing to its flexibility and elasticity, a forward convexity is in course of time produced in it in this region. By repeated efforts the convexity becomes fixed and assumes its specific character.

Along with the changes in the spinal column, a modification also takes place in the inclination of the pelvis during the extension of the hip joints and the straightening of the lower limbs. The muscle called "iliacus" is conjoined with the psoas at its attachment to the small trochanter, but instead of being connected to the spinal column by its upper end, it is attached to the anterior surface of the ilium. It exercises traction therefore on that bone, draws it forwards and increases the obliquity of the pelvic brim. This in its turn will react on the lumbar spine and assist in fixing its convexity.

By some anatomists great importance has been given to the "ilio-femoral band," situated in the anterior part of the capsular ligament of the hip joint, as causing the inclination of the pelvis, and in promoting the lumbar curve. This band is attached by its opposite ends to the femur and the ilium. As the hip joint is being extended, the ends are drawn further apart, the band is made tense, and the ilium might in consequence be drawn upon, so as to affect the inclination of the pelvis. As the ligament has no attachment to the spinal column, it cannot draw directly on it, but could only affect it indirectly through its iliac connections. It can therefore, I think, play only a subordinate part in the production of the lumbar curve.

Contemporaneous with the straightening of the lower limbs and the extension of the hip joints, the spinal column itself is elevated by muscles of the back, named "erectores spinæ," which, taking their fixed points below, draw upon the vertebræ and ribs and erect the spine. The lumbar convexity is the form of stable equilibrium which the flexible spinal column tends to take under the action of the muscular forces which pull upon it in front and behind. It is probably due to the fact that the average pull, per unit of length, of the psoæ muscles attached in front is greater than the average pull, per unit of length, of the muscles attached behind in the same region.

The muscles which lie on the back of the neck and which are attached to the occipital part of the skull, when brought into action, will necessarily affect the position of the head. The new-born infant has no power to raise the head, which is bent forward, so that the chin is approximated to the chest. As it acquires strength the head becomes raised by the muscles of the back of the neck, and the flexible spine in the cervical region loses its primary curve, concave forwards, and gradually assumes the cervical convexity. The formation of this curve is, I believe, assisted by the anterior recti muscles, the lower ends of which are attached to the front of the vertebræ, whilst their upper ends are connected to the basi-occipital. In the elevation of the head the opposite ends of the muscles are drawn apart, which would exercise a forward traction upon the cervical vertebræ. The production of the cervical convexity precedes the formation of the lumbar curve, for an infant can raise its head, and take notice of surrounding objects, months before it can stand upon its feet.

We shall now look at the bones in the thigh and leg, which possess characters that are distinctively human, and which are associated with the erect posture. These characters can be more clearly recognised when the bones are contrasted with the corresponding bones of the large Anthropoid apes.

As compared with the ape, the shaft of the human thigh bone is not so broad in relation to its length; when standing erect the shaft is somewhat more oblique, it is more convex forwards and generally more finely modelled, and it has three almost equal surfaces, the anterior of which is convex. But, further, a strong ridge (linea aspera) extends vertically down its posterior surface; so that a section through the shaft is triangular, with the two anterior angles rounded and the posterior prominent. In the Gorilla, Chimpanzee, and Orang, the shaft is flattened from before backwards, and the linea aspera is represented by two faint lines, separated from each other by an intermediate narrow area. A section through the shaft approximates to an ellipse. In the Gibbon the femur is greatly elongated, and the shaft is smooth and cylindriform. The linea aspera is for the attachment of powerful muscles, which are more closely aggregated in man than in apes, so that the human thigh possesses more graceful contours.

In the human femur the shaft is separated from the neck by a strong anterior intertrochanteric ridge, to which is attached the ilio-femoral ligament of the hip joint, which, by its strength and tension, plays so important a part in keeping the joint extended when the body is erect. In the Anthropoid apes this ridge is faint in the Gorilla, and scarcely recognisable in the Orang, Gibbon, and Chimpanzee, and the ilio-femoral ligament in them is comparatively feeble. It may safely therefore be inferred that in apes, with their semi-erect, crouching attitude, the ilio-femoral band is not subjected to, or capable of sustaining, the same strain as in man.

The head of the thigh bone is also distinctive. In the apes the surface covered by cartilage is approximately a sphere, and is considerably more than a hemisphere. It is sharply differentiated from the neck by a definite boundary, and it has a mushroom-like shape. In man the major part of the head is also approximately a sphere; but, in addition, there is an extension outwards of the articular area on the anterior surface and upper border of the neck of the bone. The form of this extended area differs from the spherical shape of the head in general. The curvature of a normal section of its surface has a much larger radius than the curvature of a normal section of the head, near the attachment of the ligamentum teres.

The amount of this extended area varies in different femora, but as a rule it is larger and more strongly marked in Europeans than in the femora of some savages which I have examined. When the joint is in the erect attitude, the area is in contact with the back of the iliac part of the ilio-femoral ligament. It provides a cartilaginous surface which, during extension of the joint, is not situated in the acetabulum, but, owing to the centre of gravity falling behind the axis of movement, is pressed against that ligament, and contributes materially to its tension. It is associated with the characteristic position of the human hip joint in standing, and may be called appropriately the extensor area. When the femur is abducted it passes within the acetabulum. The head of the femur in man is not so sharply differentiated from the neck as in the Anthropoid apes, especially in the region of the extensor articular area.

Both man and apes possess at the lower end of the femur a trochlear or pulley-like surface in front for the patella, and two condyles for the tibia. In the apes the trochlea is shallow, and the concave curve from side to side is a segment of an approximate circle, with a large radius. In man the trochlea is much deeper, and the inner and outer parts of the curve deviate considerably from a circle, and are not symmetrical; the outer part is wider and extends higher on the front of the bone than the inner part, whilst the direction of the curve changes towards the edges of the trochlea.

In the apes the articular surface of the inner condyle is very markedly larger than that of the outer condyle, both in breadth and in the extent of its backward curve, which winds upwards on the posterior part of the condyle, so that the articular surface is continued on to its upper aspect. The curve of the outer condyle is much sharper, and the condyle does not project so far backwards; its articular surface is not prolonged so high on the back of the bone. In the apes, therefore, the inner is the more important condyle in the construction of the knee joint, and the marked extension of its articular area backwards and upwards is associated with the position and movements of the knee in flexion. In the ape the thigh is more rotated outwards than in man, and the inner condyle is directed to the front of the limb.

In man there is not nearly the same disproportion in the size of the two condyles as in the apes. I have occasionally seen in man the articular area of the inner broader than that of the outer condyle, but more usually the outer is appreciably wider. The backward curve of the outer condyle is also prolonged somewhat higher than that of the inner, and thus the condition of the two condyles is the reverse of that found in the ape. It should, however, be stated, as has been shown by Dr. Havelock Charles (*Journal of Anatomy and Physiology*, vol. xxviii.), that in persons, who habitually rest in the squatting position, an upward extension of the articular area of the inner condyle exists, which is associated with the acute flexion of the knee whilst squatting. In man, the outer condyle, when seen in profile, is, as compared with the inner, more elongated antero-posteriorly than in the Gorilla. The approximate equality in the size of the two condyles in man is, without doubt, associated with the extension of the knee joint in the erect attitude, and with the more equable distribution of the weight of the body downwards on the head of the tibia. In the ape the intercondylar fossa, in relation to the size of the bones, is wider in front than in man; but it is wider behind in man than in the ape, for in the latter the inner condyle inclines nearer to the outer condyle than in man.

In man, when the knee joint is extended, the tibia is slightly rotated outwards on the femoral condyles, and the joint is fixed, partly by the tension of the lateral and posterior ligaments and the interior crucial ligament, and partly by the general tension of the muscles and fasciæ around the joint. So long as these structures remain tense, the joint cannot be bent, and no lateral movement, or rotation, is permitted. The fixation of the joint is of fundamental importance in the act of standing. Free rotation of the human knee can only take place when the joint is acutely bent.

In apes, the joint cannot be fully extended; its natural position, when the animal is standing, is partial flexion, and in this position a limited rotation is permitted, which can be greatly increased when the joint is more completely bent. In rotating the leg on the thigh the inner condyle is apparently the pivot. The rotation facilitates the use of the foot as an organ of prehension, and assists the ape to turn the sole inwards and forwards when holding an object. These movements produce results, which approximate to those occasioned by pronation and supination of the radius on the ulna, in the movements of the forearm and hand.

In the Anthropoid apes, the head of the tibia slopes very decidedly backwards at the upper end of the shaft, so that its axis forms an angle with that of the shaft, and the head may be described as retroverted. If the shaft of the tibia were held vertically, the articular surface for the inner condyle would also slope downwards and backwards, and to a greater degree than that for the outer condyle. But in the natural semiflexed position of the ape's knee the condylar articular surfaces of the tibia are essentially in the horizontal plane.

In the human tibia the axis of the head is, as a rule, almost in line with that of the shaft, and the backward and downward slope of the inner articular surface is not so great as in the ape. In some human tibiæ, however, well-marked retroversion of the head has been seen. In skeletons referred to the Quaternary period of the geologist, this character has been noticed by MM. Collignon, Fraipont, and Testut, and the inference has been drawn that the men of that period could not extend the knee joint and walk as erect as modern man. It has, however, been shown by Prof. Manouvrier (*Mémoires de la Société d'Anthropologie de Paris*, 1890) and Dr. Havelock Charles (*Journal of Anatomy and Physiology*, vol. xxviii.) that this condition of the tibia is not uncommon in some races of men, in whom there can be no question that the attitude is erect when standing. Dr. Charles has associated the production of retroversion to the habit in these races of resting on the ground in the position of squatting. I have found in the tibiæ of the people of the Bronze Age that retroversion of the head of the tibia is not uncommon. In five specimens the backward slope of the head formed with the vertical axis of the shaft an angle which ranged in the several bones from 20° to 30°. But when these tibiæ were put into the erect position alongside of similarly placed modern European bones, the condylar articular surfaces were seen to approximate to the horizontal plane in all the specimens. In order, therefore, that retroversion of the head of the tibia should be associated with inability to extend the knee joint, it is obvious that the articular surfaces should have a marked slope downwards and backwards, as is the case in the Anthropoid apes, when the shaft of the tibia is held in a vertical plane.

