the occurrence of burnt earth as an evidence of man's existence in the Miocene (?) 'Monte Hermosean.'" "The conclusions of the writers with regard to the evidence thus far furnished are that it fails to establish the claim that in South America there have been brought forth thus far tangible traces of either geologically ancient man himself or of any precursors of the human race." A. C. Haddon.

PAPERS ON INVERTEBRATES.

Unusual interest attaches to the description by Dr. A. Brinkmann, in the *Bergens Museum Aarbok* for 1912, part 3, of a new genus and species of deep-sea nemertine worm—*Bathynectes murrayii*—which differs from all previously known forms in the external position of the male genitalia. A single example was obtained so long ago as 1895, while sixteen others were collected by the *Michael Sars* in 1910. The length of females ranges from 43 to 61 mm., with a breadth of from 7·5 to 10 mm., but males are considerably smaller. Although the new organism, of which figures are given, represents an entirely new type, it forms in some degree a connecting link between Planktonemertes and Nectonemertes.

In connection with the above may be noticed a paper by Dr. M. v. Gedroyc, in *Bull. Ac. Sci. Cracovie* for February, 1913, on certain new European leeches, referred to the genera Trocheta and Hæmentaria, special interest from a distributional point of view attaching to the second determination, owing to the fact that while the genus was originally described from South America, it is now known to occur in the United States, Canada, Lapland, and Poland.

The death-feigning instinct (*Katalepsie*) among stick-insects (Phasmidæ), as exemplified by the species *Cerausius morosus*, forms the subject of a very interesting article by Mr. Peter Schmidt in *Biol. Centralblatt* of April 20. These insects, it appears, are extremely prone to assume the cataleptic phase, and may do so in almost any pose—sometimes lying flat on one side, with the limbs and antennæ stretched out parallel with the body, sometimes with the legs straddled outwards and the head and thorax raised, and at other times standing on the head. As these insects are specially modified to imitate vegetation, it seems that the cataleptic condition is another adaptation—of the muscular and nervous structures—to the same end.

The beetles, spiders and scorpions, earwigs, and flies collected during the Abor Expedition of 1911–12 form the subject of four articles by specialists in part 2 of vol viii. of Records of the Indian Museum, a number of new forms being described. In vol. iii., part 4, of Annals of the Transvaal Museum, Mr. L. B. Prout and Mr. E. A. Meyrick respectively describe new local Geometridæ and Micro-Lepidoptera.

We have received a copy of a concise "Synopsis of the Classification of Insects," drawn up by Prof. Maxwell Lefroy, and published by Messrs. Lumley, of Exhibition Road, at the price of one shilling. The arrangement of the orders is the one adopted by Messrs. Sharp and Shipley, and a brief, but apparently sufficient, definition is given of each order and family. The lack of an index is a decided drawback to the value of the work.

To the May number of *The Entomologist's Monthly Magazine* the Hon. Charles Rothschild contributes a note on the extremely rare bugs of the genus Cacodemus, which are parasitic on Old World bats. Three species are mentioned, one from South Africa, a second from India, and a third of which the home is at present unknown. Mr. Rothschild, it may be added, employs the name Clinocoridæ for the bugs, whereas Prof. Lefroy, in the synopsis just mentioned, uses Cimicidæ. R. L.

THE BRITISH ASSOCIATION AT BIRMINGHAM.

SECTION D.

ZOOLOGY.

Opening Address by H. F. Gadow, F.R.S., President of the Section.

"Address your audience about what you yourself happen to be most interested in, speak from the fullness of your heart, and make a clean breast of your troubles." That seemed good advice, and I shall endeavour to follow it, taking for my text old and new aims and methods of morphology, with special reference to resemblances in function and structure on the part of organs and their owners in the animal kingdom. First, however, allow me to tell you what has brought me to such a well-worn theme. Amongst the many impressions which it has been my good luck to gather during my travels in that enchanting country Mexico are the two following:—

First, the poisonous coral snakes, Elaps, in their beautiful black, red, and yellow garb; it varies in detail in the various species of Elaps, and this garb, with most of the variations too, occurs also in an astonishing number of genera and families of semi-poisonous and quite harmless Mexican snakes, some of which inhabit the same districts. A somewhat exhaustive study of these beauties has shown incontestably that these often astoundingly close resemblances are not cases of mimicry, but due to some other cooperations.

Secondly, in the wilds of the State of Michoacan, at two places, about twenty and seventy miles from the Pacific coast, I myself collected specimens of Typhlops which Dr. Boulenger without hesitation has determined as *Typhlops braminus*. Now, whilst this genus of wormlike, blind little snakes has a wide circumtropical distribution, *T. braminus* had hitherto been known only from the islands and countries of the Indian Ocean basin, never from America, nor from any of the Pacific Islands which possess other kinds of Typhlops. Accidental introduction is out of the question. Although the genus is, to judge from its characters, an especially old one, we cannot possibly assume that the species *braminus*, if the little thing had made its way from Asia to Mexico by a natural mode of spreading, has remained unaltered even to the slightest detail since that geological epoch during which such a journey could have taken place. There remains the assumption that amongst the of course countless generations of Typhlops in Mexico some have hit off exactly the same kind of permutation and combination of those characters which we have hitherto considered as specific of *braminus*, just as a pack of cards may in a long series of deals be dealt out more than once in the same sequence.

The two cases are impressive. They reminded me vividly that many examples of very discontinuous distribution—which anyone who has worked at zoogeography will call to mind—are exhibited by genera, families, and even orders, without our knowing whether the groups in which we class them are natural or artificial. The ultimate appeal lies with anatomy.

Introduced to zoology when Haeckel and Gegenbaur were both at their zenith, I have been long enough a worker and teacher to feel elated by its progress and depressed by its shortcomings and failures. Perhaps we have gone too fast, carried along by methods which have yielded so much and therefore have made us expect too much from them.

Gegenbaur founded the modern comparative anatomy by basing it upon the theory of descent. The leading idea in all his great works is to show that transformation, "continuous adjustment"

(Spencer), has taken place; he stated the problem of comparative anatomy as the reduction of the differences in the organisation of the various animals to a common condition; and as homologous organs he defined those which are of such a common, single origin. His first work in this new line is his classical treatise on the Carpus and Tarsus (1864).

It followed from this point of view that the degree of resemblance in structure between homologous organs and the number of such kindred organs present is a measure for the affinity of their owners. So was ushered in the era of pedigree of organs, of functions, of the animals themselves. The tracing of the divergence of homogenous parts became all-important, whilst those organs or features which revealed themselves as of different origin, and therefore as analogous only, were discarded as misleading in the all-important search for pedigrees. Functional correspondence was dismissed as "mere analogy," and even the systematist has learnt to scorn these so-called physiological or adaptive characters as good enough only for artificial keys. A curious view of things, just as if it was not one and the same process which has produced and abolished both sets of characters, the so-called fundamental or "reliable," as well as the analogous.

As A. Willey has put it happily, there was more rejoicing over the discovery of the homology of some unimportant little organ than over the finding of the most appalling unrelated resemblance. Morphology had become somewhat intolerant in the application of its canons, especially since it was aided by the phenomenal growth of embryology. You must not compare ectodermal with endodermal products. You must not make a likeness out of another germinal layer or anything that appertains to it, because if you do that would be a horror, a heresy, a homoplasy.

Haeckel went so far as to distinguish between a true homology, or homophyly, which depends upon the same origin, and a false homology, which applies to all those organic resemblances which derive from an equivalent adaptation to similar developmental conditions. And he stated that the whole art of the morphologist consists in the successful distinction between these two categories. If we were able to draw this distinction in every case, possibly some day the grand tree of each great phylum, maybe of the whole kingdom, might be reconstructed. That would indeed be a tree of knowledge, and, paradoxically enough, it would be the deathblow to classification, since in this, the one and only true natural system, every degree of consanguinity and relationship throughout all animated nature, past and present, would be accounted for; and to that system no classification would be applicable, since each horizon would require its own grouping. There could be definable neither classes, orders, families, nor species, since each of these conceptions would be boundless in an upward or downward direction.

Never mind the ensuing chaos; we should at least have the pedigree of all our fellow-creatures, and of ourselves among them. Not absolute proof, but the nearest possible demonstration that transformation has taken place. Empirically we know this already, since, wherever sufficient material has been studied, be it organs, species, or larger groups, we find first that these units had ancestors, and, secondly, that the ancestors were at least a little different. Evolution is a fact of experience, proved by circumstantial evidence. Nevertheless we are not satisfied with the conviction that life is subject to an unceasing change, not even with the knowledge of the particular adjustments. We now want to understand the motive cause. First, What, then How, and now Why?

