the kathode disc. The tube on which the observation was made has been cracked, and now ceases to give the result; nor is he able to impart rotation in one direction only by familiar mechanical means that could have existed in the tube.

From across the Atlantic, correspondents of some of the daily newspapers have sent vague reports of several developments of Röntgen ray work. By coating the inside of a Crookes' tube with fluorescent crystals, Mr. Edison is stated to have produced an electric lamp in which "all the energy which in an incandescent lamp is lost in heat is turned into light. One of the new lamps of only four-candle power is said to give a light equal to that obtained by the usual sixteen-candle power incandescent lamp."

A report from the electrical laboratory of the State University of Missouri states that experiment shows that Röntgen rays kill the bacilli of diphtheria. Two guinea-pigs were inoculated with a culture of diphtheria. One of them was exposed for four hours to these rays, and showed no signs of diphtheria. The other died within twenty-eight hours, and the post-mortem examination showed that diphtheria was the cause of death. It hardly needs pointing out, however, that this evidence is not sufficient to justify the conclusion.

In *Cosmos*, M. R. P. Leray gives the first portion of an article on kathodic rays and the kinetic theories of their nature. The writer points out that although recent investigations have cast some doubts on Crookes' original "radiant matter" theory, no satisfactory alternative theory has been suggested. M. Poincaré has propounded the hypothesis that the phenomenon is produced like a luminous phenomenon, but, as he remarks, this is a very strange form of light. M. Leray considers that this substitution of the ether for radiant matter, while failing to account for the earlier experimental results, affords no explanation of recent discoveries. The kinetic theory should not be abandoned, simply because it does not account for all the observed phenomena, until some theory has been suggested that better accords with fact.

Finally, in the *Naturwissenschaftliche Wochenschrift*, Prof. B. R. Borggreve offers a theory of the existence of Röntgen rays, and considers particularly the relation of Röntgen's discovery to Le Bon's so-called "dark light."

THE RELIEF OF THE EARTH'S CRUST.

PROF. HERMANN WAGNER, of Göttingen, one of the best-known geographers and statisticians of Germany, has recently published in *Gerland's Beiträge zur Geophysik*, a critical study[1] of a somewhat exceptional kind. The moral of the criticism is that the agreement of the final results of a prolonged series of calculations is no proof of the correctness of the individual stages of the work, and the application is that no elaborate series of calculations should be built upon until every step has stood the test of independent verification. One is tempted to suppose that all scientific workers believed in these principles, and that the steam-hammer strokes of Prof. Wagner's ponderous criticism are really more valuable in forging a firmer structure of fact, than for the sparks of proverbial philosophy elicited by battering the work of pioneers. The solid outcome of the investigation is the most detailed calculation yet arrived at of the area and volume of the portions of the earth's crust above and below sea-level, leading to a new and interesting division of the surface of the lithosphere into regions of special morphological character. Although this comes last in the discussion, we prefer to place it first in the appreciation, because constructive work is always more pleasing to contemplate than destructive efforts, and because those who, like myself, have been somewhat severely handled by Prof. Wagner, will probably be most willing to acknowledge the superior accuracy of his results.

The question of the completeness of the data from which these results are derived, and their fitness for such minute treatment, I shall consider later.

