days. The coordinates of the light curve of this variable are as follows:—

Days.		Mag.	Days.		Mag.
0·00	...	13·50	0·25	...	14·73
0·05	...	13·87	0·30	...	14·73
0·10	...	14·35	0·35	...	14·72
0·15	...	14·70	0·40	...	14·65
0·20	...	14·72	0·45	...	13·56

It thus appears that the star remains about minimum brightness during half the period, while the maximum luminosity is of relatively short duration; the decrease in light is rapid, and the rate of increase still more rapid. The succession of changes does not seem to correspond with those of any previously known class of variable stars.

RECENT RESEARCHES ON RÖNTGEN RAYS.

THE novelty of Prof. Röntgen's skeletal photographs has almost worn off, and the field of research opened up by his observations is now mainly occupied by scientific workers, who are endeavouring to analyse the rays, and to extend the knowledge of their characteristics, rather than to produce startling pictures capable of exciting the wonder of the general public. But though the interest of scientific dilettantes has waned, the investigators who remain in the field are still so numerous that it is hardly possible to keep in touch with the multitude of observations published; and published in some cases, perhaps, a little prematurely. A number of interesting results have been recorded from time to time among our "Notes"; but so many papers and communications have been received during the past few days, that they are now brought together for readier reference, as has been done in several previous issues of NATURE.

Attempt to Polarise Röntgen Rays.

Dr. John Macintyre, whose observations on the capabilities of Röntgen rays have formed the subject of several letters and notes in these columns, has sent us an account of an attempt to polarise the rays. Different views have been expressed about the possibility of polarising the rays by means of tourmalines, and although Dr. Macintyre's experiments seem to indicate a negative result, they are of such importance that they deserve to be put on record.

The source of electricity was the main, and the measurements across the terminals (with Lord Kelvin's cell-tester and ampere gauge) were 10 volts and 10 amperes. The spark of the Rhumkorff coil was 6 inches, and a mercury interrupter was used. An ordinary Crookes' focus tube, enclosed in cardboard to exclude all light, was excited by the above, and the vacuum carefully arranged to give the maximum fluorescence by gently heating the bulb with a spirit-lamp. Screens of barium platino-cyanide, potassium platino-cyanide, and lithium-rubidium-platino-cyanide were tried. The two tourmalines were got as nearly alike as possible, the measurements of each being: length, 47 mm.; breadth, 12 mm.; thickness, 2 mm.; and the experiments were carried out in a dark room.

In the first experiment, on placing one tourmaline between the source of the Röntgen rays and the screen, and directly in contact with the latter, a distinct shadow was seen due to absorption of the rays. On placing the second tourmaline parallel with the first, a difference in density of the shadow was immediately observed. When the tourmalines were gradually turned at right angles to each other, a dark square area could be seen where the two crossed. A source of error was, however, suggested in this experiment. One of the tourmalines could not be in as close contact with the screen as the other; and on account of the manner in which the Röntgen rays pass from a point on the platinum plate in such a Crookes' tube, differences were observed in the shadows of the four arms of the cross formed by the tourmalines. For example, (1) if the horizontal tourmaline were next to the screen, and the vertical one behind it, the two arms above and below the square dark central area were less sharply defined than the two arms on each side of it, and consequently the shadows appeared to be different. (2) Although on the square portion corresponding to where the tourmalines crossed, one got a darker shadow still, it might only be due to the difference in thickness of the two layers.