It is the active search for an answer to this question (Why?) which is characteristic of our time. More and more the organisms and their organs are considered as living, functional things. The mainspring of our science, perhaps of all science, is not its utility, not the desire to do good, but, as an eminently matter-of-fact man, the father of Frederick the Great, told his Royal Academicians (who, of course, were asking for monetary help) in the following shockingly homely words: "Der Grund ist derer Leute ihre verfluchte Curieusiteit." This blamed curiosity, the beginnings of which can be traced very far back in the lower animals, is most acutely centred in our desire to find out who we are, whence we have come, and whither we shall go. And even if zoology, considering the first and last of these three questions as settled, should some day solve the problem: Whence have we come? there would remain outside zoology the greater Why?

Generalisations, conclusions, can be arrived at only through comparison. Comparison leads no further where the objects are alike. If, for instance, we restrict ourselves to the search for true homologies, dealing with homogenes only, all we find is that once upon a time some organism has produced, invented, a certain arrangement or *Anlage* out of which that organ arose, the various features of which we have compared in the descendants. Result: we have arrived at an accomplished fact. These things, in spite of all their variety in structure and function, being homogenes, tell us nothing, because according to our mode of procedure we cannot compare that monophyletic *Anlage* with anything else, since we have reduced all the homogenous modifications to one. Logically it is true that there can have been only one, but in the living world of nature there are no such iron-bound categories and absolute distinctions. For instance, if we compare the organs of one and the same individual, we at once observe repetition, *e.g.* that of serial homology, which implies many difficulties, with very different interpretations. Even in such an apparently simple case as the relation between shoulder girdle and pelvis we are at a loss, since the decision depends upon our view as to the origin of the paired limbs, whether both are modified visceral arches, and in this case serially repeated homogenes, or whether they are the derivatives from one lateral fin, which is itself a serial compound, from which, however, the proximal elements, the girdles, are supposed to have arisen independently. What is metamerism? Is it the outcome of a process of successive repetitions so that the units are homogenes, or did the division take place at one time all along the line, or is it due to a combination of the two procedures?

The same vagueness finds its parallel when dealing with the corresponding organs of different animals, since these afford the absolute chance that organs of the same structure and function may not be reducible to one germ, but may be shown to have arisen independently in time as well as with reference to the space they occupy in their owners. As heterogenes they can be compared as to their causes. In the study of the evolution of homogenes the problem is to account for their divergencies, whilst the likeness, the agreements, so to speak their greatest common measure, is *eo ipso* taken to be due to inheritance. When, on the contrary, dealing with heterogenes, we are attracted by their resemblances, which since they cannot be due to inheritance must have a common cause outside themselves. Now, since a leading feature of the evolution of homogenes is divergence, whilst that of heterogenes implies convergence from different starting points, it follows that the more distant are these respective starting points (either in time or in the material) the better is our chance of extracting the greatest common measure out of the unknown number of causes which combine in the production of even the apparently simplest organ.

These resemblances are a very promising field, and the balance of importance will more and more incline towards the investigation of function, a study which, however, does not mean mere physiology with its present-day aims in the now tacitly accepted sense, but that broad study of life and death which is to yield the answer to the question Why?

Meantime, comparative anatomy will not be shelved; it will always retain the casting-vote as to the degree of affinity among resemblances, but emphatically its whole work is not to be restricted to this occupation. It will increasingly have to reckon with the functions, indeed never without them. The animal refuses to yield its secrets unless it be considered as a living individual. It is true that Gegenbaur himself was most emphatic in asserting that an organ is the result of its function. Often he held up to scorn the embryographer's method of muddling cause and effect, or he mercilessly showed that in the reconstruction of the evolution of an organ certain features cannot have been phases unless they imply physiological continuity. And yet how moderately is function dealt with in his monumental text-book and how little is there in others, even in text-books of zoology!

> Habt alle die Theile in der Hand,
> Fehlt leider nur das geistige Band—Life!

We have become accustomed to the fact that like begets like with small differences, and from the accepted point of view of evolution *versus* creation we no longer wonder that descendants slowly change and diverge. But we are rightly impressed when unlike comes to produce like, since this phenomenon seems to indicate a tendency, a set purpose, a *beau idéal*, which line of thought or rather imperfect way of expression leads dangerously near to the crassest teleology.

But, teleology apart, we can postulate a perfect agreement in function and structure between creatures which have no community of descent. The notion that such agreement *must* be due to blood-relationship involved, among other difficulties, the dangerous conclusion that the hypothetical ancestor of a given genuine group possessed in potentiality the *Anlagen* of all the characters exhibited by one or other of the component members of the said group.

The same line of thought explained the majority of human abnormalities as atavistic, a procedure which would turn the revered ancestor of our species into a perfect museum of antiquities, stocked with tools for every possible emergency.

The more elaborate certain resemblances are, the more they seem to bear the hall-mark of near affinity of their owners. When occurring in far-related groups they are taken at least as indications of the homology of the organs. There is, for instance, a remarkable resemblance between the *bulla* of the whale's ear and that of the *Pythonomorph Plioplatycarpus*. If you homologise the mammalian tympanic with the quadrate the resemblance loses much of its perplexity, and certain Chelonians make it easier to understand how the modifications may have been brought about. But, although we can arrange the Chelonian, Pythonomorph, and Cetacean conditions in a progressive line, this need not represent the pedigree of this *bulla*. Nor is it necessarily referable to the same *Anlage*. Lastly, if, as many anatomists believe, the reptilian quadrate appears in the mammals as the *incus*, then all homology and homogeny of this *bullae* is excluded. In either case we stand before the problem of the formation of a *bulla* as such. The significant point is this, that although we dismiss the *bulla* of whale and reptile as obvious homoplasy, such resemblances, if they occur in two orders of reptiles, we take as indicative of relationship until positive evidence to the contrary is produced. That this is an unsound method is brought home to us by an ever-increasing number of cases which tend to throw suspicion on many of our reconstructions. Not a few zoologists look upon such cases as a nuisance and the underlying principle as a bugbear. So far from that being the case, such study promises much beyond the pruning of our standard trees—by relieving them of what reveal themselves as grafts instead of genuine growth—namely, the revelation of one or other of the many agencies in their growth and structure.

Since there are all sorts and conditions of resemblances, we require technical terms. Of these there is abundance, and it is with reluctance that I propose adding to them. I do so because unfortunately some terms are undefined, perhaps not definable; others have not "caught on," or they suffer from that mischievous law of priority in nomenclature.

The terms concerning morphological homologies date from Owen; Gegenbaur and Haeckel rearranged them slightly. Lankester, in 1870, introduced the terms homogenous, meaning alike born, and homoplastic, or alike moulded. Mivart rightly found fault with the detailed definition and the subdivisions of homoplasy, and very logically invented dozens of new terms, few of which, if any, have survived. It is not necessary to survey the ensuing literature. For expressing the same phenomenon we have now the choice between homoplasy, homomorphy, isomorphy, heterophyletic convergence, parallelism, &c. After various papers by Osborn, who has gone very fully into these questions, and Willey's "Parallelism," Abel, in his fascinating "Grundzüge der Palæobiologie," has striven to show by numerous examples that the resemblances or "adaptive formations" are cases of parallelism if they depend upon the same function of homologous organs, and convergences if brought about by the same function of non-homologous organs.

I suggest an elastic terminology for the various resemblances indicative of the degree of homology of the respective organs, the degree of affinity of their owners, and lastly the degree of the structural likeness attained.

Homogeny.—The structural feature is invented once and is transmitted, without a break, to the descendants, in which it remains unaltered, or it changes by mutation or divergence, neither of which changes can bring the ultimate results nearer to each other. Nor can their owners become more like each other, since the respective character made its first appearance either in one individual, or, more probably, in many of one and the same homogenous community.

Homoplasy.—The feature or character is invented more than once, and independently. This phenomenon excludes absolute identity; it implies some unlikeness due to some difference in the material, and there is further the chance of the two or more inventions, and therefore also of their owners, becoming more like each other than they were before

CATEGORIES OF HOMOPLASY.

Isotely.[1]—If the character, feature, or organ has been evolved out of homologous parts or material, as is most likely the case in closely related groups, and if the subsequent modifications proceed by similar stages and means, there is a fair probability or chance of very close resemblance. *Iso-tely*: the same mark has been hit.

Homoeotely.—Although the feature has been evolved

[1] *Cf.* "Isotely and Coralsnakes." By H. Gadow, Zoolog. Jahrbüther, Abt. f. Syst., xxxi., 1911.

from homologous parts or material, the respective modifications may proceed by different stages and means, and the ultimate resemblance will be less close and deficient in detail. Such cases are most likely to happen between groups of less close affinity, whether separated by distance or by time. *Homoeo-tely*: the same end has been fairly well attained. The target has been hit, but not the mark.

Parately.—The feature has been evolved from parts and material so different that there is scarcely any or no relationship. The resulting resemblance will at best be more or less superficial; sometimes a sham, although appealing to our fancy. *Para-tely*: the neighbouring target has been hit.

EXAMPLES.

Isotely: Bill of the Ardeidæ Balæniceps (Africa) and Cancroma (tropical America).

Zygodactyle foot of cuckoos, parrots, woodpeckers $\left(\frac{2\cdot3}{1\cdot4}\right)$.