I shall now proceed to the examination of the human foot (pes), and in order to bring out more clearly its primary use as an organ of support and progression, I shall contrast it with the human hand (manus) and with the manus and pes in apes. In man, while standing erect, the arched sole of the foot is directed to the ground, and rests behind on the heel and in front on pads, placed below and in line with the metatarso-phalangeal joints, the most important of which is below the joint associated with the great toe. It is therefore a plantigrade foot. The great toe (hallux) lies parallel to the other toes, and from its size and restricted movements gives stability to the foot.

The ape's foot agrees with that of man in possessing similar bones and almost similar soft parts; but it differs materially as to the uses to which it can be put. Some apes can undoubtedly place the sole upon the ground, and in this position use the foot both for support and progression; though the Orang, and to some extent other Anthropoid apes, rest frequently upon the outer edge of the foot. But in addition these animals can use the foot as a prehensile organ like the hand. The old anatomist Tyson, in his description of a young Chimpanzee ("Anatomy of a Pygmie," 1699, p. 13), spoke of the pes as "liker a hand than a foot" and introduced the term "quadrumanous," four-handed, to designate this character. This term was adopted by Cuvier and applied by him to apes generally, and has long been in popular use. The eminent French anatomist was, however, quite alive to the fact that though the pes was capable of being used as a hand, yet that it was morphologically a foot, so that the term was employed by him to express a physiological character.

In the ape, the great toe, instead of being parallel to the other toes as in man, is set as an angle to them, not unlike the relation which the thumb (pollex) bears to the fingers in the human hand. It is able, therefore, to throw the hallux across the surface of the sole in the prehensile movement of opposition. As it can at the same time bend the other toes towards the sole, it also has the power of encircling an object more or less completely with them. By the joint action of all the toes a powerful grasping organ is produced, more important even than its hand, in which the thumb is feebly developed.

It has sometimes been assumed that the human foot is also a prehensile instrument as well as an organ of support. In a limited sense objects can undoubtedly be grasped by the human toes when bent towards the sole. In savages, this power is preserved to an extent which is not possible in civilised man, in whom, owing to the cramping, and only too frequently the distorting influence, exercised by badly fitting boots and shoes, the proper development of the functional uses of the toes is impeded and their power of independent movement is often destroyed.

Even in savages who have never worn shoes, the power of grasping objects by the toes cannot be regarded as approximately equal in functional activity and usefulness to the range of movement possessed by the ape. The four outer toes are so short and comparatively feeble, that they cannot encircle an object of any magnitude. But, what is even more important, the great toe cannot be opposed to the surface of the sole, in the way that an ape can move its hallux or a man his thumb. Savage man can no doubt pick up an object from the ground with the great toe. Many of us have doubtless seen, among civilised men, persons who have had the misfortune to be born without arms, or who have accidentally lost them in early life, who have trained themselves to hold a pen, pencil, brush, or razor with the foot, and to write, draw, paint, or even shave. But in these cases the object is held between the hallux and the toe lying next to it, and not grasped between the great toe and the sole of the foot by a movement of opposition.

If we compare the anatomical structure of the human foot with that of the foot of the ape, though the bones, joints, and muscles are essentially the same in both, important differences in arrangement may be easily recognised, the value of which will be better appreciated by first glancing at the thumb. Both in man and apes the thumb is not tied to the index digit by an intermediate ligament, which, under the name of "transverse metacarpal," binds all the fingers together, and restricts their separation from each other in the transverse plane of the hand. The great toe of the ape, similarly, is not tied to the second toe by a "transverse metatarsal ligament," such as connects together and restricts the movements of its four outer toes in the transverse plane of the foot. The hallux of the ape is therefore set free. It can, like the thumb of man and ape, be thrown into the position of opposition and be used as a prehensile digit. Very different is the case in the human foot, in which the hallux is tied to the second toe by a continuation of the same transverse metatarsal ligament which ties the smaller toes together. Hence it is impossible to oppose the great toe to the surface of the sole in the way in which the thumb can be used, and the movements of the digit in the transverse plane of the foot are also greatly restricted.

The development of a connecting transverse band, for the restriction of the movements of the great toe in man, is not the only anatomical structure which differentiates it from the hallux of an ape, or the thumb in the hand. In the manus both of man and apes the joint between the metacarpal bone of the thumb and the bone of the wrist (trapezium) is concavo-convex, or saddle-shaped, and permits of a considerable range of movement in certain directions, and notably the movement of opposition. A joint of a similar configuration, permitting similar movements, is found in the pes of the ape between the metatarsal of the hallux and the tarsal bone with which it articulates. In the foot of man, on the other hand, the corresponding joint is not saddle-shaped, but is almost plane-surfaced, and consequently the range of movement is slight, and is little more than the gliding of one articular surface on the other.

One of the chief factors in the production of the movement of opposition in the manus of man and apes is a special muscle, the opponens pollicis, which, through its insertion into the shaft of the metacarpal bone of the thumb, draws the entire digit across the surface of the palm. In the foot of the Anthropoid apes there is not complete correspondence in different species in the arrangement of the muscles which move the great toe. In the Orang the abductor hallucis, in addition to the customary insertion into the phalanx, may give rise to two slips, one of which is inserted into the base and proximal part of the first metatarsal bone, and the other into the radial border of its shaft for a limited distance; these slips apparently represent an imperfect opponens muscle, which acts along with the adductor and short flexor muscle of the great toe. In the other Anthropoid apes, the muscle seems to be altogether absent, and the power of opposition is exercised solely by the adductor and the flexor brevis hallucis, the inner head of the latter of which is remarkably well developed.[1] In the human foot there is no opponens hallucis, and the short flexor of the great toe is, in relation to the size of that digit, comparatively feeble, so that no special provision is made for a movement of opposition.

The character and direction of the movements of the digits both in hand and foot are imprinted on the integument of palm and sole. In the palm of the human hand the oblique direction of the movements of the fingers towards the thumb, when bent in grasping an object, is shown by the obliquity of the two great grooves which cross the palm from the root of the index to the root of the little finger. The deep curved groove, extending to the wrist, which marks off the eminence of the ball of the thumb from the rest of the palm, is associated with the opponent action of the thumb, which is so marked in man that the tip of the thumb can be brought in contact with a large part of the palmar surface of the hand and fingers. Faint longitudinal grooves in the palm, situated in a line with the fingers, express slight folds which indicate, where the fingers are approximated to or separated from each other, in adduction and abduction. In some hands a longitudinal groove marks off the muscles of the ball of the little finger from the rest of the palm, and is associated with a slight opponent action of that digit; by the combination of which, with a partial opposition of the thumb, the palm can be hollowed into a cup—the drinking-cup of Diogenes.

[1] For a comparative description of the muscles of the hand and foot of the Anthropoid apes consult Dr. Hepburn's memoir in *Journal of Anatomy and Physiology*, vol. xxvi.

These grooves are present in the infant's hands at the time of birth, and I have seen them in an embryo, the spine and head of which were not more than 90 mm. (three and a half inches) long. They appear in the palm months before the infant can put its hand to any use; though it is possible that the muscles of the thumb and fingers do, even in the embryo, exercise some degree of action, especially in the direction of flexion. These grooves are not therefore acquired after birth. It is a question how far the intra-uterine purposeless movements of the digits are sufficient to produce them; but even should this be the case, it is clear that they are to be regarded as hereditary characters transmitted from one generation of human beings to another. They are correlated with the movements of the digits, which give the functional power and range of movement to the hand of man.

In the palm of the hand of the Anthropoid apes grooves are also seen, which differ in various respects from those in man, and which are characteristic of the group in which they are found. In these animals the palm is traversed by at least two grooves from the index border to that of the minimus. In the Gibbon they are oblique, but in the Gorilla, Chimpanzee, and Orang they are almost transverse, which implies that in flexion the fingers do not move so obliquely towards the comparatively feeble thumb as they do in man. The curved groove which limits the ball of the thumb is present, but on account of the less development of that eminence, it is not so extensive as in man. The longitudinal grooves in the palm are deeper than in the human hand, and in the Gorilla and Orang a groove differentiates the eminence associated with the muscles of the little finger from the adjoining part of the palm. The character and direction of these grooves are such as one would associate with the hand of an arboreal animal, in which the long fingers are the chief digits employed in grasping an object more or less cylindrical, like the branch of a tree, and in which the thumb is a subordinate digit. I have not had the opportunity of examining the palm of the embryo of an Anthropoid ape, but in that of an embryo Macaque monkey I have seen both the groove for the ball of the thumb which marks its opposition, and the transverse and longitudinal grooves in the palm which are correlated with the movements of the fingers. In apes, therefore, as in man, these grooves are not acquired after birth, but have an hereditary signification.

We may now contrast the grooves in the skin of the sole of the human foot with those which we have just described in the palm. For this purpose the foot of an infant must be selected as well as that of an older person in which the toes have not been cramped and distorted by ill-fitting shoes.[1]

The toes are marked off from the sole proper by a deep diagonal depression, which corresponds with the plane of flexion of the first and second phalanges. Behind this depression, and on the sole proper, is a diagonal groove, which commences at the cleft between the great and second toes, and reaches the outer border of the foot. It is seen in the infant, but disappears as the skin of the foot becomes thickened from use and pressure. This groove marks the plane of flexure of the first phalanges on the metatarsal bones of the four smaller toes. Associated with its inner end is a short groove which curves to the inner border of the foot, and marks off the position of the joint between the first phalanx and the metatarsal bone of the great toe. The groove indicates the movements of the great toe in flexion, and in adduction to, or abduction from, the second toe. It has sometimes erroneously been regarded as the corresponding groove in the foot to the deep curved groove in the hand, which defines the muscles of the ball of the thumb and is associated with the movement of opposition. This is not its real character, for the chief joint concerned in opposition

[1] These grooves have been described generally by the late Prof. Goodsir ("Anatomical Memoirs," vol. i., 1868); by myself in a lecture on hands and feet ("Health Lectures," Edinburgh, 1884); and by Mr. Louis Robinson, the last named of whom has called special attention to their arrangement in the feet of infants (*Nineteenth Century*, vol. xxxi., 1892, p. 795). The integumentary grooves in both hands and feet of men and apes have also been described and figured in detail by Dr. Hepburn in *Journal of Anat. and Phys.*, vol. xxvii. 1893, p. 112.

is that between the metacarpal bone and the corresponding carpal bone, and not that between the metacarpal bone and the phalanx. In addition, one, or it may be two faint grooves run from within outwards near the middle of the sole. In the infant's foot a groove also extends longitudinally in the centre of the foot. The grooves on the integument of the sole are in harmony with the inner anatomy of the foot, and confirm the statement, already made, that the great toe in man cannot be opposed to the sole, as the thumb can to the palm, for the great curved groove expressing the movement of opposition is wanting.