A second observation was then made. One of the tourmalines was broken in two portions, and one of these was placed parallel with and the other perpendicular to the other tourmaline. Again the dark square area was seen by direct vision. Dr. Macintyre could not say, however, that the density was greater than where the other portion of the broken tourmaline was laying parallel with the whole one. This rather suggested that the square dark area was caused by difference of density only. In a third series of observations photographs were taken with different exposures—one with a single flash of the tube, due to one interruption of the coil; others with much longer exposures, but in all the same difficulties in distinguishing between the two conditions arose. (Copies of these photographs have been received from Dr. Macintyre.) In the first photograph a shadow of one tourmaline was obtained, proving the absorption of some of the Röntgen rays. In the second photograph, of one whole tourmaline and a portion of the other, a greater density can be noted where two layers are lying parallel with each other than where only one tourmaline interferes with the rays. The third photograph shows the unbroken tourmaline covered at one part by a portion of the broken tourmaline lying parallel with its axis. The other part of the broken tourmaline is placed at right angles, and Dr. Macintyre raises the question whether the density of the square area is greater than where the two tourmalines are lying parallel with each other. In his opinion, the photographs bear out the observations by direct vision, and appear to give negative results; and an examination of the two photographs which form the result of his crucial experiment, leads us to conclude that there is not any appreciable difference of brightness between them.

Röntgen Rays and the Resistance of Selenium.

Mr. J. W. Giltay, Delft, Holland, has sent us the following important communication on the influence of Röntgen rays upon the resistance of selenium.

Some weeks ago, the possibility of Röntgen rays having an influence on the resistance of selenium occurred to me. I made a preliminary experiment to put this idea to the test, but, probably owing to the poor state of my induction coil, I failed to get any effect. Want of time prevented me from trying again with another coil.

I told my failure to Prof. H. Haga, of Groningen University, who kindly undertook to investigate the subject. The selenium cell I made for him was of the Shelford-Bidwell type (NATURE, November 18, 1880), the working surface was 20 × 44 mm. The resistance of this cell was in darkness 31,600 ohms, in diffuse daylight it was about 15,300.

Prof. Haga with this cell got the following results, which I publish in this letter with his full approval.

The Crookes' tube he used was of the ordinary pear form (not a focus tube), and highly evacuated, giving undoubtedly a very strong Röntgen effect. The induction coil was one of Ruhmkorff's, of a length of 60 cm.; the battery for driving the coil consisted of five accumulator cells.

The distance between the selenium cell and the under part of the tube was 3 cm. The cell was covered with pasteboard, and over this was laid a thick sheet of zinc. The resistance of the cell was now measured by the bridge method, one dry cell acting as the battery, contact being of course made only momentarily. The resistance in the dark was found to be 31,600, as I remarked before. Now the induction coil was started and worked during just one minute; the resistance of the cell was then immediately measured again, and found to be exactly the same. This proved the wires carrying the induced currents and the coil itself to have no influence on the cell.

Now the zinc plate was removed and replaced by two thin aluminium sheets (two instead of one, to prevent heat rays falling on the cell). The coil was now worked during one minute, and immediately after stopping it the resistance of the cell was taken. This was now found to be 26,400.

The resistance was not measured *during* the radiation, else it would probably have been found to be a little less than 26,400, but immediately after the coil having been stopped. The measuring of the resistance took about one minute. After having left the cell at rest during 20′, the resistance had risen to 29,500 again.

Prof. Haga made several experiments, always with the same qualitative results.

A simple kind of bolometer, consisting of strips of tinfoil (11·85 Ω) did not show any change of resistance by Röntgen radiation.

It follows from these experiments of Haga's, that Röntgen rays act on the resistance of selenium in the same way as light and heat rays do. I think selenium will be found to be very useful in investigating the opacity of different substances for the Röntgen rays, and also for experimental work on the polarisation of those rays, as the deflection of a galvanometer is much easier to appreciate than the value of the photochemical action of the rays. It also follows from these experiments, that selenium is a very unfit material for making photometers.

It must always be kept in mind, when working with selenium, that the cell takes very little time in diminishing its resistance under the action of light, or other rays, but that it takes a much longer time (often half an hour or so) to return to its state of high resistance. It follows from this, that if one wishes to compare the action of two emissions, one must begin with the feebler radiation and afterwards let the stronger radiation hit the cell.

The Nature of Röntgen Rays.

The nature of Röntgen rays is so far from being settled, that the following remarks by Prof. W. N. Hartley, in favour of the ultra-violet theory, will be read with interest:—

The great doubt which prevails as to the nature of Röntgen rays arises from the fact that it is difficult to imagine radiations which make their existence manifest in a manner which, at first sight, appears very extraordinary.