Patterns and coloration of Elaps and other snakes.

Parachute of Petaurus (marsupial); Pteromys (rodent) and Galeopithecus.

Perissodactylism of Litopterna and Hippoids.

Bulla auris of Plioplatecarpus (Pythonomorphe) and certain whales; if tympanic = quadrate

Grasping instruments or nippers in Arthropods: pedipalps of Phryne; chelæ of squill; first pair of mantis' legs.

General appearance of moles and Notoryctes, if both considered as mammals; of gulls and petrels, if considered as birds.

Homoeotely: Heterodactyle foot of Trogons $\left(\frac{3\cdot4}{2\cdot1}\right)$.

Jumping foot of Macropus, Dipus, Tarsius.

Intertarsal and cruro-tarsal joint.

Fusion and elongation of the three middle metarsals of Dipus and Rhea.

Paddles of Ichthyosaurs. Turtles, whales, penguins.

"Wings" of Pterosaurs and bats.

Long flexible bill of Apteryx and snipes.

Proteroglyph dentition of cobras and Solenoglyph dentition of vipers.

Loss of the shell of Limax and Aplysia.

Complex molar pattern of horse and cow.

Parately: Bivalve shell of Brachiopods and Lamellibranchs.

Stretcher-sesamoid bone of Pterodactyls (radial carpal); of flying squirrels (on pisiform); of Anomalurus (on olecranon).

Bulla auris of Pythonomorph (quadrate) and Wale (tympanic); if *incus* = quadrate.

"Wings" of Pterosaurs, or bats, and birds.

The distinction between these three categories must be vague because that between homology and analogy is also arbitrary, depending upon the standpoint of comparison. As lateral outgrowths of vertebræ all ribs are homogenes, but if there are at least hæmal and pleural ribs, then those organs are not homologous even within the class of fishes. If we trace a common origin far enough back we arrive near bedrock with the germinal layers. So there are specific, generic, ordinal, &c., homoplasies. The potentiality of resemblance increases with the kinship of the material.

Bateson, in his study of Homœosis, has rightly made the solemn quotation: "There is the flesh of fishes . . . birds . . . beasts, &c." Their flesh will not and cannot react in exactly the same way under otherwise precisely the same conditions, since each kind of flesh is already biased, encumbered by inheritances. If a certain resemblance between a reptile and mammal dates from Permian times, it may be homogenous, like the pentadactyle limb which as such has persisted; but if that resemblance has first appeared in the Cretaceous period it is Homoplastic, because it was brought about long after the class division. To cases within the same order we give the benefit of the doubt more readily than if the resemblance concerned members of two orders, and between the phyla we rightly seek no connection. However, so strongly is our mode of thinking influenced by the principle of descent that, if the same feature happen to crop up in more than two orders, we are biased against Homoplasy.

The readiness with which certain Homoplasies appear in related groups seems to be responsible for the confounding of the potentiality of convergent adaptation with a latent disposition, as if such cases of Homoplasy were a kind of temporarily deferred repetition, *i.e.* after all due to inheritance. This view instances certain recurring tooth patterns, which, developing in the embryonic teeth, are said not to be due to active adaptation or acquisition, but to selection of accomplished variations, because it is held inconceivable that use, food, &c., should act upon a finished tooth. It is not so very difficult to approach the solution of this apparently contradictory problem. Teeth, like feathers, can be influenced long before they are ready by the life experiences of their predecessors. A very potent factor in the evolution of Homoplasies is correlation, which is sympathy, just as inheritance is reminiscence. The introduction of a single new feature may affect the whole organism profoundly, and one serious case of Isotely may arouse unsuspected correlations and thus bring ever so many more homoplasies in its wake.

Function is always present in living matter; it is life. It is function which not only shapes, but creates the organ or suppresses it, being indeed at bottom a kind of reaction upon some stimulus, which stimuli are ultimately all fundamental, elementary forces, therefore few in number. That is a reason why nature seems to have but few resources for meeting given "requirements"—to use an everyday expression which really puts the cart before the horse. This paucity of resources shows itself in the repetition of the same organs in the most different phyla. The eye has been invented dozens of times. Light, a part of the environment, has been the first stimulus. The principle remains the same in the various eyes; where light found a suitably reacting material a particular evolution was set going, often round about, or topsy-turvy, implying amendments; still, the result was an eye. In advanced cases a scientifically constructed dark chamber with lens, screen, shutters, and other adjustments. The detail may be unimportant, since in the various eyes different contrivances are resorted to.

Provided the material is suitable, plastic, amenable to prevailing environmental or constitutional forces, it makes no difference what part of an organism is utilised to supply the requirements of function. You cannot make a silk purse out of a sow's ear, but you can make a purse, and that is the important point. The first and most obvious cause is function, which itself may arise as an incidental action due to the nature of the material. The oxydising of the blood is such a case, and respiratory organs have been made out of whatever parts invite osmotic contact of the blood with air or water. It does not matter whether respiration is carried on by ecto- or by endodermal epithelium. Thus are developed internal gills, or lungs, both of which may be considered as referable to pharyngeal pouches; but where the outer skin has become suitably osmotic, as in the naked Amphibia, it may evolve external gills. Nay, the whole surface of the body may become so osmotic that both lungs and gills are suppressed, and the creature breathes in a most pseudo-primitive fashion. This arrangement, more or less advanced, occurs in many Urodeles, both American and European, belonging to several sub-families, but not in every species of the various genera. It is therefore a case of apparently recent Isotely.

There is no prejudice in the making of a new organ except in so far that every organism is conservative, clinging to what it or its ancestors have learnt or acquired, which it therefore seeks to recapitulate. Thus in the vertebrata the customary place for respiratory organs is the pharyngeal region. Every organism, of course, has an enormous back history; it may have had to use every part in every conceivable way, and it may thereby have been trained to such an extent as to yield almost at once, like a bridle-wise horse to some new stimulus, and thus initiate an organ straight to the point.

Considering that organs put to the same use are so very often the result of analogous adaptation, homoplasts with or without affinity of descent, are we not justified in accusing morphology of having made rather too much of the organs as units, as if they were concrete instead of inducted abstract notions? An organ which changes its function may become a unit so different as to require a new definition. And two originally different organs may come to resemble each other so much in function and structure that they acquire the same definition as one new unit. To avoid this dilemma the morphologist has, of course, introduced the differential of descent, whether homologous or analogous, into his diagnoses of organs.

The same principles must apply to the classification of the animals. To group the various representative owners of cases of isotely together under one name, simply because they have lost those characters which distinguished their ancestors, would be subversive of phyletic research. It is of the utmost significance that such "convergences" (rather "mergers," to use an administrative term) do take place, but that is another question. If it could be shown that elephants in a restricted sense have been evolved independently from two stems of family rank, the convergent terminals must not be named Elephantinæ, nor can the representatives of successive stages or horizons of a monophyletic family be designated and lumped together as subfamilies. And yet something like this practice has been adopted from Cope by experienced zoologists with a complete disregard of history, which is an inalienable and important element in our science.

This procedure is no sounder than would be the sorting of our Cartwrights, Smiths, and Bakers of sorts into as many natural families. It would be subversive of classification, the aim of which is the sorting of a chaos into order. We must not upset the well-defined relative meaning of the classificatory terms which have become well established conceptions; but what such an assembly as the terminal elephants should be called is a new question, the urgency of which will soon become acute. It applies at least to assemblies of specific, generic, and family rank, for each of which grades a new term, implying the principle of convergence, will have to be invented. In some cases geographical terms may be an additional criterion. Such terms will be not only most convenient, but they will at once act as a warning not to use the component species for certain purposes. There is, for instance, the case of *Typhlops braminus*, mentioned at the beginning of this address. Another case is the dog species, called *Canis familiaris*, about which it is now the opinion of the best authorities that the American dogs of sorts are the descendants of the coyote, while some Indian dogs are descendants of a jackal, and others again are traceable to some wolf. The "dog," a definable conception, has been invented many times, and in different countries and out of different material. It is an association of converged heterogeneous units. We have but a smile for those who class whales with fishes, or the blind-worm with the snakes; not to confound the amphibian Cœcilians with reptilian Amphisbænas requires some training; but what are we to do with creatures who have lost or assimilated all those differential characters which we have got used to rely upon?

In a homogeneous crowd of people we are attracted by their little differences, taking their really important agreements for granted; in a compound crowd we at once sort the people according to their really unimportant resemblances. That is human nature.

The terms "convergence" and "parallelism" are convenient if taken with a generous pinch of salt. Some authors hold that these terms are but imperfect similes, because two originally different organs can never converge into one identical point, still less can their owners whose acquired resemblance depresses the balance of all their other characters. For instance, no lizard can become a snake, in spite of ever so many additional snake-like acquisitions, each of which finds a parallel, an analogy in the snakes. Some zoologists therefore prefer contrasting only parallelism and divergence. A few examples may illustrate the justification of the three terms. If out of ten very similar black-haired people only two become white by the usual process, whilst the others retain their colour, then these two diverge from the rest; but they do not, by the acquisition of the same new feature, become more alike each other than they were before. Only with reference to the rest do they seem to liken as they pass from black through grey to white, our mental process being biased by the more and more emphasised difference from the majority.