In the apes, the condition of the tegumentary grooves in the sole is very different from the human foot. In the Anthropoid group, the ball of the great toe, with its muscles, is marked off by a deep curved groove, which extends from the margin of the cleft between it and the second toe, backwards along the middle of the sole almost as far as the heel. Its depth and extent are associated with the powerful opponent, or grasping action of the hallux. Two other grooves, in front of that just described, pass obliquely across the sole from the cleft between the hallux and the second toe, and reach the outer border of the foot. They are associated with the movements of the four smaller toes, and their obliquity shows that, when the foot is used as a prehensile organ, the object is grasped not only by the great toe being moved towards the sole, but by the smaller toes being moved towards the hallux. From these arrangements it is obvious that the pes of the ape is, physiologically speaking, a foot-hand, it is pedimanous. Though anatomically a foot, it can be used not only for support and progression, but for prehension, and, for the latter-named office, the hallux is a more potent digit in the foot than is the pollex in the hand. The external rotation of the thigh at the hip joint, and the power of rotating the leg inwards on the thigh at the knee joint, contribute to make the foot of the ape a more important prehensile instrument, and enable the animal to use it more efficiently for this purpose when sitting, than would have been the case if there had been no contributory movements at the hip and knee.

The power of assuming the erect attitude, the specialisation of the upper limbs into instruments of prehension, and of the lower limbs into columns of support and progression, are not in themselves sufficient to give that distinction to the human body which we know that it possesses. They must have coordinated with them the controlling and directing mechanism placed in the head, known as the brain and organs of sense.

The head, situated at the summit of the spine, holds a commanding position. Owing to the joints for articulation with the atlas vertebra being placed on the under surface of the skull, and not at the back of the head, and to the great reduction in the size of the jaws, as compared with apes and quadrupeds generally, the head is balanced on the top of the spine. The ligaments supporting it and connected with it are comparatively feeble, and do not require for their attachment strong bony ridges on the skull, or massive projecting processes in the spine, such as one finds in apes and many other mammals. The head with the atlas vertebra can be rotated about the axis vertebra by appropriate muscles. The face looks to the front, the axis of vision is horizontal, and the eyes sweep the horizon with comparatively slight muscular effort.

The cranial cavity, with its contained brain, is of absolutely greater volume in man than in any other vertebrate, except in the elephant and in the large whales, in which the huge mass of the body demands the great sensory-motor centres in the brain to be of large size. Relatively also to the mass and weight of the body, the brain in man may be said to be in general heavier than the brains of the lower vertebrates, though it has been stated that some small birds and mammals are exceptions to this rule.

We have abundant evidence of the weight of the brain in Europeans, in whom several thousand brains have been tested. In the men, the average brain-weight is from 49 to 50 oz. (1390 to 1418 grm.). In the women, from 44 to 45 oz. (1248 to 1283 grm.). The difference in weight is doubtless in part correlated with differences in the mass, weight, and stature of the body in the two sexes, although it seems questionable if the entire difference is capable of this explanation. It is interesting to note that even in new-born children the boys have bigger heads and heavier brains than the girls. Dr. Boyd gives the average for the girl infants as 10 oz., and for boys 11·67 oz. A distinction in the brain weight of the two sexes is obviously established, therefore, before the child is born, and is not to be accounted for by the training and educational advantages enjoyed by the male sex being superior to those of the female sex.

The brains of a number of men of ability and intellectual distinction have been weighed, and ascertained to be from 55 to 60 oz. In a few exceptional cases, as in the brains of Cuvier and Dr. Abercrombie, the weight has been more than 60 oz.; but it should also be stated that brains weighing 60 oz. and upwards have occasionally been obtained from persons who had shown no sign of intellectual eminence.

On the other hand, it has been pointed out by M. Broca and Dr. Thurnam, that if the brain falls below a certain weight it cannot properly discharge its functions. They place this minimum weight for civilised people at 37 oz. for the men, and 32 oz. for the women. These weights are, I think, too high for savage men, more especially in the dwarf races. We may, however, safely assume that if the brain-weight in adults does not reach 30 oz. (851 grm.), it is associated with idiocy or imbecility. There would seem, therefore, to be a minimum brain-weight, which is necessary in order that the mental functions may be actively discharged.

We have unfortunately not much evidence of the weight of the brain in the uncultivated and savage races. The weighings made by Tiedemann, Barkow, Reid, and Peacock give the mean of the brain in the negro as between 44 and 45 oz., a weight which corresponds with that of European women; whilst in the negress the mean weight is less than in the female sex in Europeans. In two Bush girls from South Africa—representatives of a dwarf race—the brain is said to have been 34 and 38 oz. respectively.[1]

From the weighings which have been published of the brains of the Orang and Chimpanzee, it would seem that the brain-weight in these apes ranges from 11 to 15 oz. (312 to 426 grm.), and the brain-weight appears to be much about the same in the Gorilla. These figures are greatly below those of the human brain, even in so degraded a people as the dwarf Bush race of South Africa. They closely approximate to the weight of newly-born male infants, in whom, as has just been stated, the average weight was 11·67 oz. For the purposes of ape-life, the low brain-weight is sufficient to enable the animal to perform every function of which it is capable. Its muscular and nervous systems are so accurately coordinated that it can move freely from tree to tree, and swing itself to and fro; it can seize and retain objects with great precision, and can search for and procure its food. In all these respects it presents a striking contrast to the infant, having an almost similar brain-weight, which lies helpless on its mother's knee.

Another line of evidence, of which we may avail ourselves, in order to test the relative size of the brain in the different races of men and in the large apes is to be obtained by determining the internal capacity of the cranium. Examples of the brains of different races (except Europeans) are few in number in our collections, but the crania are often well represented, the volume of the cavity in which the brain is lodged can be obtained from them, and an approximate conception of the size and weight of the brain can be estimated. In pursuing this line of inquiry, account has of course to be taken of the space occupied by the membranes investing the brain, by the blood vessels and the cerebro-spinal fluid. A small deduction from the total capacity will have to be made on their behalf.

There is a general consensus of opinion amongst craniologists that the mean internal capacity of the cranium in adult male Europeans is about 1500 c.c. (91·5 cub. in.). The mean capacity of the cranium of fifty Scotsmen that I have measured by a method, which I described some years ago,[2] was 1493 c.c. (91·1 cub. in.). The most capacious of these skulls was 1770 c.c., and the one with the smallest capacity was 1240 c.c. Thus, in a highly civilised and admittedly intellectual people, the range in the volume of the brain-space amongst the men was as much as 530 c.c. in the specimens under examination, none of which was known or believed to be the skull of an idiot or imbecile, whilst some were known to be the crania of persons of education and position. In twenty-three Scotswomen the mean capacity was 1325 c.c., and the range of variation was from a maximum 1625 to a minimum 1100 c.c.—viz., 525 c.c.

Again I have taken the capacity, by the same method, of a number of crania of the Australian aborigines, a race incapable

[1] Sir R. Quain in *Pathological Transactions*, 1850, p. 182, and Messrs. Flower and Murie in *Journal of Anatomy and Phys.*, vol. i. p. 206.
[2] Human Crania, *Challenger* Reports, Pt. xxix., 1884, p. 9.

apparently of intellectual improvement beyond their present low state of development. In thirty-nine men the mean capacity was only 1280 c.c. (78·1 cub. in.). The maximum capacity was 1514 c.c., the minimum was 1044 c.c. The range of variation was 470 c.c. In twenty-four women the mean capacity was 1115·6 c.c., the maximum being 1240 and the minimum 930, and the range of variation was 310 c.c. It is noticeable that in this series of sixty-three Australian skulls, all of which are in the Anatomical Museum of the University of Edinburgh, eight men had a smaller capacity than 1200 c.c., and only four were above 1400 c.c. Of the women's skulls ten were below 1100 c.c., four of which were between 900 and 1000 c.c., and only three were 1200 c.c. and upwards.

Time does not admit of further detail on the cranial capacities of other races of men. Sufficient has been said to show the wide range which prevails, from the maximum in the Europeans to the minimum in the Australians, and that amongst persons presumably sane and capable of discharging their duties in their respective spheres of activity; for we must assume that the crania of the Australians, having the small capacities just referred to, were yet sufficiently large for the lodgment of brains competent to perform the functions demanded by the life of a savage. From a large number of measurements of capacity which I have made of the skulls of the principal races of men, I would draw the following conclusions: First, that the average cranial capacity, and consequently the volume and weight of the brain, are markedly higher in the civilised European than in the savage races; second, that the range of variation is greater in the former than in the latter; third, that in uncivilised man the proportion of male crania having a capacity equal to the European mean, 1500 c.c., is extremely small; fourth, that though the capacity of the men's skulls is greater than that of the women's, there is not quite the same amount of difference between the sexes in a savage as in a civilised race.

It may now be of interest to say a few words on the capacity of the cranium in the large Anthropoid apes. I have measured, by the method already referred to, the capacity of the skulls of five adult male Gorillas, and obtained a mean of 494 c.c., the maximum being 590 c.c. and the minimum 410 c.c., the range of variation being 180 c.c. Dr. Delisle found the old male Orang (Maurice),[1] which died a short time ago in the Jardin des Plantes, to have a capacity of 385 c.c., whilst the younger male (Max) had a capacity of 470 c.c.[2] The mean of eleven specimens measured by him was 408 c.c., which is somewhat less than the measurements of males recorded by M. Topinard and Dr. Vogt; but it should be stated that in some of Dr. Delisle's specimens the sex could not be properly discriminated, and possibly some of them may have been females. The cranial capacity of seven male Chimpanzees is stated by M. Topinard to be 421 c.c.

The determination of the mass and weight of the brain as expressed in ounces, and of the capacity of the cranial cavity as expressed in cubic centimetres, are only rough methods of comparing brain with brain, either as between different races of men, or as between men and other mammals. Much finer methods are needed in order to obtain a more exact comparison.