By means of the hypsographic curve connecting elevations and percentages of area (previously employed by Penck in his discussion of Murray's data) derived from measurements of height, depth and area of land and water, the surface of the lithosphere is divided by Wagner into five regions in place of the three suggested by Dr. John Murray, and hitherto accepted by most physical geographers. The five are as follows. The *Culminating Area* of the earth's crust, occuping 6 per cent. of the surface, and lying altogether above 1000 metres, with a mean height of 2200 metres (or 7200 feet) above the sea. The *Continental Plateau*, occupying all the surface from the 1000 metre contour-line of elevation to the 200 metre contour-line of depth, *i.e.* to the margin of the shallow sea-border or continental shelf. It comprises 28·3 per cent. of the surface, and has a mean elevation of 250 metres (or 800 feet) above the sea. The *Continental Slope*, from a depth of 200 metres to 2300 below sea-level, covers 9 per cent. of the earth's surface, and has a mean depth of 1300 metres (or 4300 feet). The *Oceanic Plateau*, between the depths of 2300 and 5000 metres, occupies no less than 53·7 per cent. of the surface, and has a mean depth of 4100 metres (or 13,500 feet). Finally the *Depressed Area*, deeper than 5000 metres, is assumed to occupy 3 per cent. of the surface, with a mean depth of 6000 metres (say 20,000 feet). In this classification of regions the coast-line is ignored, the abrupt change of slope at 200 metres (or rather the familiar 100-fathom line of our charts) being rightly given the greatest weight in a hypsographic study. The mean level of the surface of the earth's crust is placed by these calculations at a depth of 2300 metres, or 7500 feet below actual sea-level. The area of the continental-block, or region above the mean level of the crust, is found to be 43·3 per cent. of the surface, leaving 56·7 per cent. for the deeper region, instead of the 50 per cent. to which my first estimate of mean-sphere-level from Murray's data pointed. Although I suggested in April 1890, the restriction of Murray's term Abysmal Area to the ocean floor below mean-sphere-level (instead of including everything below 1000 fathoms), and to class the whole slope up to sea-level as the Transitional Area, keeping the term Continental Area for the land; I gladly recognise the importance of Wagner's new division into five zones, as shown on the accompanying curve (p. 113). Two further subdivisions might be appropriately introduced—the *Flat lands* below 200 metres of elevation, and the *Continental Shelf*, or shallow sea above 200 metres of depth. From the anthropogeographical point of view, these are the most important regions of the globe. The height of 200 metres above actual sea-level corresponds by Wagner's showing to the mean level of the physical globe (lithosphere and hydrosphere), and is thus as fitted to be a limit as is the line of mean-sphere-level itself.

The total area of land is worked out at 28·3 per cent., and that of sea as 71·7 of the earth's surface, certain assumptions being made for the unknown polar regions. The ratio of land to water surface is thus 1 : 2·54. Other interesting levels are that of the mean height of the land 700 metres (or 2300 feet) above actual sea-level; and of the condensation spheroid, *i.e.* the physical globe if the water were condensed to the density of the rocks of the crust, 1300 metres (or 4260 feet) below present sea-level.

While Prof. Wagner has sought to give more exactness to the calculations on which our knowledge of the forms of the earth's crust depends, he has shown little sympathy with any suggestions towards an explanation of terrestrial relief. We have not space at present to consider his criticism of the remarkable relations between the various natural divisions of the crust involving the ratio of the densities and volumes of land and sea pointed out by Romieux in December 1890. Similarly the strictures on Penck's "Morphologie der Erdoberfläche" may be left for that distinguished physical geographer to treat personally.

The problem of finding the areas and volumes of the portions of the earth's crust above water or covered by water, and so of arriving at some knowledge of the true forms of the earth's crust, has been attacked by several physical geographers during the last twelve years. Prof. De Lapparent, in 1883, was the first to repeat Humboldt's attempts in this direction. Dr. John Murray, in 1888, published a very elaborate calculation based on contoured maps specially prepared by Bartholomew on Lambert's equivalent projection on the scale of 1 : 45,000,000. This work was criticised on publication by Prof. Penck and Dr. A. Supan, but attained wide acceptance. Prof. Wagner, for the purposes of his well-known statistical annual, "Die Bevölkerung der Erde," had collected the best estimates of the areas of the various continents and countries, and has caused corrections and new measurements to be made from time to time. All this work may be said to depend on the measurement of

[1] "Areal und mittlere Erhebung der Landflächen sowie der Erdkruste. Eine kritische Studie insbesondere über den Anwendungsbereich der Simpson'sche Formel" Von Hermann Wagner. *Gerland's Beiträge zur Geophysik*, II. Band, 2-4 Heft (1895), pp. 667-772.