10 Ax Bx Cx D E F
9
8
7
6
5
4
3
2 Ax Bx
1 A B C D E F

Supposing A and B both acquire the character x and this continues through the next ten generations, while in the descendants of C the same character is invented in the tenth generation, and whilst the descendants of D, E, F still remain unaltered. Then we should be strongly inclined, not only to "key together $C\frac{x}{10}$ with $A\frac{x}{10}$ and $B\frac{x}{10}$, but take this case for one of convergence, although it is really one of parallelism. If it did not sound so contradictory it might be called parallel divergence. The inventors diverge from the majority in the same direction: Isotely.

Third case.—Ten people, contemporaries, are alike but for the black or red hair. Black A turns white and red E turns white, not through exactly identical stages, since E will pass through a reddish-grey tinge. But the result is that A and E become actually more like each other than they were before. They *converge*, although they have gone in for exactly the same divergence with reference to the majority.

In all three cases the variations begin by divergence from the majority, but we can well imagine that all the members of a homogeneous lot change orthogenetically (this term has been translated into the far less expressive "rectigrade") in one direction, and if there be no lagging behind, they all reach precisely the same end. This would be a case of transmutation (true mutations in Waagen's and Scott's sense), producing new species without thereby increasing their number, whilst divergence always implies, at least potentially, increase of species, genera, families, &c.

If for argument's sake the mutations pass through the colours of the spectrum, and if each colour be deemed sufficient to designate a species, then, if all the tenth generations have changed from green to yellow and those of the twentieth generation from yellow to red, the final number of species would be the same. And even if some lagged behind, or remained stationary, these epistatic species (Eimer) are produced by a process which is not the same as that of divergence or variation in the usual sense.

The two primary factors of evolution are environment and heredity. Environment is absolutely inseparable from any existing organism, which therefore must react (adaptation) and at least some of these results gain enough momentum to be carried into the next generation (heredity).

The life of an organism, with all its experiments and doings, is its ontogeny, which may therefore be called the subject of evolution, but not a factor. Nor is selection a primary and necessary factor, since, being destructive, it invents nothing. It accounts, for instance, for the composition of the present fauna, but has not made its components. A subtle scholastic insinuation lurks in the plain statement that by ruthless elimination a black flock of pigeons can be produced, even that thereby the individuals have been made black. (But, of course, the breeder has thereby not invented the black pigment.)

There can be no evolution, progress, without response to stimulus, be this environmental or constitutional, *i.e.* depending upon the composition and the correlated working of the various parts within the organism. Natural selection has but to favour this plasticity, by cutting out the non-yielding material, and through inheritance the adaptive material will be brought to such a state of plasticity that it is ready to yield to the spur of the moment, and the foundation of the same new organs will thereby be laid, whenever the same necessity calls for them. Here is a dilemma. On one hand, the organism benefits from the ancestral experience; on the other, there applies to it de Rosa's law of the reduction of variability, which narrows the chances of change into fewer directions. But in these few the changes will proceed all the quicker and farther. Thus progress is assured, even hypertely, which may be rendered by "over-doing a good thing."

Progress really proceeds by mutations, spoken of before, orthogenesis, and it would take place without selection and without necessarily benefiting the organism. It would be mere presumption that the seven-gilled shark is worse off than its six- or five-gilled relations; or to imagine that the newt with double trunk-veins suffers from this arrangement, which morphologically is undoubtedly inferior to the unpaired, azygous, &c., modifications. The fact that newts exist is proof that they are efficient in their way. Such orthogenetic changes are as predictable in their results as the river which tends to shorten its course to the direct line from its head waters to the sea. That is the rivers Entelechy and no more due to purpose or design than is the series of improvements from the many gill-bearing partitions of a shark to the fewer and more highly finished comb-shaped gills of a Teleostean fish.

The success of adaptation, as measured by the morphological grade of perfection reached by an organ, seems to depend upon the phyletic age of the animal when it was first subjected to these "temptations." The younger the group, the higher is likely to be the perfection of an organic system, organ, or detail. This is not a platitude. The perfection attained does not depend merely upon the length of time available for the evolution of an organ. A recent Teleostean has had an infinitely longer time as a fish than a reptile, and this had a longer time than a mammal, and yet the same problem is solved in a neater, we might say in a more scientifically correct, way by a mammal than by a reptile, and the reptile in turn shows an advance in every detail in comparison with an amphibian, and so forth.

A few examples will suffice:—

The claws of reptiles and those of mammals; there are none in the amphibians, although some seem to want them badly, like the African frog Gampsosteonyx, but its cat-like claws, instead of being horny sheaths, are made out of the sharpened phalangeal bones which perforate the skin.

The simple contrivance of the rhinocerotic horn, introduced in Oligocene times, compared with the antlers of Miocene Cervicornia and these with the response made by the latest of Ruminants, the hollow-horned antelopes and cattle. The heel-joint; unless still generalised, it tends to become intertarsal (attempted in some lizards, pronounced in some dinosaurs and in the birds) by fusion of the bones of the tarsus with those above and below, so that the tarsals act like epiphysial pads. Only in mammals epiphyses are universal. Tibia and fibula having their own, the pronounced joint is cruro-tarsal, and all the tarsals could be used for a very compact, yet non-rigid arrangement. The advantage of a cap, not merely the introduction of a separate pad, is well recognised in engineering.

Why is it that mammalian material can produce what is denied to the lower classes? In other words, why are there still lower and middle classes? Why have they not all by this time reached the same grade of perfection? Why not indeed, unless because every new group is less hampered by tradition, much of which must be discarded with the new departure; and some of its energy is set free to follow up this new course, straight, with ever-growing results, until in its turn this becomes an old rut out of which a new jolt leads once more into fresh fields.

SECTION E.

GEOGRAPHY.

OPENING ADDRESS BY PROF. H. N. DICKSON, PRESIDENT OF THE SECTION.

SINCE the last meeting of this Section the tragic fate of Captain Scott's party, after its successful journey to the South Pole, has become known; and our hopes of welcoming a great leader, after great achievement, have been disappointed. There is no need to repeat here the narrative of events, or to dwell upon the lessons afforded by the skill, and resource, and heroic persistence, which endured to the end. All these have been, or will be, placed upon permanent record. But it is right that we should add our word of appreciation, and proffer our sympathy to those who have suffered loss. It is for us also to take note that this last of the great Antarctic expeditions has not merely reached the Pole, as another has done, but has added, to an extent that few successful exploratory undertakings have ever been able to do, to the sum of scientific geographical knowledge. As the materials secured are worked out it will, I believe, become more and more apparent that few of the physical and biological sciences have not received contributions, and important contributions, of new facts; and also that problems concerning the distribution of the different groups of phenomena and their action and reaction upon one another—the problems which are specially within the domain of the geographer—have not merely been extended in their scope but have been helped to their solution.

The reaching of the two poles of the earth brings to a close a long and brilliant chapter in the story of geographical exploration. There is still before us a vista of arduous research in geography, bewildering almost in its extent, in such a degree indeed that "the scope of geography" is in itself a subject of perennial interest. But the days of great pioneer discoveries in topography are definitely drawn to their close. We know the size and shape of the earth, at least to a first approximation, and as the map fills up we know that there can be no new continents and no new oceans to discover, although all are still, in a sense, to conquer. Looking back, we find that the qualities of human enterprise and endurance have shown no change; we need no list of names to prove that they were alike in the days of the earliest explorations, of the discovery of the New World or of the sea route to India, of the "Principall Navigations," or of this final attainment of the Poles. The love of adventure and the gifts of courage and endurance have remained the same: the order of discovery has been determined rather by the play of imagination upon accumulated knowledge, suggesting new methods and developing appropriate inventions. Men have dared to do risky things with inadequate appliances, and in doing so have shown how the appliances may be improved and how new enterprises may become possible as well as old ones easier and safer. As we come to the end of these "great explorations," and are restricted more and more to investigations of a less striking sort, it is well to remember that in geography, as in all other sciences, research continues to make as great demands as ever upon those same qualities, and that the same recognition is due to those who continue in patient labour.

When we look into the future of geographical study, it appears that for some time to come we shall still be largely dependent upon work similar to that of the pioneer type to which I have referred, the work of perfecting the geographer's principal weapon, the map. There are many parts of the world about which we can say little except that we know they exist; even the topographical map, or the material for making it, is wanting; and of only a few regions are there really adequate distributional maps of any kind. These matters have been brought before this Section and discussed very fully in recent years, so I need say no more about them, except perhaps to express the hope and belief that the production of topographical maps of difficult regions may soon be greatly facilitated and accelerated with the help of the new art of flying.