The school of Phrenologists represented in the first half of the century by Gall, Spurzheim, and George Combe, whilst recognising the importance of the size of the brain as a measure of intellectual activity, also attached value to what was called its quality. At that time the inner mechanism of the brain was almost unknown, for the methods had not been discovered by which its minute structure could be determined. It is true that a difference was acknowledged, between the cortical grey matter situated on the surface of the hemispheres and the subjacent white matter. Spurzheim had also succeeded in determining the presence of fibres in the white matter of the encephalon, and had, to a slight extent, traced their path. The difference between the smooth surface of the hemispheres of the lower mammals and the convoluted surface of the brain of man and the higher mammals, and the influence which the development of the convolutions exercised in increasing the area of the cortical grey matter, were also known.

A most important step in advance was made, when, through the investigations of Leuret and Gratiolet, it became clear that the convolutions of the cerebrum, in their mode of arrangement, were not uniform in the orders of mammals which possessed convoluted brains, but that different patterns existed in the orders examined. By his further researches Gratiolet determined that in the Anthropoid apes, notwithstanding their much smaller brains, the same general plan of arrangement existed as in man, though differences occurred in many of the details, and that the key to unlock the complex arrangements in man was to be obtained by the study of the simpler disposition in the apes. These researches have enabled anatomists to localise the convolutions and the fissures which separate them from each other, and to apply to them precise descriptive terms. These investigations were necessarily preliminary to the histological study of the convolutions, and to experimental inquiry into their functions.

[1] "Nouvelles Archives du Muséum d'Histoire naturelle," 1895.
[2] The stature of Maurice was 1 m. 40; that of Max 1 m. 28.

By the employment of the refined histological methods now in use, it has been shown that the grey matter in the cortex of the hemispheres, and in other parts of the brain, is the seat of enormous numbers of nerve-cells, and that those in the cortex, whilst possessing a characteristic pyramidal shape, present many variations in size. Further, that these nerve-cells give origin to nerve axial fibres, through which areas in the cortex become connected directly or indirectly, either with other areas in the same hemisphere, with parts of the brain and spinal cord situated below the cerebrum, with the muscular system, or with the skin and other organs of sense.

Every nerve-cell, with the nerve axial fibre arising from and belonging to it, is now called a Neurone, and both brain and spinal cord are built of tens of thousands of such neurones. It may reasonably be assumed that the larger the brain the more numerous are the neurones which enter into its constitution. The greater the number of the neurones, and the more complete the connections which the several areas have with each other through their axial fibres, the more complex becomes the internal mechanism, and the more perfect the structure of the organ. We may reasonably assume that this perfection of structure finds its highest manifestations in the brain of civilised men.

The specialisation in the relations and connections of the axial fibre processes of the neurones, at their termination in particular localities, obviously points to functional differences in the cortical and other areas, to which these processes extend. It has now been experimentally demonstrated that the cortex of the cerebrum is not, as M. Flourens conceived, of the same physiological value throughout; but that particular functions are localised in definite areas and convolutions. In speaking of localisation of function in the cerebrum, one must not be understood as adopting the theory of Gall, that the mental faculties were definite in their number, that each had its seat in a particular region of the cortex, and that the locus of this region was marked on the surface of the skull and head by a more or less prominent "bump."

The foundation of a scientific basis for localisation dates from 1870, when Fritsch and Hitzig announced that definite movements followed the application of electrical stimulation to definite areas of the cortex in dogs. The indication thus given was at once seized upon by David Ferrier, who explored not only the hemispheres of dogs, but those of monkeys and other vertebrates.[1] By his researches and those of many subsequent inquirers, of whom amongst our own countrymen we may especially name Beevor, Horsley, and Schäfer, it has now been established that, when the convolutions bounding, and in close proximity to the fissure of Rolando are stimulated, motor reactions in the limbs, trunk, head and face follow, which have a definite purposive character, corresponding with the volitional movements of the animal. The Rolandic region is therefore regarded as a part of the motor apparatus; it is called the motor area, and the function of exciting voluntary movements is localised in its cortical grey matter.

By the researches of the same and other inquirers it has been determined that certain other convolutions are related to the different forms of sensibility, and are sensory or perceptive centres, localised for sight, hearing, taste, smell, and touch.

Most important observations on the paths of conduction of sensory impressions in the cortex of the convolutions were announced last year by Dr. Flechsig,[2] of Leipzig, so well known by his researches on the development of the tracts of nerve-fibres in the columns of the spinal cord, published several years ago. He discovered that the nerve-fibres in the cord did not become myelinated, *i.e.* attain their perfect structure, at a

[1] "West Riding Asylum Reports," 1873.
[2] "Die localisation der Geistigen Vorgänge," Leipzig, 1896.

uniform period of time, so that some acquired their complete functional importance before others. He has now applied the same method of research to the study of the development of the human brain, and has shown that in it also there is a difference in the time of attaining perfect structural development of the nerve-tracts. Further, he has discovered that the nerve-fibres in the cerebrum become myelinated, subsequent to the fibres of the other divisions of the cerebro-spinal nervous axis. When a child is born, very few of the fibres of its cerebrum are myelinated, and we have now an anatomical explanation of the reason why an infant has so inactive a brain and is so helpless a creature. It will therefore be of especial interest to determine, whether in those animals which are active as soon as they are born, and which can at once assume the characteristic attitude of the species, the fibres of the cerebrum are completely developed at the time of birth. Flechsig has also shown that the sensory paths myelinate before the motor tracts; that the paths of transmission of touch, and the other impulses conducted by the dorsal roots of the spinal nerves, are the first to become completely formed, whilst the fibres for auditory impulses are the last.

Flechsig names the great sensory centre which receives the impulses associated with touch, pain, temperature, muscular sense, &c., *Körperfühlsphäre*, the region of general-body-sensation, or the somæsthetic area, as translated by Dr. Barker.[1] The tracts conducting these impulses myelinate at successive periods after birth. They pass upwards from the inner and outer capsules and the optic thalamus as three systems.[2] Some enter the central convolutions of the Rolandic area, others reach the paracentral lobule, the inferior frontal convolution, the insula, and small parts of the middle and superior frontal convolutions; whilst considerable numbers reach the gyrus fornicatus and the hippocampal gyrus, which Ferrier had previously localised as a centre of common or tactile sensibility.

The Rolandic area, therefore, is not exclusively a motor area, but is a centre associated also with the general sensibility of the body. The motor fibres in it are not myelinated until after the sensory paths have become developed. As the motor paths become structurally complete, they can be traced downwards as the great pyramidal tract from the pyramidal nerve-cells in this area, from which they arise, into the spinal cord, where they come into close relation with the nerve-cells in the anterior horn of grey matter, from which the nerve axial fibres proceed that are distributed to the voluntary muscles.

Flechsig's observations agree with those of previous observers in placing the visual centre in the occipital lobe; the auditory centre in and near the superior temporal convolution; and the olfactory centre in the uncinate and hippocampal convolutions. Of the position of the taste centre he does not speak definitely, although he thinks it to be in proximity either to the centre of general sensation, or to the olfactory centre.

The centres of special sense in the cortex, and the large Rolandic area, which is the centre both for motion and general sensation, do not collectively occupy so much as one-half of the superficial area of the convolutions of the cortex. In all the lobes of the brain—frontal, parietal, occipito-temporal, and insula—convolutions are situated, not directly associated with the reception of sensory impressions, or as centres of motor activity, the function of which is to be otherwise accounted for. These convolutions lie intermediary to the sensory and motor centres. Flechsig has shown that in them myelination of the nerve-fibres does not take place until some weeks after birth, so that they are distinctly later in acquiring their structural perfection and functional activity. As the nerve-fibres become differentiated, they are seen to pass from the sense-centres into these intermediate convolutions, so as to connect adjacent centres together, and bring them into association with each other.[3] Hence he has called them the association centres, the function of which is to connect together centres and convolutions otherwise disconnected.[1]

We have now, therefore, direct anatomical evidence, based upon differences in their stages of development, that, in addition to the sensory and motor areas in the cortex of the human brain, a third division—the association centres—is to be distinguished.

If we compare the cerebrum in man and the apes, we find those convolutions which constitute the motor and sensory centres distinctly marked in both. An ape, like a man, can see, hear, taste, smell and touch; it also exhibits great muscular activity and variety of movement. It possesses, therefore, similar fundamental centres of sensation and motion, which are situated in areas of the cortex, resembling in arrangement and relative position, though much smaller in size than, the corresponding convolutions in the adult human brain. It is not unlikely, though the subject needs additional research, that the minute structure of these centres resembles that of man, though, from the comparatively restricted area of grey matter in the ape, the neurones will necessarily be much fewer in number.

In the cerebrum of a new-born infant, whilst the motor and sensory convolutions are distinct, the convolutions for the association areas, though present, are comparatively simple, and do not possess as many windings as are to be seen in the brain of a Chimpanzee not more than three or four years old.

Again, if we compare the brain of the Bushwoman, miscalled the Hottentot Venus, figured by Gratiolet and by Bischoff, or the one studied by Mr. John Marshall, with that of the philosopher Gauss, figured by Rudolph Wagner, we also recognise the convolutions in which the motor and sensory areas are situated. In all these brains they have a comparative simplicity of form and arrangement which enables one readily to discriminate them. When we turn, however, to the association areas in the three tiers of convolutions in the frontal lobe, and in the parieto-occipital and occipito-temporal regions where the bridging or annectant convolutions are placed, we cannot fail to observe that in a highly developed brain, like that of Gauss, the association convolutions have a complexity in arrangement, and an extent of cortical surface much more marked than in the Bushwoman, and to a still greater degree than in the ape. The naked-eye anatomy of the brain therefore obviously points to the conclusion that these association areas are of great physiological importance.

The problem which has now to be solved is the determination of their function. Prolonged investigation into the development and comparative histology of the brain will be necessary before we can reach a sound anatomical basis on which to found satisfactory conclusions. It will especially be necessary to study the successive periods of development of the nerve-fibre tracts in the cerebrum of apes and other mammals, as well as the magnitude and intimate structure of the association areas in relation to that of the motor and sensory areas in the same species.

Flechsig, however, has not hesitated to ascribe to the association centres functions of the highest order. He believes them to be parts of the cerebral cortex engaged in the manifestations of the higher intelligence, such as memory, judgment, and reflection; but in the present state of our knowledge such conclusions are of course quite speculative.