Their intractability to the action of ordinary refractive media, and the facility with which they are transmitted by matter which has the property of absorbing light, has led to their being regarded as being propagated by vibrations differing in direction from those of other known forms of energy. I have given expression to the view on more than one occasion that they are simply ultra-violet radiations of much greater oscillation frequency than any we have yet been able to recognise and manipulate with prisms and lenses. The following comparison of the properties of the ultra-violet with those of the Röntgen rays are my reasons for this view:—

(1) Ultra-violet rays can be reflected and refracted.
(2) They are capable of energetic chemical action.
(3) They cause fluorescence.
(4) They facilitate the discharge of electricity through air.

(1) The Röntgen rays can be reflected, but have not hitherto been refracted.
(2) They cause energetic chemical action.
(3) They cause fluorescence and also phosphoresence.
(4) They cause the discharge of electricity through a non-conductor.

The ultra-violet rays are also subject to energetic absorption, which increases with the molecular mass of the absorbing substance in certain cases, but is dependent upon molecular structure in other instances. Röntgen rays are also absorbed energetically by some substances, and the absorption appears to be dependent upon the molecular mass of the absorbing medium, but in other cases it appears to depend upon what is probably molecular structure. Both the ultra-violet and Röntgen rays are revealed to us by their action on a photographic plate and on fluorescent substances, or rather substances which they render fluorescent.

The ultra-violet rays excite fluorescence in almost all substances, and with very remarkable effects in many cases (*J. Chem. Soc.*, vol. clxiii. p. 247, 1893). The effect of substances on the rays which enter them is to retard their rate of vibration. By retardation the length of the waves is increased to dimensions which bring them within the limits of visibility, and the result is either fluorescence or phosphorescence. This is usually expressed by saying the rays are lowered in refrangibility. It is quite probable that we may soon have evidence of refraction of Röntgen rays. They are undoubtedly reflected, since Jackson has shown that the most effective form of Crookes' tube is one in which a plate of platinum at an angle of 45° reflects the rays through the side of the vessel (*Proc. Chem. Soc.*, March 6, 1896).

Röntgen rays are in all probability of the same character as the ultra-violet rays; they produce the same effects, and no other rays are known to do this, except such as are of the same character and are capable of being "lowered in refrangibility," or retarded But it is evident that they must be of much greater oscillation frequency, or what amounts to the same thing, of much shorter wave-length than any which have hitherto been studied with lenses and prisms of rock-crystal or fluor-spar.

Mr. Jackson has declared his adherence to the belief that they are propagated by transverse, and not by longitudinal, vibrations (*J. Chem. Soc.*, vol. clxv. p. 734, 1894; also *Proc. Chem. Soc.*, March 6, 1896).

I have been induced to place these remarks on record, because in NATURE (p. 45) there appears an abstract of a paper in *Wiedemann's Annalen*, by D. A. Goldhammer, which renders it evident that from other considerations he is of the same opinion. He points out that the peculiarities of Röntgen rays are not inconsistent with transverse vibrations of very small wave-length. His reference to the absence of reflection appears to be not strictly accurate, so far as one may judge from the words of the abstract; but it is not fair to draw conclusions from an author's views without regard to his *ipsissima verba.*

Analysis of Röntgen Rays.

Mr. T. C. Porter, of Eton College, appears to have made an interesting discovery in connection with the Röntgen rays, viz. that they are of at least two different kinds. We print in full a preliminary account of the experiments which have led to this conclusion, with the remark that the photographs received just as we go to press entirely bear out the description.