I wish to-day rather to ask your attention for a short time to a phase of pioneer exploration which has excited an increasing amount of interest in recent years. Civilised man is, or ought to be, beginning to realise that in reducing more and more of the available surface of the earth to what he considers a habitable condition he is making so much progress, and making it so rapidly, that the problem of finding suitable accommodation for his increasing numbers must become urgent in a few generations. We are getting into the position of the merchant whose trade is constantly expanding and who foresees that his premises will shortly be too small for him. In our case removal to more commodious premises elsewhere seems impossible—we are not likely to find a means of migrating to another planet—so we are driven to consider means of rebuilding on the old site, and so making the best of what we have, that our business may not suffer.

In the type of civilisation with which we are most familiar there are two fundamental elements—supplies of food energy, and supplies of mechanical energy. Since at present, partly because of geographical conditions, these do not necessarily (or even in general) occur together, there is a third essential factor, the line of transport. It may be of interest to glance, in the cursory manner which is possible upon such occasions, at some geographical points concerning each of these factors, and to hazard some speculations as to the probable course of events in the future.

In his presidential address to the British Association at its meeting at Bristol in 1898, Sir William Crookes gave some valuable estimates of the world's supply of wheat, which, as he pointed out, is "the most sustaining food-grain of the great Caucasian race." Founding upon these estimates, he made a forecast of the relations between the probable rates of increase of supply and demand, and concluded that "Should all the wheat-growing countries add to their (producing) area to the utmost capacity, on the most careful calculation the yield would give us only an addition of some 100,000,000 acres, supplying, at the average world-yield of 12·7 bushels to the acre, 1,270,000,000 bushels, just enough to supply the increase of population among bread-eaters till the year 1931." The president then added, "Thirty years is but a day in the life of a nation. Those present who may attend the meeting of the British Association thirty years hence will judge how far my forecasts are justified."

Half the allotted span has now elapsed, and it may be useful to inquire how things are going. Fortunately this can be easily done, up to a certain point at any rate, by reference to a paper published recently by Dr. J. F. Unstead (*Geographical Journal*, August, 1913), in which comparisons are given for the decades 1881–90, 1891–1900, and 1901–10. Dr. Unstead shows that the total wheat harvest for the world may be estimated at 2258 million bushels for the first of these periods, 2575 million for the second, and 3233 million for the third, increases of 14 per cent. and 25 per cent. respectively. He points out that the increases were due "mainly to an increased acreage," the areas being 192, 211, and 242 million acres, but also "to some extent (about 8 per cent.) to an increased average yield per acre, for while in the first two periods this was 12 bushels, in the third period it rose to 13 bushels per acre."

If we take the period 1891–1900, as nearly corresponding to Sir William Crookes's initial date, we find that the succeeding period shows an increase of 658 million bushels, or about half the estimated increase required by 1931, and that attained chiefly by "increased acreage."

But signs are not wanting that increase in this way will not go on indefinitely. We note (also from Dr. Unstead's paper) that in the two later periods the percentage of total wheat produced which was exported from the United States fell from 32 to 19, the yield per acre showing an increase meanwhile to 14 bushels. In the Russian Empire the percentage fell from 26 to 23, and only in the youngest of the new countries—Canada, Australia, the Argentine—do we find large proportional increases. Again, it is significant that in the United Kingdom, which is, and always has been, the most sensitive of all wheat-producing countries to variations in the floating supply, the *rate* of falling-off of home production shows marked if irregular diminution.

Looking at it in another way, we find (still from Dr. Unstead's figures) that the total amount sent out by the great exporting countries averaged, in 1881–90, 295 million bushels, 1891–1900, 402 millions, 1901–10, 532 millions. These quantities represent respectively 13·0, 15·6, and 16·1 per cent. of the total production, and it would appear that the percentage available for export from these regions is, for the time at least, approaching its limit, *i.e.* that only about one-sixth of the wheat produced is available from surpluses in the regions of production for making good deficiencies elsewhere.

There is, on the other hand, abundant evidence that improved agriculture is beginning to raise the yield per acre over a large part of the producing area. Between the periods 1881–90 and 1901–10 the average in the United States rose from 12 to 14 bushels; in Russia from 8 to 10; in Australia from 8 to 10. It is likely that, in these last two cases at least, a part of the increase is due merely to more active occupation of fresh lands as well as to use of more suitable varieties of seed, and the effect of improvements in methods of cultivation alone is more apparent in the older countries. During the same period the average yield increased in the United Kingdom from 28 to 32 bushels, in France from 17 to 20, Holland 27 to 33, Belgium 30 to 35, and it is most marked in the German Empire, for which the figures are 19 and 29.

In another important paper (*Geographical Journal*, April and May, 1912) Dr. Unstead has shown that the production of wheat in North America may still, in all likelihood, be very largely increased by merely increasing the area under cultivation, and the reasoning by which he justifies this conclusion certainly holds good over large districts elsewhere. It is of course impossible, in the present crude state of our knowledge of our own planet, to form any accurate estimate of the area which may, by the use of suitable seeds or otherwise, become available for extensive cultivation. But I think it is clear that the available proportion of the total supply from "extensive" sources has reached, or almost reached, its maximum, and that we must depend more and more upon intensive farming, with its greater demands for labour.

The average total area under wheat is estimated by Dr. Unstead as 192 million acres for 1881–90, 211 million acres for 1891–1900, and 242 million acres for 1901–10. Making the guess, for we can make nothing better, that this area may be increased to 300 million acres, and that under ordinary agriculture the average yield may eventually be increased to 20 bushels over the whole, we get an average harvest of 6000 million bushels of wheat. The average wheat-eater consumes, according to Sir William Crookes's figures, about four and a half bushels per annum; but the amount tends to increase. It is as much (according to Dr. Unstead) as six bushels in the United Kingdom and eight bushels in France. Let us take the British figure, and it appears that on a liberal estimate the earth may in the end be able to feed permanently 1000 million wheat-eaters. If prophecies based on population statistics are trustworthy, the crisis will be upon us before the end of this century. After that we must either depend upon some substitute to reduce the consumption per head of the staple foodstuff, or we must take to intensive farming of the most strenuous sort, absorbing enormous quantities of labour and introducing, sooner or later, serious difficulties connected with plant-food. We leave the possibility of diminishing the rate of increase in the number of bread-eaters out of account for the moment.

We gather, then, that the estimates formed in 1898 are in the main correct, and the wheat problem must become one of urgency at no distant date, although actual shortage of food is a long way off. What is of more immediate significance to the geographer is the element of change, of return to earlier conditions, which is emerging even at the present time. If we admit, as I think we must do, that the days of increase of extensive farming on new land are drawing to a close, then we admit that the assignment of special areas for the production of the food-supply of other distant areas is also coming to its end. The opening up of such areas, in which a sparse population produces food in quantities largely in excess of its own needs, has been the characteristic of our time, but it must give place to a more uniform distribution of things, tending always to the condition of a moderately dense population, more uniformly distributed over large areas, capable of providing the increased labour necessary for the higher type of cultivation, and self-supporting in respect of grain-food at least. We observe in passing that the colonial system of our time only became possible on the large scale with the invention of the steam-locomotive, and that the introduction of railway systems in the appropriate regions, and the first tapping of nearly all such regions on the globe, has taken less than a century.

Concentration in special areas of settlement, formerly chiefly effected for military reasons, has in modern times been determined more and more by the distribution of supplies of energy. The position of the manufacturing district is primarily determined by the supply of coal. Other forms of energy are, no doubt, available, but, as Sir William Ramsay showed in his presidential address at the Portsmouth meeting in 1911, we must in all probability look to coal as being the chief permanent source.

In the early days of manufacturing industries the main difficulties arose from defective land transport. The first growth of the industrial system, therefore, took place where sea transport was relatively easy; raw material produced in a region near a coast was carried to a coalfield also near a coast, just as in times when military power was chiefly a matter of "natural defences," the centre of power and the food-producing colony had to be mutually accessible. Hence the Atlantic took the place of the Mediterranean, Great Britain eventually succeeded Rome, and eastern North America became the counterpart of northern Africa. It is to this, perhaps more than to anything else, that we owe our tremendous start amongst the industrial nations, and we observe that we used it to provide less favoured nations with the means of improving their system of land transport, as well as actually to manufacture imported raw material and redistribute the products.

But there is, of course, this difference between the supply of foodstuff (or even military power) and mechanical energy, that in the case of coal at least it is necessary to live entirely upon capital; the storing up of energy in new coalfields goes on so slowly in comparison with our rate of expenditure that it may be altogether neglected. Now in this country we began to use coal on a large scale a little more than a century ago. Our present yearly consumption is of the order of 300 millions of tons, and it is computed (General Report of the Royal Commission on Coal Supplies, 1906) that at the present rate of increase "the whole of our available supply will be exhausted in 170 years." With regard to the rest of the world we cannot, from lack of data, make even the broad assumptions that were possible in the case of wheat supply, and for that and other reasons it is therefore impossible even to guess at the time which must elapse before a universal dearth of coal becomes imminent; it is perhaps sufficient to observe that to the best of our knowledge and belief one of the world's largest groups of coalfields (our own) is not likely to last three centuries in all.