It is not unlikely, however, that the impulses which are conveyed by the intermediate nerve-tracts, either on the one hand, from the sense centres to the association centres, or on the other, from the association centres to the sensory and motor centres, are neither motor nor sensory impulses, but a form of nerve energy, determined by the terminal connections and contacts of the nerve-fibres. It is possible that the association centres, with the intermediate connecting tracts, may serve to harmonise and control the centres for the reception of sensory impressions that we translate into consciousness, with those which excite motor activity, so as to give to the brain a completeness and perfection of structural mechanism, which without them it could not have possessed.

We know that an animal is guided by its instincts, through which it provides for its individual wants, and fulfils its place in nature. In man, on the other hand, the instinctive acts are under the influence of the reason and intelligence, and it is

1 *Johns Hopkins Bulletin*, No. 70, January 1897.

2 Drs. Ferrier and Aldren Turner communicated to the Royal Society of London a few weeks ago (*Proc. Roy. Soc.*, June 17, 1897) an account of an elaborate research on the tracts which convey general and special sensibility to the cerebral cortex of monkeys. Their results were obtained by the aid of destructive lesions and the study of the consecutive degenerations in the nerve-tracts. From the brief abstract in the *Proceedings*, their research, though conducted by a different method, harmonises with the observations of Flechsig on the human brain, in regard to the course and connections of the great thalamic cortico-petal sensory fibres. They have also traced association fibres in connection with both the visual and auditory systems.

3 The term association fibres was introduced a number of years ago to express fibres of the cerebrum which connect together parts of the cortex in the same hemisphere. Flechsig's fibres belong to this system.

1 The association centres had previously been referred to by other observers as "silent portions" of the cortex, not responding to electrical stimulus. Their possible function had been discussed by Prof. Calderwood in "Relations of Mind and Brain," 2nd edit., 1884.

possible that the association centres, with the intermediate association fibres which connect them with the sensory and motor centres, may be the mechanism through which man is enabled to control his animal instincts, so far as they are dependent on motion and sensation.

The higher we ascend in the scale of humanity, the more perfect does this control become, and the more do the instincts, emotions, passions and appetites become subordinated to the self-conscious principle which regulates our judgments and beliefs. It will therefore now be a matter for scientific inquiry to determine, as far as the anatomical conditions will permit, the proportion which the association centres bear to the other centres both in mammals and in man, the period of development of the association fibres, in comparison with that of the motor and sensory fibres in different animals, and, if possible, to obtain a comparison in these respects between the brains of savages and those of men of a high order of intelligence.

The capability of erecting the trunk; the power of extending and fixing the hip and knee joints when standing; the stability of the foot; the range and variety of movement of the joints of the upper limb; the balancing of the head on the summit of the spine; the mass and weight of the brain, and the perfection of its internal mechanism, are distinctly human characters. They are the factors concerned in adapting the body of man, under the guidance of reason, intelligence, the sense of responsibility and power of self-control, for the discharge of varied and important duties in relation to himself, his Maker, his fellows, the animal world and the earth on which he lives.

SECTION I.

PHYSIOLOGY.

OPENING ADDRESS BY PROF. MICHAEL FOSTER, M.A., M.D., D.C.L., LL.D., SEC.R.S., PRESIDENT OF THE SECTION.

WE who have come from the little island on the other side of the great waters to take part in this important gathering of the British Association, have of late been much exercised in retrospection. We have been looking back on the sixty years reign of our beloved Sovereign, and dwelling on what has happened during her gracious rule. We have, perhaps, done little in calling to mind the wrongs, the mistakes and the failures of the Victorian era; but our minds and our mouths have been full of its achievements and its progress; and each of us, of himself or through another, has been busy in bringing back to the present the events of more than half a century of the past. It was while I, with others, was in this retrospective mood that the duty of preparing some few words to say to you to-day seemed suddenly to change from an impalpable cloud in the far distance to a heavy burden pressing directly on the back; and in choosing something to say I have succumbed to the dominant influence. Before putting pen to paper, however, I recovered sufficiently to resist the temptation to add one more to the many reviews which have appeared of the progress of physiology during the Victorian era. I also rejected the idea of doing that for which I find precedents in past presidential addresses—namely, of attempting to tell what has been the history of the science to which a Section is devoted during the brief interval which has elapsed since the Section last met; to try and catch physiology, or any other science, as it rushes through the brief period of some twelve months seemed to me not unlike photographing the flying bullet without adequate apparatus; the result could only be either a blurred or a delusive image. But I bethought me that this is not the first, we hope it will not be the last, time that the British Association has met in the Western Hemisphere; and though the events of the thirteen years which have slipped by since the meeting at Montreal in 1884 might seem to furnish a very slender oat on which to pipe a presidential address, I have hoped that I might be led to sound upon it some few notes which might be listened to.

And indeed, though perhaps when we come to look into it closely almost every period would seem to have a value of its own, the past thirteen years do, in a certain sense, mark a break between the physiology of the past and that of the future. When the Association met at Montreal in 1884, Darwin, whose pregnant ideas have swayed physiology in the limited sense of that word, as well as that broader study of living beings which we sometimes call biology, as indeed they have every branch of natural knowledge, had been taken from us only some two years before, and there were still alive most of the men who did the great works of physiology of the middle and latter half of this century. The gifted Claude Bernard had passed away some years before, but his peers might have been present at Montreal. Bowman, whose classic works on muscle and kidney stand out as peaks in the physiological landscape of the past, models of researches finished and complete so far as the opportunities of the time would allow, fruitful beginnings and admirable guides for the labours of others. Brown-Sequard, who shares with Bernard the glory of having opened up the great modern path of the influence of the nervous system on vascular and thus on nutritional events, and who, if he made some mistakes, did many things which will last for all time. Brücke, whose clear judgment, as shown in his digestive and other work, gave permanent value to whatever he put forth. Du Bois Reymond, who, if he laboured in a narrow path, set a brilliant example of the way in which exact physical analysis may be applied to the phenomena of living beings, and in other ways had a powerful influence on the progress of physiology. Donders, whose mind seemed to have caught something of the better qualities of the physiological organ to which his professional life was devoted, and our knowledge of which he so largely extended, so sharply did he focus his mental eye on every physiological problem to which he turned—and these were many and varied. Helmholtz, whose great works on vision and hearing, to say nothing of his earlier distinctly physiological researches, make us feel that if physics gained much, physiology lost even more when the physiologist turned aside to more distinctly physical inquiries. Lastly, and not least, Ludwig, who by his own hands or through his pupils did so much to make physiology the exact science which it is to-day, but which it was not when he began his work. I say lastly, but I might add the name of one who, though barred by circumstances from contributing much directly to physiology by way of research, so used his powerful influence in many ways in aid of physiological interests as to have helped the science onward to no mean extent, at least among English-speaking people—I mean Huxley. All these might have met at Montreal. They have all left us now. Among the peers of the men I have mentioned whose chief labours were carried on in the forties, the fifties and the sixties of the century, one prominent inquirer alone seems to be left, Albert von Kölliker, who in his old age is doing work of which even he in his youth might have been proud. The thirteen years which have swept the others away seem to mark a gulf between the physiological world of to-day and that of the time in which most of their work was done.

They are gone, but they have left behind their work and their names. May they of the future, as I believe we of the present are doing, take up their work and their example, doing work other than theirs but after their pattern, following in their steps.

In the thirteen years during which these have passed away physiology has not been idle. Indeed, the more we look into the period the more it seems to contain.

The study of physiology, as of other sciences, though it may be stimulated by difficulties (and physiology has the stimulus of a special form of opposition unknown to other sciences), expands under the sunshine of opportunity and aid. And it may be worth while to compare the opportunities for study of physiology in 1884 with those in 1897. At this meeting of the British Association I may fitly confine myself, I was going to say, to British matters; but I feel at this point, as others have felt, the want of a suitable nomenclature. We who are gathered here to-day have, with the exception of a few honoured guests from the Eastern Hemisphere, one common bond, one common token of unity, and, so far as I know, one only; I am speaking now of outward tokens; down deeper in our nature there are, I trust, yet others. We all speak the English tongue. Some of us belong to what is called Great Britain and Ireland, others to that which is sometimes spoken of as Greater Britain. But there are others here who belong to neither; though English in tongue, they are in no sense British. To myself, to whom the being English in speech is a fact of far deeper moment than any political boundary, and who wish at the present moment to deal with the study of physiology among all those who speak the English tongue, there comes the great want of some word which will denote all such. I hope, indeed I think, that others feel the same want too. The term Anglo-Saxon is at once pedantic and incorrect, and yet there is none other; and, in the absence of such a better term, I shall be forgiven if I venture at times to use the seemingly narrow word English as really meaning something much broader than British in its very broadest sense.

Using English in this sense, I may, I think, venture to say that the thirteen years which separate 1884 from to-day have witnessed among English people a development of opportunities for physiological study such as no other like period has seen. It is not without significance that only a year or two previous to this period, in England proper, in little England, neither of the ancient Universities of Oxford and Cambridge, which, historically at least, represent the fullest academical aspirations of the nation, possessed a chair of physiology; the present professors, who are the first, were both appointed in 1883. Up to that time the science of physiology had not been deemed worthy, by either university, of a distinctive professorial mechanism. The act of these ancient institutions was only a manifestation of modern impulses, shared also by the metropolis and by the provinces at large. Whereas up to that time the posts for teaching physiology, by whatever name they were called, had been in most cases held by men whose intellectual loins were girded for other purposes than physiology, and who used the posts as stepping-stones for what they considered better things, since that time, as each post became vacant, it has almost invariably been filled by men wishing and purposing at least to devote their whole energies to the science. Scotland, in many respects the forerunner of England in intellectual matters, had not so much need of change; but she, too, has moved in the same direction, as has also the sister island.

And if we turn to this Western Continent, we find in Canada and in the States the same notable enlargement of physiological opportunity, or even a still more notable one. If the English-speaking physiologist dots on the map each place on this Western Hemisphere which is an academic focus of his science, he may well be proud of the opportunities now afforded for the development of English physiology; and the greater part of this has come within the last thirteen years.

Professorial chairs or their analogues are, however, after all but a small part of the provision for the development of physiological science. The heart of physiology is the laboratory. It is this which sends the life-blood through the frame; and in respect to this, perhaps, more than to anything else, has the progress of the past thirteen years been striking. Doubtless, on both sides of the waters there were physiological laboratories, and good ones, in 1884; but how much have even these during that period been enlarged and improved, and how many new ones have been added? In how many places, even right up to about 1884, the professor or lecturer was fain to be content with mere lecture experiments and a simple course of histology, with perhaps a few chemical exercises for his students! Now each teacher, however modest his post, feels and says that the authorities under whom he works are bound to provide him with the means of leading his students along the only path by which the science can be truly entered upon, that by which each learner repeats for himself the fundamental observations on which the science is based.