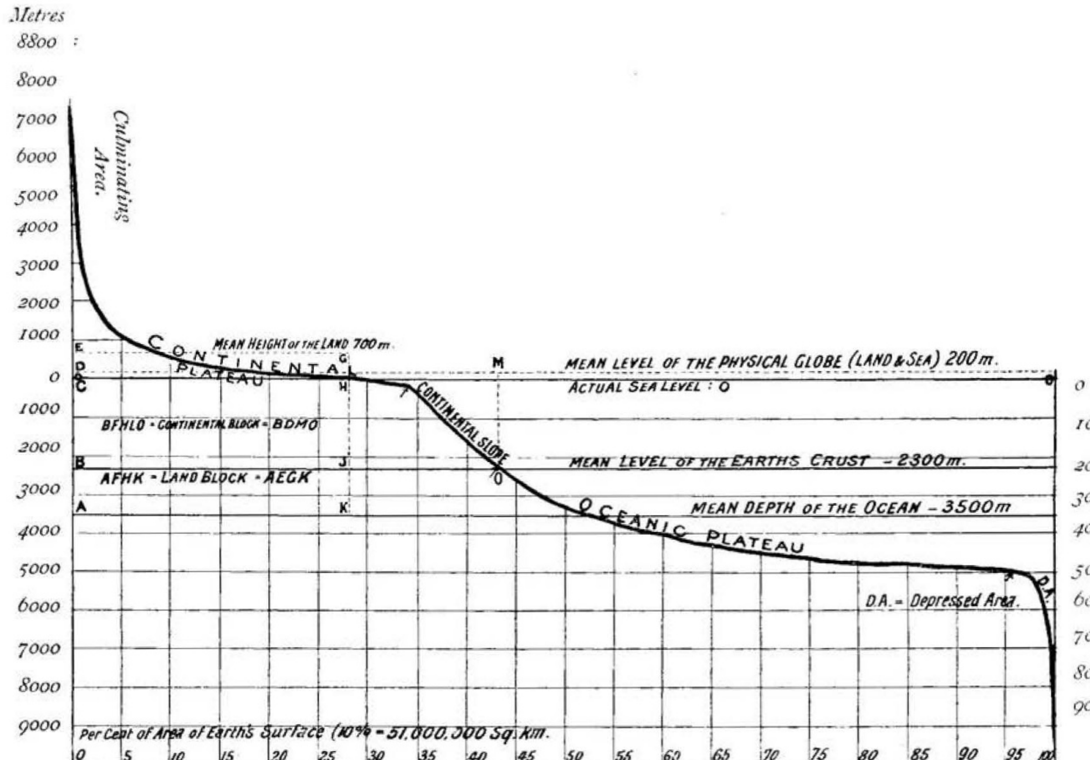
areas on maps by means of the planimeter. In 1891 Dr. Heiderich, a student of Prof. Penck's, published a series of calculations of areas and volumes of land and sea, based on an entirely different process. His method was to draw profiles of the earth's crust from contoured maps along parallels 5° apart, from the highest northern to the highest southern latitude for which data could be found. The areas of land or water for each zone of 10° of latitude wide were calculated from the length of the land or water on the three parallels 5° apart, by Simpson's formula

$$F = h/6\,(d + 4d_1 + d_2)$$

where F = the area of the zone 10° wide, h the value of the 10° interval in units of length, d, d_2 the length of the land (or of water) on the parallels bounding the zone, and d_1 the length on the parallel midway between them. Then using the *areas* of the profile above or below sea-level on each parallel, the volume of land (or of sea) in a zone of 10° is calculated by the same formula; in this case F standing for volume, and d for measured areas.

much importance. Were it not for the balancing of innumerable errors of measurement, we could not hope to gain any information at all from planimeter work on small scale maps, and no two independent measurements could possibly agree. Visible errors must of course be excluded by the exercise of all possible vigilance; but even in Prof. Wagner's critical pages there are one or two examples which show that the best intentions, the utmost vigilance, and a life-long experience of the desperate deceitfulness of proofs cannot guarantee perfect accuracy. On page 688 "II." occurs instead of "IV." in a reference to a volume, but the date being given correctly neutralises the error. On page 738 "g" should be "g_1" in referring to the mathematical formula there given, and on page 745 the expression "9,620,000 qkm. (9,000,000 + 6,200,000)" contains just such an oversight as might very seriously vitiate a calculation, the last number being obviously intended for 620,000.

The results obtained by Murray in 1888 are criticised in detail, and various sources of error pointed out. The corrections we do not hesitate to accept, but we cannot look on the original work as claiming the degree of accuracy which Wagner's criticism



WAGNER'S HYPSOGRAPHIC CURVE.