Here again the present interest lies rather in the phases of change which are actually with us. During the first stages of the manufacturing period energy in any form was exceedingly difficult to transport, and this led to intense concentration. Coal was taken from the most accessible coalfield and used, as far as possible, on the spot. It was chiefly converted into mechanical energy by means of the steam-engine, an extremely wasteful apparatus in small units, and hence still further concentration; thus the steam-engine is responsible in part for the factory system in its worst aspect. The less accessible coalfields were neglected. Also, the only other really available source of energy—water-power—remained unused, because the difficulties in the way of utilising movements of large quantities of water through small vertical distances (as in tidal movements) are enormous; the only easily applied source occurs where comparatively small quantities of water fall through considerable vertical distances, as in the case of waterfalls. But, arising from the geographical conditions, waterfalls (with rare exceptions such as Niagara) occur in the "torrential" part of the typical river-course, perhaps far from the sea, almost certainly in a region too broken in surface to allow of easy communication or even of industrial settlement of any kind.

However accessible a coalfield may be to begin with, it sooner or later becomes inaccessible in another way, as the coal near the surface is exhausted and the workings get deeper. No doubt the evil day is postponed for a time by improvements in methods of mining—a sort of intensive cultivation—but as we can put nothing back the end must be the same, and successful competition with more remote but more superficial deposits becomes impossible. And every improvement in land transport favours the geographically less accessible coalfield.

From this point of view it is impossible to over-estimate the importance of what is to all intents and purposes a new departure of the same order of magnitude as the discovery of the art of smelting iron with coal, or the invention of the steam-engine, or of the steam-locomotive. I mean the conversion of energy into electricity, and its transmission in that form (at small cost and with small loss) through great distances. First we have the immediately increased availability of the great sources of cheap power in waterfalls. The energy may be transmitted through comparatively small distances and converted into heat in the electric furnace, making it possible to smelt economically the most refractory ores, as those of aluminium, and converting such unlikely places as the coast of Norway or the West Highlands of Scotland into manufacturing districts. Or it may be transmitted through greater distances to regions producing quantities of raw materials, distributed there widespread to manufacturing centres, and reconverted into mechanical energy. The Plain of Lombardy produces raw materials in abundance, but Italy has no coal supply. The waterfalls of the Alps yield much energy, and this transmitted in the form of electricity, in some cases for great distances, is converting northern Italy into one of the world's great industrial regions. Chisholm gives an estimate of a possible supply of power amounting to 3,000,000 horse-power, and says that of this about one-tenth was already being utilised in the year 1900.

But assuming again, with Sir William Ramsay, that coal must continue to be the chief source of energy, it is clear that the question of accessibility now wears an entirely different aspect. It is not altogether beyond reason to imagine that the necessity for mining, as such, might entirely disappear, the coal being burnt *in situ* and energy converted directly into electricity. In this way some coalfields might conceivably be exhausted to their last pound without serious increase in the cost of getting. But for the present it is enough to note that, however inaccessible any coalfield may be from supplies of raw material, it is only necessary to establish generating stations at the pit's mouth and transport the energy to where it can be used. One may imagine, for example, vast manufactures carried on in what are now the immense agricultural regions of China, worked by power supplied from the great coal deposits of Shan-si.

There is, however, another peculiarity of electrical power which will exercise increasing influence upon the geographical distribution of industries. The small electric motor is a much more efficient apparatus than the small steam-engine. We are, accordingly, already becoming familiar with the great factory in which, instead of all tools being huddled together to save loss through shafting and belting, and all kept running all the time, whether busy or not (because the main engine must be run), each tool stands by itself and is worked by its own motor, and that only when it is wanted. Another of the causes of concentration of manufacturing industry is therefore reduced in importance. We may expect to see the effects of this becoming more and more marked as time goes on and other forces working towards uniform distribution make themselves more felt.

The points to be emphasised so far, then, are, first, that the time when the available areas whence food supply as represented by wheat is derived are likely to be taxed to their full capacity within a period of about the same length as that during which the modern colonial system has been developing in the past; secondly, that cheap supplies of energy may continue for a longer time, although eventually they must greatly diminish; and, thirdly, there must begin in the near future a great equalisation in the distribution of population. This equalisation must arise from a number of causes. More intensive cultivation will increase the amount of labour required in agriculture, and there will be less difference in the cost of production and yield due to differences of soil and climate. Manufacturing industries will be more uniformly distributed, because energy, obtained from a larger number of sources in the less accessible places, will be distributed over an increased number of centres. The distinction between agricultural and industrial regions will tend to become less and less clearly marked, and will eventually almost disappear in many parts of the world.

The effect of this upon the third element is of first-rate importance. It is clear that as the process of equalisation goes on the relative amount of long-distance transport will diminish, for each district will tend more and more to produce its own supply of staple food and carry on its own principal manufactures. This result will naturally be most marked in what we may call the "east-and-west" transport, for as climatic controls primarily follow the parallels of latitude, the great *quantitative* trade, the flow of food-stuffs and manufactured articles to and fro between peoples of like habits and modes of life, runs primarily east and west. Thus the transcontinental functions of the great North American and Eurasian railways, the east-and-west systems of the inland waterways of the two continents, and the connecting links furnished by the great ocean ferries, must become of relatively less importance.

The various stages may be represented, perhaps, in some such manner as this. If **I** is the cost of producing a thing locally at a place A by intensive cultivation or what corresponds to it, if **E** is the cost of producing the same thing at a distant place B, and **T** the cost of transporting it to A, then at A we may at some point of time have a more or less close approximation to

$$\mathbf{I} = \mathbf{E} + \mathbf{T}.$$

We have seen that in this country, for example, **I** has been greater than **E**+**T** for wheat ever since, say, the introduction of railways in North America, that the excess tends steadily to diminish, and that however much it may be possible to reduce **T** either by devising cheaper modes of transport or by shortening the distance through which wheat is transported, **E**+**T** must become greater than **I**, and it will pay us to grow all or most of our own wheat. Conversely, in the 'seventies of last century **I** was greater than **E**+**T** in North America and Germany for such things as steel rails and rolling-stock, which we in this country were cultivating "extensively" at the time on more accessible coalfields, with more skilled labour and better organisation than could be found elsewhere. In many cases the positions are now, as we know, reversed, but geographically **I** must win all round in the long run.

In the case of transport between points in different latitudes the conditions are, of course, altogether dissimilar, for in this case commodities consist of foodstuffs, or raw materials, or manufactured articles, which may be termed luxuries, in the sense that their use is scarcely known until cheap transport makes them easily accessible, when they rapidly become "necessaries of life." Of these the most familiar examples are tea, coffee, cocoa and bananas, india-rubber and manufactured cotton goods. There is here, of course, always the possibility that wheat as a staple might be replaced by a foodstuff produced in the tropics, and it would be extremely interesting to study the geographical consequences of such an event as one-half of the surface of the earth suddenly coming to help in feeding the two quarters on either side; but for many reasons, which I need not go into here, such a consummation is exceedingly unlikely. What seems more probable is that the trade between different latitudes will continue to be characterised specially by its variety, the variety doubtless increasing, and the quantity increasing in still larger measure. The chief modification in the future may perhaps be looked for in the occasional transference of manufactures of raw materials produced in the tropics to places within the tropics, especially when the manufactured article is itself largely consumed near regions of production. The necessary condition here is a region, such as (*e.g.*) the monsoon region, in which there is sufficient variation in the seasons to make the native population laborious; for then, and apparently only then, is it possible to secure sufficient industry and skill by training, and therefore to be able to yield to the ever-growing pressure in more temperate latitudes due to increased cost of labour. The best examples of this to-day are probably the familiar ones of cotton and jute manufacture in India. With certain limitations, manufacturing trade of this kind is, however, likely to continue between temperate and strictly tropical regions, where the climate is so uniform throughout the year that the native has no incentive to work. There the collection of the raw material is as much as, or even more than can be looked for—as in the case of mahogany or wild rubber. Where raw material has to be cultivated—as cotton, cultivated rubber, &c.—the raw material has to be produced in regions more of the monsoon type, but it will probably—perhaps as much for economic as geographical reasons—be manufactured at some centre in the temperate zones, and the finished product transported thence, when necessary, to the point of consumption in the tropics.

We are here, however, specially liable to grave disturbances of distribution arising from invention of new machinery or new chemical methods; one need only mention the production of sugar or indigo. Another aspect of this which is not without importance may perhaps be referred to here, although it means the transference of certain industries to more accessible regions merely, rather than a definite change of such an element as latitude. I have in mind the sudden conversion of an industry in which much labour is expended on a small amount of raw material into one where much raw material is consumed, and by the application of power-driven machinery the labour required is greatly diminished. One remembers when a fifty-shilling Swiss watch, although then still by tradition regarded as sufficiently valuable to deserve enclosure in a case constructed of a precious metal, was considered a marvel of cheapness. American machine-made watches, produced by the ton, are now encased in the baser metals and sold at some five shillings each, and the watch-making industry has ceased to be specially suited to mountainous districts.