But there is a still larger outcome from the professorial chair and the physiological laboratory than the training of the student; these are opportunities not for teaching only, but also for research. And perhaps in no respect has the development during the past thirteen years been so marked as in this. Never so clearly as during this period has it become recognised that each post for teaching is no less a post for learning, that among academic duties the making knowledge is as urgent as the distributing it, and that among professorial qualifications the gift of garnering in new truths is at least as needful as facility in the didactic exposition of old ones. Thirteen years has seen a great change in this matter, and the progress has been perhaps greater on this side of the water than on the other, so far as English-speaking people are concerned. We on the other side have witnessed with envy the establishment on this side of a university, physiology having in it an honoured place, the keynote of which is the development of original research. It will, I ventur to think, be considered a strong confirmation of my present theme that the Clark University at Worcester was founded only ten years ago.

And here, as an English-speaking person, may I be allowed to point out, not without pride, that these thirteen years of increased opportunity have been thirteen years of increased fruitfulness. In the history of our science, among the names of the great men who have made epochs, English names, from Harvey onwards, occupy no mean place; but the greatness of such great men is of no national birth; it comes as it lists, and is independent of time and of place. If we turn to the more every-day workers, whose continued labours more slowly build up the growing edifice and provide the needful nourishment for the greatness of which I have just spoken, we may, I will dare to say, affirm that the last thirteen years has brought contributions to physiology, made known in the English tongue, which, whether we regard their quantity or their quality, significantly outdo the like contributions made in any foregoing period of the same length. Those contributions have been equally as numerous, equally as good on this side as on the other side of the waters. And here I trust I shall be pardoned if personal ties and affection lead me to throw in a personal word. May I not say that much which has been done on this side has been directly or indirectly the outcome of the energy and gifts of one whom I may fitly name on an occasion such as this, since, though he belonged to the other side, his physiological life was passed and his work was done on this side, one who has been taken from us since this Association last met, Henry Newell Martin?

Yes, during these thirteen years, if we put aside the loss of comrades, physiology has been prosperous with us and the outlook is bright; but, as every cloud has its silver lining, so shadow follows all sunshine, success brings danger, and something bitter rises up amid the sweet of prosperity. The development of which I have spoken is an outcome of the progressive activity of the age, and the dominant note of that activity is heard in the word "commercial." Noblemen and noblewomen open shop, and every one, low as well as high, presses forward towards large or quick profits. The very influences which have made devotion to scientific inquiry a possible means of livelihood, and so fostered scientific investigation, are creating a new danger. The path of the professor was in old times narrow and straight, and only the few who had a real call cared to tread it; nowadays there is some fear lest it become so broad and so easy as to tempt those who are in no way fitted for it. There is an increasing risk of men undertaking a research, not because a question is crying out to them to be answered, but in the hope that the publication of their results may win for them a lucrative post. There is, moreover, an even greater evil ahead. The man who lights on a new scientific method holds the key of a chamber in which much gold may be stored up; and strong is the temptation for him to keep the new knowledge to himself until he has filled his fill, while all the time his brother-inquirers are wandering about in the dark through lack of that which he possesses. Such a selfish withholding of new scientific truth is beginning to be not rare in some branches of knowledge. May it never come near us!

Now I will, with your permission, cease to sound the provincial note, and ask your attention for a few minutes while I attempt to dwell on what seem to me to be some of the salient features of the fruits of physiological activity, not among English-speaking people only, but among all folk, during the past thirteen years.

When we review the records of research and discovery over any lengthened period, we find that in every branch of the study progress is irregular, that it ebbs and flows. At one time a particular problem occupies much attention, the periodicals are full of memoirs about it, and many of the young bloods flesh their maiden swords upon it. Then again for awhile it seems to lie dormant and unheeded. But quite irrespective of this feature, which seems to belong to all lines of inquiry, we may recognise two kinds of progress. On the one hand, in such a period, in spite of the waves just mentioned, a steady advance continually goes on in researches which were begun and pushed forward in former periods, some of them being of very old date. On the other hand, new lines of investigation, starting with quite new ideas or rendered possible by the introduction of new methods, are or may be begun. Such naturally attract great attention, and give a special character to the period.

In the past thirteen years we may recognise both these kinds of progress. Of the former kind I might take, as an example, the time-honoured problems of the mechanics of the circulation. In spite of the labour which has been spent on these in times of old, something always remains to be done, and the last thirteen years have not been idle. The researches of Hürthle and Tigerstedt, of Roy and Adami, not to mention others, have left us wiser than we were before. So again, with the also old problems of muscular contraction, progress, if not exciting, has been real; we are some steps measurably nearer an understanding what is the exact nature of the fundamental changes which bring about contraction and what are the relations of those changes to the structure of muscular fibre. In respect to another old problem, too, the beat of the heart, we have continued to creep nearer and nearer to the full light. Problems again, the method of attacking which is of more recent origin, such as the nature of secretion, and the allied problem of the nature of transudation, have engaged attention and brought about that stirring of the waters of controversy which, whatever be its effects in other departments of life, is never in science wholly a waste of time, if indeed it be a waste of time at all, since, in matters of science, the tribunal to which the combatants of both sides appeal is always sure to give a true judgment in the end. In the controversy thus arisen, the last word has perhaps not yet been said, but whether we tend at present to side with Heidenhain, who has continued into the past thirteen years the brilliant labours which were perhaps the distinguishing features of physiological progress in preceding periods, and who in his present sufferings carries with him, I am sure, the sympathies if not the hopes of all his brethren, or whether we are more inclined to join those who hold different views, we may all agree in saying that we have, in 1897, distinctly clearer ideas of why secretion gathers in an alveolus or lymph in a lymph space than we had in 1884.

I might multiply such examples of progress on more or less old lines until I wearied you; but I will try not to do so. I wish rather to dwell for a few minutes on some of what seem to be the salient new features of the period under review.

One such feature is, I venture to think, the development of what may perhaps be called the new physiological chemistry. We always are, and for a long time always have been, learning something new about the chemical phenomena of living beings. During the years preceding those immediately recent, great progress, for which we have especially, perhaps, to thank Kühne, was made in our knowledge of the bodies which we speak of as proteids and their allies. But while admitting to the full the high value of all these researches, and the great light which they threw on many of the obscurer problems of the chemical changes of the body, such, for instance, as the digestive changes and the clotting of blood, it could not but be felt that their range was restricted and their value limited. Granting the extreme usefulness of being able to distinguish bodies through their solution or precipitation by means of this or that salt or acid, this did not seem to promise to throw much light on the all-important problem as to what was the connection between the chemical constitution of such bodies and their work in the economy of a living being. For it need not be argued that this is an all-important problem. To-day, as yesterday and as in the days before, the mention of the word vitalism or its equivalent separates as a war-cry physiologists into two camps, one contending that all the phenomena of life can, and the other that they cannot, be explained as the result of the action of chemico-physical forces. For myself, I have always felt that while such a controversy, like other controversies as I ventured to say just now, is useful as a stirring of the waters, through which much oxygen is brought home to many things and no little purification effected, the time for the final judgment on the question will not come until we shall more clearly understand than we do at present what we mean by physical and chemical, and may perhaps be put off until somewhere near the end of all things, when we shall know as fully as we ever shall what the forces to which we give these names can do and what they cannot. Meanwhile the great thing is to push forward, so far as may be, the chemical analysis of the phenomena presented by living beings. Hitherto the physiological chemists, or the chemical physiologists as perhaps they ought rather to be called, have perhaps gone too much their own gait, and have seemed to be constructing too much a kind of chemistry of their own. But that, may I say, has in part been so because they did not receive from their distinctly chemical brethren the help of which they were in need. May I go so far as to say that to us physiologists these our brethren seemed to be lagging somewhat behind, at least along those lines of their science which directly told on our inquiries? That is, however, no longer the case. They are producing work and giving us ideas which we can carry straight into physiological problems. The remarkable work of Emil Fischer on sugars, one of the bright results of my period of thirteen years, may fully be regarded as opening up a new era in the physiology of the carbohydrates, opening up a new era because it has shown us the way how to investigate physiological problems on purely and distinctively chemical lines. Not in the carbohydrates only, but in all directions our younger investigators are treating the old problems by the new chemical methods; the old physiological chemistry is passing away; nowhere, perhaps, is the outlook more promising than in this direction; and we may at any time receive the news that the stubborn old fortress of the proteids has succumbed to the new attack.

Another marked feature of the period has been the increasing attention given to the study of the lower forms of life, using their simpler structures and more diffuse phenomena to elucidate the more general properties of living matter. During the greater part of the present century physiologists have, as a rule, chosen as subjects of their observations almost exclusively the vertebrata; by far the larger part of the results obtained during this time have been gained by inquiries restricted to some half a dozen kinds of backboned animals; the frog and the myograph, the dog and the kymograph have almost seemed the alpha and the omega of the science. This has been made a reproach by some, but, I cannot help thinking, unjustly. Physiology is, in its broad meaning, the unravelling of the potentialities of things in the condition which we call living. In the higher animals the evolution by differentiation has brought these potentialities, so to speak, near the surface, or even laid them bare as actual properties capable of being grasped. In the lower animals they still lie deep buried in primeval sameness; and we may grope among them in vain unless we have a clue furnished by the study of the higher animal. This truth seems to have been early recognised during the progress of the science. In the old time, observers such as Spallanzani, with but a moderate amount of accumulated knowledge behind them, and a host of problems before them, with but few lines of inquiry as yet definitely laid down, were free to choose the subjects of their investigation where they pleased, and in the wide field open to them prodded, so to speak, among all living things, indifferent whether they possessed a backbone or no. But it soon became obvious that the study of the special problems of the more highly organised creature was more fruitful, or at least more easily fruitful, than that of the general problems of the simpler forms; and hence it came about that inquiry, as it went on, grew more and more limited to the former. But an increasing knowledge of the laws of life as exemplified in the differentiated phenomena of the mammal is increasingly fitting us for a successful attack on the more general phenomena of the lowly creatures possessing little more than that molecular organisation, if such a phrase be permitted, which alone supplies the conditions for the manifestation of vital activities. And, though it may be true that in all periods men have from time to time laboured at this theme, I think that I am not wrong in saying that the last dozen years or so mark a distinct departure both as regards the number of researches directed to it, and also, what is of greater moment, as regards the definiteness and clearness of the results thereby obtained. One has only to look at the results recorded in the valuable treatises of Verworn and Biedermann, whether obtained by the authors themselves or by others, to feel great hope that in the immediately near future a notable advance will be made in our grasp of the nature of that varying collection of molecular conditions, potencies and changes, slimy hitherto to the intellectual no less than to the physical touch, which we are in the habit of denoting by the more or less magical word protoplasm. And perhaps one happy feature of such an advance will be one step in the way of that reintegration which men of science fondly hope may ultimately follow the differentiation of studies now so fierce and attended by many ills; in the problems of protoplasm the animal physiologist touches hands with the botanist, and both find that under different names they are striving towards the same end.