Prof. Wagner's main effort is to show the errors of Heiderich's work, first by comparison with his own new planimeter measurements, and then on theoretical grounds from the consideration of the natural difficulties introduced in Simpson's formula. In the former task Wagner was able to confirm his own estimates of the area of the land in a very neat and satisfactory way by comparison with Karsten's measurement of the oceans in zones of 10°, and he had the satisfaction of finding that the two sets of figures when added together gave a near approximation to the calculated area of the zones. The nett result of the inquiry is to show that Simpson's formula to be satisfactory must be applied to narrower zones than 10°, and that means must be taken to ensure that the intermediate values, which have four times the weight of either extreme in the final result, are really typical of the whole intermediate region. But Prof. Wagner enters into the minutest criticism of Heiderich's work, detecting errors of calculation and of typography, and showing how the use of round numbers gives rise to fresh errors in the totals. The balancing of errors which produces a fair consistency in the final result is interesting, but we believe that it receives too

implies. Had Murray's measurements been made on maps of a much larger scale, contoured at the same intervals, the results would probably have been nearer Wagner's; but we must also remember that it is the stimulus to this particular study, given by Murray's work, which has, in the ordinary course of the advancement of science, furnished his critic with data superior to those possessed in 1888.

While in several places Prof. Wagner acknowledges that his figures are only approximations, with no claims to absolute exactness on account of the uncertainty of the data, it does not appear that he realises the magnitude of this uncertainty. In the first instance measurements, even on large scale maps, are so difficult that increased precautions almost always show different results. The best example is in the case of France, where the re-measurement on the plates of the 1:80,000 map in 1894 showed that the area of that country was 1·48 per cent. greater than had previously been supposed. Again, it must be borne in mind that outside Europe, India, and some parts of the United States, there is not a single continental coast-line the position of which can be taken as correct. Some coast-line has to be assumed, but, except on small-scale maps, the true position is not likely to lie within the thickness of the stroke which marks it, and deviation means change of area. Finally, we have the vast uncertainty of the utterly unknown Antarctic and Arctic regions, which are estimated by Wagner to amount to 16,000,000 and 5,000,000 square kilometres respectively, or together 4 per cent. of the whole earth's surface. In the face of all this uncertainty, does it not seem that only the balancing of errors can give an approximation to the truth regarding the areas of land and water; and that from the circumstances of the case, the fact that one set of estimates disagrees with another, independently made, is of small account? While every precaution should be taken to exclude errors of computation or of typography, it may be affirmed as a principle, that to subject uncertain data to a too rigorous discussion is waste of labour. Round figures alone can be justified for many a long day in estimating the areas of the earth's surface, and for longer still in estimating the volumes of oceans and continents.

The contour-lines on any ordinary map of a continent are only the roughest generalisation of the height, even when numerous points of altitude are fixed by exact levelling. But where a whole continent, like Africa, is measured for volume by the few barometer and boiling-point altitudes which have been taken by travellers of varying skill and in unknown meteorological conditions, the most laborious calculation can only be an elaborate guess. The temerity of the map-draughtsman in laying down the contour-lines of the oceans is justifiable as the expression of probability, not as any exact delineation. In the Atlantic they may indeed be guessed at with some confidence, but in the Pacific and Southern Oceans the mean depth might easily be hundreds of fathoms greater or less than is supposed from the scattered points which have been measured as yet.

It is right to guess at mean measurements, and to reason hypothetically from them, but there is a risk of men accustomed to critical rather than to practical work being misled against their knowledge by the firm lines of maps and the means of ingeniously grouped observations. That Prof. Wagner has obtained the best results possible by means of his calculations we recognise with sincere pleasure, but he has had the good, though naturally imperfect, work of others to start from, and a reader of his criticism might be led to disparage those workers but for whom the ambitious attempt to calibrate the earth's inequalities might have been postponed for another century.

For myself I gladly accept the new value of the mean-sphere-level as better than the avowedly rough guess which I hazarded six years ago. And although Prof. Wagner calls me "a friend of round figures," with a touch of rebuke in his tone, I shall still try to deserve the name in connection with such calculations until the improvement of geographical measurements justifies the use of decimals in percentages, and fifties of fathoms in average oceanic depths. HUGH ROBERT MILL.

THE WORK OF LOCAL SOCIETIES.