In considering the differences which seem likely to arise in what we may call the regional pressures of one kind and another, pressures which are relieved or adjusted by and along certain lines of transport, I have made a primary distinction between "east-and-west" and "north-and-south" types, because both in matters of food supply and in the modes of life which control the nature of the demand for manufactured articles climate is eventually the dominant factor; and, as I have said, climate varies primarily with latitude. This is true specially of atmospheric temperature; but temperature varies also with altitude, or height above the level of the sea. To a less extent rainfall, the other great element of climate, varies with latitude, but the variation is much more irregular. More important in this case is the influence of the distribution of land and sea, and more especially the configuration of the land surface, the tendency here being sometimes to strengthen the latitude effect where a continuous ridge is interposed, as in Asia, practically cutting off "north-and-south" communication altogether along a certain line emphasising the parallel-strip arrangement running east and west to the north of the line, and inducing the quite special conditions of the monsoon region to the south of it. We may contrast this with the effect of a "north-and-south" structure, which (in temperate latitudes especially) tends to swing what we may call the regional lines round till they cross the parallels of latitude obliquely. This is typically illustrated in North America, where the angle is locally sometimes nearly a right angle. It follows, therefore, that the contrast of "east-and-west" and "north-and-south" lines, which I have here used for purposes of illustration, is necessarily extremely crude, and one of the most pressing duties of geographers at the present moment is to elaborate a more satisfactory method of classification. I am very glad that we are to have a discussion on "Natural Regions" at one of our sederunts. Perhaps I may be permitted to express the hope that we shall concern ourselves with the types of region we want, their structure or "grain," and their relative positions, rather than with the precise delimitation of their boundaries, to which I think we have sometimes been inclined, for educational purposes, to give a little too much attention.

Before leaving this I should like to add, speaking still in terms of "east-and-west" and "north-and-south," one word more about the essential east-and-west structure of the Old World. I have already referred to the great central axis of Asia. This axis is prolonged westward through Europe, but it is cut through and broken to such an extent that we may include the Mediterranean region with the area lying further north, to which indeed it geographically belongs in any discussion of this sort. But the Mediterranean region is bounded on the other side by the Sahara, and none of our modern inventions facilitating transport has made any impression upon the dry desert; nor does it seem likely that such a desert will ever become a less formidable barrier than a great mountain mass or range. We may conclude, then, that in so far as the Old World is concerned, the "north-and-south" transport can never be carried on as freely as it may in the New, but only through certain weak points, or "round the ends," *i.e.* by sea. It may be further pointed out that the land areas in the southern hemisphere are so narrow that they will scarcely enter into the "east-and-west" category at all—the transcontinental railway as understood in the northern hemisphere cannot exist; it is scarcely a pioneer system, but rather comes into existence as a later by-product of local east-and-west lines, as in Africa.

These geographical facts must exercise a profound influence upon the future of the British Isles. Trade south of the great dividing line must always be to a large extent of the "north-and-south" type, and the British Isles stand practically at the western end of the great natural barrier. From their position the British Isles will always be a centre of immense importance in *entrepôt* trade, importing commodities from "south" and distributing "east and west," and similarly in the reverse direction. This movement will be permanent, and will increase in volume long after the present type of purely "east-and-west" trade has become relatively less important than it is now, and long after the British Isles have ceased to have any of the special advantages for manufacturing industries which are due to their own resources either in the way of energy or of raw material. We can well imagine, however, that this permanent advantage of position will react favourably, if indirectly, upon certain types of our manufactures, at least for a very long time to come.

Reverting briefly to the equalisation of the distribution of population in the wheat-producing areas and the causes which are now at work in this direction, it is interesting to inquire how geographical conditions are likely to influence this on the smaller scale. We may suppose that the production of staple foodstuffs must always be more uniformly distributed than the manufacture of raw materials, or the production of the raw materials themselves, for the most important raw materials of vegetable origin (as cotton, rubber, &c.) demand special climatic conditions, and, apart from the distribution of energy, manufacturing industries are strongly influenced by the distribution of mineral deposits, providing metals for machinery, and so on. It may, however, be remarked that the useful metals, such as iron, are widely distributed in or near regions which are not as a rule unfavourable to agriculture. Nevertheless, the fact remains that while a more uniform distribution is necessary and inevitable in the case of agriculture, many of the conditions of industrial and social life are in favour of concentration; the electrical transmission of energy removes, in whole or in part, only one or two of the centripetal forces. The general result might be an approximation to the conditions occurring in many parts of the monsoon areas—a number of fairly large towns pretty evenly distributed over a given agricultural area, and each drawing its main food supplies from the region surrounding it. The positions of such towns would be determined much more by industrial conditions, and less by military conditions, than in the past (military power being in these days mobile, and not fixed); but the result would on a larger scale be of the same type as was developed in the central counties of England, which, as Mackinder has pointed out, are of almost equal size and take the name of the county town. Concentration within the towns would, of course, be less severe than in the early days of manufacturing industry. Each town would require a very elaborate and highly organised system of local transport, touching all points of its agricultural area, in addition to lines of communication with other towns and with the great "north-and-south" lines of world-wide commerce, but these outside lines would be relatively of less importance than they are now. We note that the more perfect the system of local transport, the less the need for points of intermediate exchange. The village and the local market-town will be "sleepy" or decadent as they are now, but for a different reason; the symptoms are at present visible mainly because the country round about such local centres is overwhelmed by the great lines of transport which pass through them; they will survive for a time through inertia and the ease of foreign investment of capital. The effect of this influence is already apparent since the advent of the "commercial motor," but up to the present it has been more in the direction of distributing from the towns than collecting to them, producing a kind of "suburbanisation" which throws things still further out of balance. The importance of the road motor in relation to the future development of the food-producing area is incalculable. It has long been clear that the railway of the type required for the great through lines of fast transport is ill-adapted for the detailed work of a small district, and the "light" railway solves little and introduces many complications. The problem of determining the direction and capacity of a system of roads adequate to any particular region is at this stage one of extraordinary difficulty; experiments are exceedingly costly, and we have as yet little experience of a satisfactory kind to guide us. The geographer, if he will, can here be of considerable service to the engineer.

In the same connection, the development of the agricultural area supplying an industrial centre offers many difficult problems in relation to what may be called accessory products, more especially those of a perishable nature, such as meat and milk. In the case of meat the present position is that much land which may eventually become available for grain crops is used for grazing, or cattle are fed on some grain, like maize, which is difficult to transport or is not satisfactory for bread-making The meat is then temporarily deprived of its perishable property by refrigeration, and does not suffer in transport. Modern refrigerating machinery is elaborate and complicated, and more suited to use on board ship than on any kind of land transport. Hence the most convenient regions for producing meat for export are those near the sea-coast, such as occur in the Argentine or the Canterbury plains of New Zealand. The case is similar to that of the "accessible" coalfield. Possibly the preserving processes may be simplified and cheapened, making overland transport easier, but the fact that it usually takes a good deal of land to produce a comparatively small quantity of meat will make the difficulty greater as land becomes more valuable. Cow's milk, which in modern times has become a "necessary of life" in most parts of the civilised world, is in much the same category as meat, except that difficulties of preservation, and therefore of transport, are even greater. That the problem has not become acute is largely due to the growth of the long-transport system available for wheat, which has enabled land round the great centres of population to be devoted to dairy produce. If we are right in supposing that this state of things cannot be permanent, the difficulty of milk supply must increase, although relieved somewhat by the less intense concentration in the towns; unless, as seems not unlikely, a wholly successful method of permanent preservation is devised.

In determining the positions of the main centres, or rather, in subdividing the larger areas for the distribution of towns with their supporting and dependent districts, water supply must be one of the chief factors in the future, as it has been in the past; and in the case of industrial centres the quality as well as the quantity of water has to be considered. A fundamental division here would probably be into districts having a natural local supply, probably of hard water, and districts in which the supply must be obtained from a distance. In the latter case engineering works of great magnitude must often be involved, and the question of total resources available in one district for the supply of another must be much more fully investigated than it has been. In many cases, as in this country, the protection of such resources pending investigation is already much needed. It is worth noting that the question may often be closely related to the development and transmission of electrical energy from waterfalls, and the two problems might in such cases be dealt with together. Much may be learned about the relation of water supply to distribution of population from a study of history, and a more active prosecution of combined historical and geographical research would, I believe, furnish useful material in this connection, besides throwing interesting light on many historical questions.