Closely allied to and indeed a part of the above line of inquiry is the study of the physiological attributes of the cell and of their connection with its intrinsic organisation. This is a study which, during the last dozen years, has borne no mean fruits; but it is an old study, one which has been worked at from time to time, reviving again and again as new methods offered new opportunities. Moreover, it will probably come directly before us in our sectional work, and therefore I will say nothing more of it here.

Still another striking feature of the past dozen years has been the advance of our knowledge in regard to those events of the animal body which we have now learnt to speak of as "internal secretion." This knowledge did not begin in this period. The first note was sounded long ago in the middle of the century, when Claude Bernard made known what he called "the glycogenic function of the liver." Men, too, were busy with the thyroid body and the suprarenal capsules long before the meeting of the British Association at Montreal. But it was since then, namely in 1889, that Minkowski published his discovery of the diabetic phenomena resulting from the total removal of the pancreas. That, I venture to think, was of momentous value, not only as a valuable discovery in itself, but especially, perhaps, in confirming and fixing our ideas as to internal secretion, and in encouraging further research.

Minkowski's investigation possessed this notable feature, that it was clear, sharp and decided, and, moreover, the chief factor, namely sugar, was subject to quantitative methods. The results of removing the thyroid body had been to a large extent general, often vague, and in some cases uncertain; so much so as to justify, to a certain extent, the doubts held by some as to the validity of the conclusion that the symptoms witnessed were really and simply due to the absence of the organ removed. The observer who removes the pancreas has to deal with a tangible and measurable result, the appearance of sugar in the urine. About this there can be no mistake, no uncertainty. And the confidence thus engendered in the conclusion that the pancreas, besides secreting the pancreatic juice, effects some notable change in the blood passing through it, spread to the analogous conclusions concerning the thyroid and the suprarenal, and moreover suggested further experimental inquiry. By those inquiries all previous doubts have been removed; it is not now a question whether or no the thyroid carries on a so-called internal secretion; the problem is reduced to finding out what it exactly does and how exactly it does it. Moreover, no one can at the present day suppose that this feature of internal secretion is confined to the thyroid, the suprarenal, and the pancreas; it needs no spirit of prophecy to foretell that the coming years will add to physiological science a large and long chapter, the first marked distinctive verses of which belong to the dozen years which have just passed away.

The above three lines of advance are of themselves enough to justify a certain pride on the part of the physiologist as to the share which his science is taking in the forward movements of the time. And yet I venture to think that each and all of these is wholly overshadowed by researches of another kind, through which knowledge has made, during the past dozen years or so, a bound so momentous and so far-reaching that all other results gathered in during the time seem to shrink into relative insignificance.

It was a little before my period, in the year 1879, that Golgi published his modest note, "Un nuovo processo di technica microscopica" ("Rendiconti del reale Istituto Lombardo," vol. xii. p. 206). That was the breaking out from the rocks of a little stream which has since swollen into a great flood. It is quite true that long before a new era in our knowledge of the central nervous system had been opened up by the works of Ferrier and of Fritsch and Hitzig. Between 1870 and 1880 progress in this branch of physiology had been continued and rapid. Yet that progress had left much to be desired. On the one hand the experimental inquiries, even when they were carried out with the safeguard of an adequate psychical analysis of the phenomena which presented themselves, and this was not always the case, sounded a very uncertain note, at least when they dealt with other than simply motor effects. They were, moreover, not unfrequently in discord with clinical experience. In general the conclusions which were arrived at through them, save such as were based on the production of easily recognised and often measurable movements, were regarded by many as conclusions of the kind which could not be ignored, which demanded respectful attention, and yet which failed to carry conviction. It seemed to be risking too much to trust too implicitly to the apparent teaching of the results arrived at; something appeared wanting to give these their full validity, to explain their full and certain meaning by showing their connection with what was known in other ways and by other methods. On the other hand, during nearly all this time, in spite of the valuable results acquired by the continually improving histological technique, by the degeneration method, and by the developmental method, by the study of the periods of myelination, most of us, at all events, were sitting down, as our forefathers had done, before the intricate maze of encephalic structure, fascinated by its complexity, but wondering what it all meant. Even when we attempted to thread our way through the relatively simple tangle of the spinal cord, to expect that we should ever see our way so to unravel out the strands of fibres, here thick, there thin, now twisting and turning, and anon running straight, or so to set out in definite constellations the seeming milky way of star-like cells, so to do this as to make the conformation of the cord explain the performances of which it is capable, appeared to be something beyond our reach. And when we passed from the cord to those cerebral structures the even gross topography of which is the despair of the beginner in anatomical studies, the multiple maze of grey and white matter seemed to frame itself into the letters graven on the gateway of the city of Dis, and bid us leave all hope behind.

What a change has come upon us during the past dozen years, and how great is the hope of ultimate success which we have to-day. Into what at the meeting at Montreal seemed a cloudy mass, in which most things were indistinct and doubtful, and into which each man could read images of possible mechanisms according as his fancy led, the method of Golgi has fallen like a clarifying drop, and at the present moment we are watching with interest and delight how that vague cloud is beginning to clear up and develop into a sharp and definite picture, in which lines objectively distinct and saying one thing only reveal themselves more and more. This is not the place to enter into details, and I will content myself with pointing out as illustrative of my theme the progress which is being made in our knowledge of how we hear and how sounds affect us. A dozen years ago we possessed experimental and clinical evidence which led us to believe that auditory impulses sweeping up the auditory nerve became developed into auditory sensations through events taking place in the temporo-sphenoidal convolution, and we had some indications that as these passed upward through the lower and middle brain the striæ acusticæ and the lateral fillet had some part to play. Beyond this we knew but little. To-day we can with confidence construct a diagram which he who runs can read, showing how the impulses undergoing a relay in the tuberculum acusticum and accessory nucleus pass by the striæ acusticæ and trapezoid fibres to the superior olive and trapezoid nucleus, and onwards by the lateral fillet to the posterior corpus quadrageminum and to the cortex of the temporo-sphenoidal convolution. And if much, very much, yet remains to be done even in tracking out yet more exactly the path pursued by the impulses while they are still undeveloped impulses, not as yet lit up with consciousness, and in understanding the functional meaning of relays and apparently alternate routes, to say nothing of the deeper problems of when and how the psychical element intervenes, we feel that we have in our hands the clue by means of which we may hope to trace out clearly the mechanisms by which, whether consciousness plays its part or no, sounds affect so profoundly and so diversely the movements of the body, and haply some time or other to tell, in a plain and exact way, the story of how we hear. I have thus referred to hearing because the problems connected with this seemed, thirteen years ago, so eminently obscure; it appeared so pre-eminently hard a task, that of tracing out the path of an auditory impulse through the confused maze of fibre and cell presented by the lower and middle brain. Of the mechanism of sight we seemed even then to have better knowledge, but how much more clearly do we, so to speak, see vision now? So also with all other sensations, even those most obscure ones of touch and pain; indeed, all over the nervous system light seems breaking in a most remarkable way.

This great and significant progress we owe, I venture to say, to Golgi, to the method introduced by him; and I for one cannot help being glad that this important contribution to science, as well as another contingent and most valuable one, the degeneration method of Marchi, should be among the many tokens that Italy, the mother of all sciences in times gone by, is now once more taking her right place in scientific no less than in political life. We owe, I say, this progress to Golgi in the sense that the method introduced by him was the beginning of the new researches. We owe, moreover, to Golgi not the mere technical introduction of the method, but something more. He himself pointed out the theoretical significance of the results which his method produced; and if in this he has been outstripped and even corrected by others, his original merit must not be allowed to be forgotten. Those others are many, in many lands; but two names stand out conspicuous among them. If rejuvenescent Italy invented the method, another ancient country, whose fame, once brilliant in the past, like that of Italy, suffered in later times an eclipse, produced the man who, above all others, has showed us how to use it. At the meeting at Montreal a voice from Spain telling of things physiological would have seemed a voice crying out of the wilderness; to-day the name of Ramon-y-Cayal is in every physiologist's mouth. That is one name, but there is yet another. Years ago, when those of us who are now veterans and see signs that it is time for us to stand aside were spelling out the primer of histology, one name was always before us as that of a man who touched every tissue and touched each well. It is a consoling thought to some of us elder ones that histological research seems to be an antidote to senile decay. As the companion of the young Spaniard in the pregnant work on the histology of the central nervous system done in the eighties and the nineties of the century, must be named the name of the man who was brilliant in the fifties, Albert von Kölliker.