THE practical methods of modern biological research have been developed to such a high state of perfection since the introduction of the appliances of physics and chemistry, that the system of training in biology has within a comparatively short period undergone a complete revolution. As one result of this change the student is tempted from the fields and hedgerows, from the downs, heaths and woodlands, from the banks of streams, and from the sea-shore into the laboratory. He knows the structure of a certain number of "types," but he walks as a stranger among the living animals and plants that surround him. His knowledge is not of that kind attributed to the wise king who "spake of trees, from the cedar-tree that is in Lebanon, even unto the hyssop that springeth out of the wall: he spake also of beasts and of fowls, and of creeping things, and of fishes." The organism is to the modern student not a living entity having a beautifully adjusted relationship to its environment, but a complicated collection of tissues capable by appropriate treatment of being spread out into a panorama of thin slices. His acquaintance with the living plant or animal is of about the same kind as that which a chemist ignorant of mechanics would acquire by endeavouring to understand the working of a watch by making a chemical analysis of its wheels and springs. In brief, the extreme specialisation of laboratory work begins too early in his curriculum. Since the introduction of the system of instruction by "types," there has arisen an estrangement between the old school of field naturalists and the modern biologist—a result which was not anticipated by the founders of this system, and against which a healthy reaction, led by Mr. Thiselton-Dyer and others, is beginning to take place.

It is true that certain departments of biology have gained enormously by the introduction of modern methods, and it must also be admitted that some branches, such as morphology and physiology, are best dealt with in laboratory and dissecting-room. But at the same time it is to be deplored that the department which Prof. Ray Lankester has happily termed "bionomics" should be allowed to suffer by competition with the new methods. If biology has gained in some directions, it is certainly the case that as a subject for the scientific training of the observing faculties, it has suffered deterioration by leaving the field naturalist outside the pale. The latter, finding himself threatened with scientific excommunication, is driven into the pages of popular magazines, or writes books which, although often very pleasant reading, are painfully sterile from the purely scientific point of view, and most disappointing when the capabilities of the writers are taken into consideration. Between the cabinet systematist who studies nature in museums, on the one hand, and the laboratory worker, who ignores the animal or plant as a living organism, on the other hand, the student of the old school of natural history is being hard pressed to find a footing. In a country like ours, with its immense colonies and dependencies in every quarter of the globe, it is most regretable that our educational authorities do not recognise field natural history as a subject worthy of their most serious encouragement.

While the modern development of biological teaching has led to the result above indicated, the local societies of this country have, in an unpretending way, been doing good work by keeping alive the spirit of the old school of naturalists. There are now on the list of Corresponding Societies of the British Association sixty-three societies distributed over the United Kingdom.[1] All of these are more or less actively engaged in carrying on local observations in various fields of science, and their very existence is good evidence that there is a store of available energy in this country which is by no means a negligible quantity in estimating the scientific status of the nation. Field natural history forms a large part of the work of these societies, and this is certainly one of the directions in which every encouragement should be given by all who are interested in their welfare. Under field natural history would be included the collecting and recording of species so as to furnish materials for the compilation of local faunas and floras, observations on the habits and life-histories of individual species, the systematic recording of dates of appearance of species, &c., comprised under the general subject of phenological observations. The local societies have already done much work in these subjects, and much more remains to be accomplished. In connection with the collecting of specimens it might be well to point out that these societies can do an enormous service by discouraging on every occasion the unnecessary destruction of life—by teaching by precept and showing by example that the mere acquisition of specimens is not the end and aim of natural history work, and that when a typical collection has once been formed the needs of science have been met. Most particularly is the assistance of the local societies wanted in protecting the "lower orders" of the animal kingdom and the rare species of plants from the depredations of the "dealer" or the avarice of the collector, for while our birds are now likely to flourish under a beneficent Act of Parliament, it is impossible to make a public appeal to the argument from sympathy with sentient beings in the case of the invertebrate classes of animals, or in the case of the rare plants which still linger in unfrequented districts. These are cases fo appeal to scientific reason rather than to sentiment. Is it too much to hope that the societies in each district should approach the landowners on whose estates rare species are know to occur, and invite them to co-operate in 'securing the protection of our choicest forms of animal and vegetable life?

In many other directions is there scope for useful scientific work on the part of local observers.[2] In geology, for instance,

[1] The total number of members registered as belonging to these societies is nearly 24,000. It is of course difficult to arrive at the actual numbers, because the same member may belong to more than one society; but after making every allowance for such repetitions, it will be seen that the volunteer army of scientific workers is much stronger than has hitherto been realised.

[2] For some valuable suggestions with respect to meteorological work, see the address to the Conference of Delegates at the last (Ipswich) meeting of the British Association, by Mr. G. J. Symons, F.R.S., Chairman of the Conference.