Continued exchange of the "north-and-south" type and at least a part of that described as "east-and-west" gives permanence to a certain number of points where, so far as can be seen, there must always be a change in the mode of transport. It is not likely that we shall have heavy freight-carrying monsters in the air for a long time to come, and until we have the aërial "tramp" transport must be effected on the surfaces of land and sea. However much we may improve and cheapen land transport, it cannot in the nature of things become as cheap as transport by sea. For on land the essential idea is always that of a prepared road of some kind, and, as Chisholm has pointed out, no road can carry more than a certain amount; traffic beyond a certain quantity constantly requires the construction of new roads. It follows, then, that no device is likely to provide transport indifferently over land and sea, and the seaport has in consequence inherent elements of permanence. Improved and cheapened land transport increases the economy arising from the employment of large ships rather than small ones, for not only does transport inland become relatively more important, but distribution along a coast from one large seaport becomes as easy as from a number of small coastal towns. Hence the conditions are in favour of the growth of a comparatively small number of immense seaport cities like London and New York, in which there must be great concentration not merely of work directly connected with shipping, but of commercial and financial interests of all sorts. The seaport is, in fact, the type of great city which seems likely to increase continually in size, and provision for its needs cannot in general be made from the region immediately surrounding it, as in the case of towns of other kinds. In special cases there is also, no doubt, permanent need of large inland centres of the type of the "railway creation," but under severe geographic control these must depend very much on the nature and efficiency of the systems of land transport. It is not too much to say (for we possess some evidence of it already) that the number of distinct geographical causes which give rise to the establishment and maintenance of individual great cities is steadily diminishing, but that the large seaport is a permanent and increasing necessity. It follows that aggregations of the type of London and Liverpool, Glasgow and Belfast will always be amongst the chief things to be reckoned with in these islands, irrespective of local coal supply or accessory manufacturing industries, which may decay through exhaustion.

I have attempted in what precedes to direct attention once more to certain matters for which it seems strangely difficult to get a hearing. What it amounts to is this, that as far as our information goes the development of the steamship and the railway, and the universal introduction of machinery which has arisen from it, have so increased the demand made by man upon the earth's resources that in less than a century they will have become fully taxed. When colonisation and settlement in a new country proceeded slowly and laboriously, extending centrifugally from one or two favourable spots on the coast, it took a matter of four centuries to open up a region the size of England. Now we do as much for a continent like North America in about as many decades. In the first case it was not worth troubling about the exhaustion of resources, for they were scarcely more than touched, and even if they were exhausted there were other whole continents to conquer. But now, so far as our information goes, we are already making serious inroads upon the resources of the whole earth. One has no desire to sound an unduly alarmist note, or to suggest that we are in imminent danger of starvation, but surely it would be well, even on the suspicion, to see if our information is adequate and trustworthy and if our conclusions are correct; and not merely to drift in a manner which was justifiable enough in Saxon times, but which, at the rate things are going now, may land us unexpectedly in difficulties of appalling magnitude.

What is wanted is that we should seriously address ourselves to a stocktaking of our resources. A beginning has been made with a great map on the scale of one to a million, but that is not sufficient; we should vigorously proceed with the collection and discussion of geographical data of all kinds, so that the major natural distributions shall be adequately known, and not merely those parts which commend themselves, for one reason or another, to special national or private enterprises. The method of Government survey, employed in most civilised countries for the construction of maps, the examination of geological structure or the observation of weather and climate, is satisfactory as far as it goes, but it should go further, and be made to include such things as vegetation, water supply, supplies of energy of all kinds, and, what is quite as important, the bearings of one element upon others under different conditions. Much, if not most, of the work of collecting data would naturally be done as it is now by experts in the special branches of knowledge, but it is essential that there should be a definite plan of a *geographical* survey as a whole, in order that the regional or distributional aspect should never be lost sight of. I may venture to suggest that a committee formed jointly by the great national geographical societies, or by the International Geographical Congress, might be entrusted with the work of formulating some such uniform plan and suggesting practicable methods of carrying it out. It should not be impossible to secure international cooperation, for there is no need to investigate too closely the secrets of anyone's particular private vineyard—it is merely a question of doing thoroughly and systematically what is already done in some regions, sometimes thoroughly, but not systematically. We should thus arrive eventually at uniform methods of stock-taking, and the actual operations could be carried on as opportunity offered and indifference or opposition was overcome by the increasing need for information. Eventually we shall find that "country-planning" will become as important as town-planning, but it will be a more complex business, and it will not be possible to get the facts together in a hurry. And in the meanwhile increased geographical knowledge will yield scientific results of much significance about such matters as distribution of populations and industries, and the degree of adjustment to new conditions which occurs or is possible in different regions and amongst different peoples. Primary surveys on the large scale are specially important in new regions, but the best methods of developing such areas and of adjusting distributions in old areas to new economic conditions are to be discovered by extending the detailed surveys of small districts. An example of how this may be done has been given by Dr. Mill in his "Fragment of the Geography of Sussex." Dr. Mill's methods have been successfully applied by individual investigators to other districts, but a definitely organised system, marked out on a carefully matured uniform plan, is necessary if the results are to be fully comparable. The schools of geography in this country have already done a good deal of local geography of this type, and could give much valuable assistance if the work were organised beforehand on an adequate scale.

But in whatever way and on whatever scale the work is done, it must be clearly understood that no partial study from the physical, or biological, or historical, or economic point of view will ever suffice. The urgent matters are questions of distribution upon the surface of the earth, and their elucidation is not the special business of the physicist, or the biologist, or the historian, or the economist, but of the geographer.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LEEDS.—In connection with the work on animal nutrition which is being conducted under a grant from the Development Commissioners, Dr. H. W. Dudley, of the Herter Research Laboratory, New York, has been appointed lecturer in biochemistry. The experimental station in flax growing, which is also supported by the Development Commissioners, has been placed under the direction of Mr. F. K. Jackson, formerly of the agricultural departments of the Universities of Leeds and Cambridge.

LONDON.—The following courses of advanced science lectures are announced:—"The Cytology and Affinities of the Higher Fungi," by Dr. Gwynne-Vaughan, at University College, beginning on October 23; "The Physiological Significance of Acidosis," by Drs. Kennaway and Poulton, at Guy's Hospital, beginning on October 9; "The Cerebro-spinal Fluid," by Profs. Halliburton and Dixon, at King's College, beginning on November 3; "Mechanism and Teleology," by Prof. Hans Driesch, at King's College, beginning on October 21; "The Theory of Heat in Relation to Atmospheric Changes," by Dr. W. N. Shaw, F.R.S., at the Meteorological Office, beginning on January 23. All the lectures are free.

THE Maharaja Scindia of Gwalior has contributed 25,000 rupees to the Yunani Vedic Medical College at Delhi.

DR. T. FRANKLIN SIBLY, lecturer in geology at King's College, London, has been appointed professor of geology in the University College of South Wales and Monmouthshire, Cardiff.

THE report by cable that Mr. W. Robbie, a pioneer gold-digger, who died at Ballarat a short time ago, had left a large bequest to the University of Aberdeen, has been confirmed by mail. The estimated amount of the bequest, however, is 23,000*l.*—not 30,000*l.* as at first reported—and it is to be applied for scholarships in mathematics, natural philosophy, and chemistry.

SOCIETIES AND ACADEMIES.

NEW SOUTH WALES.

Linnean Society, July 30.—Mr. W. S. Dun, president, in the chair.—T. G. **Sloane**: Revisional notes on Australian Carabidæ. Part iv., The genus Notonomus. The number of species recognised is eighty-nine, of which fifteen are proposed as new.—J. J. **Fletcher**: A case of natural hybridism in the genus Grevillea (N.O. Proteaceæ. *Grevillea laurifolia*, Sieb., and *G. acanthifolia*, A. Cunn., are two common and characteristic members of the flora of the higher portion of the Blue Mountain area. Certain other rare forms are sometimes associated with one or both of them, some of which have been described under the name of *G. gaudichaudii*, R. Br. The object of this paper is to justify the contention, that the rare plants to which the name *G. gaudichaudii*, R. Br., has been applied, or is applicable, form one group only of a series of transitional forms between *G. laurifolia and G. acanthifolia*, of which another, equally remarkable, group has escaped notice; that the entire series is one series of naturally related forms; and that the explanation of their real relationship is, that they are hybrids between the two species mentioned. Seven recognisably different types are described. The two parent-species are markedly contrasted in most of their morphological characters, in their habit of growth, and in being members of two different plant-associations and consequently in their habitats; but cross-pollination is possible, because the racemes of both are of the same pattern (elongated and secund). As the two species belong to different plant-associations, the conditions favouring cross-pollination arise only at or close to the boundary between them, while circumstances prevent the hybrids from spreading laterally.

BOOKS RECEIVED.

Papers and Proceedings. Seventh Annual Meeting, American Sociological Society held at Boston, Mass., December 28, 30, 31, 1912. Vol. vii. Pp. vi+223. (Chicago, Ill.: University of Chicago Press; Cambridge, England: University Press.) 6*s.* net.

Moths of the Limberlost. By Gene S. Porter. Pp. xiv+370. (London: Hodder and Stoughton.) 10*s.* 6*d.* net.

Pedagogical Anthropology. By M. Montessori. Translated from the Italian by F. T. Cooper. Pp. xi+508. (London: William Heinemann.) 14*s.* net.

Proceedings of the Aristotelian Society. New series. Vol. xiii. Containing the Papers read before the