A Röntgen tube (Newton and Co.'s and Griffin's focus tubes have been used in these experiments) emits two different kinds of rays. To one kind, which I venture to call X_1, flesh is fairly transparent, and bone opaque; to the rays of which this is a preliminary account, which will be called hereafter X_2, flesh seems nearly, if not quite as opaque as bone. Under ordinary circumstances, in the cold, using an induction coil ($3\frac{1}{2}''$ spark) and somewhat rapid hammer contact breaker, most, but not all, of the rays are X_1; but if the tube be heated, less and less of X_1 are emitted and more of X_2 until the fluorescent screen (mine is one of Messrs. Reynolds and Branson's, of Leeds, bright yellowish green in colour, and apparently of uranium glass, though of this I am not sure) shows the shadow of a hand held behind it sharply defined and very dark all over, *the bones not being visible.* The back of the screen is covered with a layer of very opaque (to ordinary light) thick black paper. Up to a certain temperature the green fluorescence of the glass of the tube increases very markedly, but the X_2 rays do not come from it, as the sharpness of the shadow shows; nor are the X_2 rays ordinary kathode rays, for the same discharge sent through a highly exhausted Crookes' tube showing "independence" of the positive pole failed to excite any fluorescence whatever on the screen, though the glass of the tube was fluorescing brilliantly opposite the concave kathode, and the violet cone of rays within the tube was plainly visible. At a certain temperature, judging from the fluorescence on the *screen*, the emission of these X_2 rays reaches a maximum, and on further heating the emission of any rays whatever capable of exciting fluorescence or photographic action falls off rapidly, though, so far as my experiments have gone, *some* fluorescence and photographic action have been plain up to the highest temperature to which I judged it wise to heat the tube. Wood and paper seem very fairly transparent to the X_2 rays, but glass seems very opaque, aluminium much more opaque than to the X_1 rays, judging by the following experiment, which shows best the existence of these radiations and their difference from the X_1 radiations.

A "Röntgen" whole plate was wrapped in two thicknesses of the black paper generally used for the purpose, and supplied with the plates by the Sandell Plate Co., and brought in darkness into the room for experiment, lit dimly by a single candle at some distance from the place where the plate was to lie. The plate was then laid film uppermost (still, of course, wrapped in the black paper) six inches below the exhausted tube (the latter placed in the usual position). A piece of plate-glass, one-third of an inch thick, was then laid over half of it, and a left hand laid on the other half, together with a piece of a small aluminium tray, and exposure was made for one minute with the exhausted tube cold (16° C.). The paper over the exposed half was then marked for the purpose of recognition; this half was then covered with the glass, to protect it from any further action, and the photographic plate turned in its own plane through 180° about a vertical axis, to enable the operator to place his hand on the other half in exactly the same way as at first. The tube was then heated with a spirit-lamp giving a large flame for about forty-five seconds, and, the left hand being in position, the current was switched on for one minute; at the end of this time the appearance of the discharge in the tube showing that the latter was growing cold, the current was switched off, the spirit-lamp again applied to the tube with the right hand, the operator's left hand being kept rigidly in position over the plate, then the current put on again for a minute, and so on, the spirit-lamp and current alternately, till six and a half minutes' (the current at the last time ran a minute and a half) exposure had been given. The plate was then removed and developed uncut, with a hydroquinone developer, with the result that *whilst the far denser background of the last exposed half of the plate showed that it had received by far the greater amount of radiant energy* from the heated tube during its six and a half minutes' exposure, only the very faintest traces of the bone shadow could be made out in the very bold shadow of the flesh of the fingers; and on the other half, which had received but one minute's exposure to the cold tube, images of the bones were very clearly shown. This experiment proves that the radiation received from the hot tube resemble the rays hitherto called X rays (which I have called X_1) in being able to pass through paper opaque to ordinary light, but differ from them in being unable to pass through flesh, and in other ways, an account of which must be postponed for a short time. The effect of *cooling* the X-ray tube is being investigated.

I have spoken of these rays as a new *kind* of X rays. They may be related to the X_1 rays in the same kind of way as red is related to violet light, and if so are not essentially different. Hence I could think of no better nomenclature than to retain the letter X for them, and call them provisionally X_2; but *if they have the power of penetrating aluminium at all*, they certainly act in some respects so differently from the X_1 rays, that one might feel inclined to suspect them of some greater difference than the fluorescent and photographic experiments indicate.