When I say that the progress of our knowledge of the central nervous system during the past thirteen years has been largely due to the application of the method of Golgi, I do not mean that it, alone and by itself, has done what has been done. That is not the way of science. Almost every thrust forward in science is a resultant of concurrent forces working along different lines; and in most cases at least significant progress comes when efforts from different quarters meet and join hands. And especially as regards methods it is true that their value and effect depend on their coming at their allotted times. As I said above, neither experimental investigation nor clinical observation nor histological inquiry by the then known methods, had been idle before 1880. They had moreover borne even notable fruits, but one thing was lacking for their fuller fruition. The experimental and clinical results all postulated the existence of clear definite paths for impulses within the central nervous system, of paths moreover which, while clear and sharp, were manifold and, under certain conditions, alternate or even vicarious, and were so constructed that the impulses as they swept along them underwent from time to time—that is, at some place or other—transformations or at least changes in nature. But the methods of histological investigations available before that of Golgi, though they taught us much, failed to furnish such an analysis of the tangle of grey and white matter as would clearly indicate the paths required. This the method of Golgi did, or rather is doing. Where gold failed silver has succeeded, and is succeeding. Thanks to the black tract which silver when handled in a certain way leaves behind it in the animal body, as indeed it does elsewhere, we can now trace out, within the central nervous system, the pathway afforded by the nerve cell and the nerve cell alone. We see its dendrites branching out in various directions, each alert to dance the molecular dance assigned to it at once by the more lasting conditions which we call structural, and the more passing ones which we call functional, so soon as some partner touch its hand. We see the body of the cell with its dominant nucleus ready to obey and yet to marshal and command the figure so started. We see the neuraxon prepared to carry that figure along itself, it may be to far-distant parts, it may be to near ones, or to divert it along collaterals, it may be many, or it may be few, or to spread out at once among numerous seemingly equipollent branches. And whether it prove ultimately true or no that the figure of the dancing molecules sweeps always onwards along the dendrites towards the nucleus, and always outwards away from the nucleus along the neuraxon, or whatever way in the end be shown to be the exact differences in nature and action between the dendrites and the neuraxon, this at least seems sure, that cell plays upon cell only by such a kind of contact as seems to afford an opportunity for change in the figure of the dance, that is to say, in the nature of the impulse, and that in at least the ordinary play it is the terminal of the neuraxon (either of the main core or a collateral) of one cell which touches with a vibrating touch the dendrite or the body of some other cell. We can thus, I say, by the almost magic use of a silver token—I say magic use, for he who for the first time is shown a Golgi preparation is amazed to learn that it is such a sprawling thing as he sees before him which teaches so much, and yet when he comes to use it acquires daily increased confidence in its worth—it is by the use of such a silver token that we have been able to unravel so much of the intricate tangle of the possible paths of nervous impulses. By themselves, the acquisition of a set of pictures of such black lines would be of little value. But, and this I venture to think is the important point, to a most remarkable extent, and with noteworthy rapidity, the histological results thus arrived at, aided by analogous results reached by the degeneration method, especially by the newer method akin to that of Golgi, that of Marchi, have confirmed or at times extended and corrected the teachings of experimental investigation and clinical observation. It is this which gives strength to our present position; we are attacking our problems along two independent lines. On the one hand we are tracing out anatomical paths, and laying bare the joints of histological machinery; on the other hand, beginning with the phenomena, and analysing the manifestations of disorder, whether of our own making or no, as well as of order, we are striving to delineate the machinery by help of its action. When the results of the two methods coincide, we may be confident that we are on the road of all truth; when they disagree, the very disagreement serves as the starting-point for fresh inquiries along the one line or the other.

Fruitful as have been the labours of the past dozen years, we may rightly consider them as but the earnest of that which is to come; and those of us who are far down on the slope of life may wistfully look forward to the next meeting of the Association on these Western shores, wondering what marvels will then be told.

Physiology, even in the narrower sense to which, by emphasis on the wavering barrier which parts the animal from the plant, it is restricted in this Section, deals with many kinds of being, and with many things in each. But, somewhat as man, in one aspect a tiny fragment of the world, still more of the universe, in another aspect looms so great as to overshadow everything else, so the nervous system, seen from one point of view, is no more than a mere part of the whole organism, but, seen from another point of view, seems by its importance to swallow up all the rest. As man is apt to look upon all other things as mainly subserving his interests and purposes, so the physiologist, but with more justice, may regard all the rest of the body as mainly subserving the welfare of the nervous system; and, as man was created last, so our natural knowledge of the working of that nervous system has been the latest in its growth. But, if there be any truth in what I have urged to-day, we are witnessing a growth which promises to be as rapid as it has seemed to be delayed. Little spirit of prophecy is needed to foretell that in the not so distant future the teacher of physiology will hurry over the themes on which he now dwells so long, in order that he may have time to expound the most important of all the truths which he has to tell, those which have to do with the manifold workings of the brain.

And I will be here so bold as to dare to point out that this development of his science must, in the times to come, influence the attitude of the physiologist towards the world, and ought to influence the attitude of the world towards him. I imagine that if a plebiscite, limited even to instructed, I might almost say scientific, men, were taken at the present moment, it would be found that the most prevalent conception of physiology is that it is a something which is in some way an appendage to the art of medicine. That physiology is, and always must be, the basis of the science of healing, is so much a truism that I would not venture to repeat it here were it not that some of those enemies, alike to science and humanity, who are at times called anti-vivisectionists, and whose zeal often outruns, not only discretion, but even truth, have quite recently asserted that I think otherwise. Should such a hallucination ever threaten to possess me, I should only have to turn to the little we yet know of the physiology of the nervous system and remind myself how great a help the results of pure physiological curiosity—I repeat the words, pure physiological curiosity, for curiosity is the mother of science—have been, alike to the surgeon and the physician, in the treatment of those in some way most afflicting maladies, the diseases of the nervous system. No, physiology is, and always must be, the basis of the science of healing; but it is something more. When physiology is dealing with those parts of the body which we call muscular, vascular, glandular tissues and the like, rightly handled she points out the way not only to mend that which is hurt, to repair the damages of bad usage and disease, but so to train the growing tissues and to guide the grown ones as that the best use may be made of them for the purposes of life. She not only heals, she governs and educates. Nor does she do otherwise when she comes to deal with the nervous tissues. Nay, it is the very prerogative of these nervous tissues that their life is above that of all the other tissues, contingent on the environment and susceptible of education. If increasing knowledge gives us increasing power so to mould a muscular fibre that it shall play to the best the part which it has to play in life, the little knowledge we at present possess gives us at least much confidence in a coming far greater power over the nerve cell. This is not the place to plunge into the deep waters of the relation which the body bears to the mind; but this at least stares us in the face, that changes in what we call the body bring about changes in what we call the mind. When we alter the one, we alter the other. If, as the whole past history of our science leads us to expect, in the coming years a clearer and clearer insight into the nature and conditions of that molecular dance which is to us the material token of nervous action, and a fuller, exacter knowledge of the laws which govern the sweep of nervous impulses along fibre and cell, give us wider and directer command over the moulding of the growing nervous mechanism and the maintenance and regulation of the grown one, then assuredly physiology will take its place as a judge of appeal in questions not only of the body, but of the mind; it will raise its voice not in the hospital and consulting-room only, but also in the senate and the school.

One word more. We physiologists are sorely tempted towards self-righteousness, for we enjoy that blessedness which comes when men revile you and persecute you and say all manner of evil against you falsely. In the mother country our hands are tied by an Act which was defined by one of the highest legal authorities as a "penal" Act; and though with us, as with others, difficulties may have awakened activity, our science suffers from the action of the State. And some there are who would go still further than the State has gone, though that is far, who would take from us even that which we have, and bid us make bricks wholly without straw. To go back is always a hard thing, and we in England can hardly look to any great betterment for at least many years to come. But unless what I have ventured to put before you to-day be a mocking phantasm, unworthy of this great Association and this great occasion, England in this respect at least offers an example to be shunned alike by her offspring and her fellows.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. W. ERNEST THOMSON has been appointed to the chair of Physiology at Anderson's College, Glasgow, in succession to Dr. Campbell Black.

THE *Athenæum* states that Peoria, Illinois, is to have a university. A millionaire has endowed the proposed institution with 1,000,000 dollars, placing the estate in the hands of trustees to be named by himself. His instructions are that the estate shall be conserved until the interest accretions, together with the principal, amount to 1,500,000 dollars, when the buildings are to be erected, the faculty secured, and the library, laboratories, &c., equipped.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 25.—M. A. Chatin in the chair.—Persian truffles. Note by M. Chatin on a letter received from the late Dr. Tholozan.—The recent storms in France, July and August 1897, and the solar period, by M. Ch. V. Zenger. Further evidence in support of the author's theory of the parallelism of atmospheric, electric, magnetic and seismic disturbances, and their connection with the electro-dynamic action of the sun.—Summary of solar observations made at the Royal Observatory of the Roman College during the first half of the year 1897, by M. P. Tacchini.—Observations of the solar eclipse of July 29 at the observatory of Rio de Janeiro, by M. L. Cruls.—On the reduction of vectors and metric properties, by M. J. Andrade.—Critical constants of some gases, by MM. A. Leduc and P. Sacerdote. The authors have determined the temperature and pressure, at the critical point, of hydrogen sulphide, chloride and phosphide. The results in the first two cases are in accordance with those obtained by Dewar. The critical constants of hydrogen phosphide are here given for the first time.—Absorption of the X-rays, by M. Abel Buguet. Methods are described by which the relation of the thickness of a substance to its opacity for the X-rays, and also its specific absorption of the latter, may be determined.—Presence of *Acari* in wines, by M. L. Mathieu. Several species of *Acari*, particularly *Glyciphagus cursor* and *Tiroglyphus farinæ*, have been observed in genuine unsweetened wines.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Valves and Valve-Gearing: C. Hurst (Griffin).—Analytic Geometry: P. A. Lambert (Macmillan). P. J. van Benedin: La Vie et L'Œuvre d'un Zoologiste: Dr. A. Kemna (Anvers, Buschmann).—A Guide to Zermatt: E. Whymper (Murray).—Durham College of Science Calendar, Session 1897–98 (Reid).

PAMPHLETS.—A Monograph on the Mechanics and Equilibrium of Kites: Prof. C. F. Marvin (Washington).—First Report upon Magnetic Work in Maryland: L. A. Bauer (Baltimore).—Report to the Local Government Board on the Preparation and Storage of Glycerinated Calf Vaccine Lymph (Eyre).

SERIALS.—English Illustrated Magazine, September (198 Strand).—Verhandlungen des Naturhistorischen Vereins, 53 Jahrg. 2 Hälfte (Bonn).—Longman's Magazine, September (Longmans).—Proceedings of the Society for Psychical Research, July (K. Paul).—Journal of the College of Science, Imperial University, Japan, Vol. x. Part 2 (Tōkyō).—Quarterly Journal of the Royal Meteorological Society, July (Stanford).—Scientific Transactions of the Royal Dublin Society, Vol. vi. Series ii. ix. (Williams).—Humanitarian, September (Hutchinson).—Zeitschrift für Physikalische Chemie, xxiii. Bd. 4 Heft (Leipzig).—Chambers's Journal, September (Chambers).—Good Words, September (Isbister).—Sunday Magazine, September (Isbister).—Natural Science, September (Dent).—Century Magazine, September (Macmillan).—History of Mankind: F. Ratzel, translated, Part 20 (Macmillan).—Journal of the Royal Horticultural Society, August (Victoria Street).—Journal of the Anthropological Institute, August (K. Paul).

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