Plant Structure Revealed by Röntgen Rays.

Mr. George J. Burch sends the following account of experiments from the University Extension College, Reading:—

Since February 13, I have been engaged, in conjunction with my colleague Mr. Dodgson, and Messrs. Herbert, Hooper, Soper, Twiney, West and Yetts, in a series of experiments with Röntgen rays. In investigating the influence of colour upon the relative opacity of certain substances, it occurred to Mr. West to compare a purple hyacinth with a piece of purple glass which had proved remarkably opaque. I found upon development that details of the structure of the flower were distinctly visible. Following up this clue, we have photographed a number of flowers with the Röntgen rays. By suitably arranging the exposure and the development, we can show the ovules inside the ovary in an unopened bud, the seeds within a seed vessel, and even the veins upon the white petal of a flower.

Apparently these results are due to refraction and reflection of the rays when the incidence is sufficiently oblique. Similar indications are visible in a photograph of a fish's eye prepared by Mr. Yetts, in which there is a narrow dark shadow that can only be due to internal total reflection. The feathers are seen in a bird by Mr. Soper, and a foot, developed by Mr. Herbert, shows the fabric of the stocking.

I am directing the experiments with the view of photographing the soft tissues of the human body.

A Photometer for Röntgen Rays.

All those who have had occasion to use Crookes' tubes to produce Röntgen rays will have noticed the extraordinary variations in the intensity of the radiation produced by an apparently trifling change in the vacuum and the make and break of the coil. A useful step towards some quantitative measurement of the intensity of Röntgen rays has been made by M. Meslin, who, in the current number of the *Journal de Physique*, gives an account of a photometer for the rays. The principle on which this photometer depends is the matching of the brilliancy of the two halves of a circular patch of barium-platino-cyanide, one half being rendered fluorescent by Röntgen rays, and the other rendered fluorescent by the light rays proceeding from some standard source, such as a candle or lamp. The light is passed through a coloured glass, so that the fluorescence produced has the same tint as that produced by Röntgen rays. The author finds that the barium-platino-cyanide, under the influence of Röntgen rays fluoresces with a light of such a colour that the maximum brilliancy occurs for a wave-length of about $0{\cdot}500\,\mu$. The barium-platino-cyanide fluoresces most strongly when exposed to light having a wave-length of about $0{\cdot}460\,\mu$. By means of this arrangement the author has been able to verify the law that the intensity varies inversely as the square of the distance, the following numbers being obtained:—

Distance of photometer.	mm.	mm.	Quotient.
From luminous source	350 ...	410 ...	0·853
From source of Röntgen rays	54 ...	63 ...	0·857

The Fluorescence of Photographic Plates.

As recently stated in NATURE (*ante* p. 62), it is well known that a photographic dry plate exhibits fluorescence when Röntgen rays fall upon it. With reference to this, Mr. Shelford Bidwell believes the seat of the fluorescence appears not to be in the sensitive film, but entirely in the glass support. Writing under date May 27, he says:—

I find that bromide, iodide and nitrate of silver do not by themselves show the slightest trace of fluorescence, neither does photographic gelatine; bromide paper and coated celluloid sheets are also quite invisible under Röntgen radiation. On the other hand almost any specimen of glass will, with a good tube, fluoresce sufficiently to show coins in a purse &c.; indeed, some of the pieces that I tried happened to be more efficient than any of the ordinary dry plates that were at hand.

No doubt certain photographic plates—possibly those used by Mr. Walker—are for special purposes prepared with fluorescent substances, and it is not surprising that such should fluoresce more strongly than others.

Miscellaneous Observations.

From the *Sitzungsberichte der Kaiserlichen Wiener Akademie* we learn that Prof. G. Jaumann has investigated the deviation of kathodic rays produced by electrostatic force. The rays follow the lines of electrostatic force, and such forces produce a strong deviation in the rays. This deviation is a temporary effect, which is soon brought to an end by the lengthening of the rays. Simultaneously with this electrostatic deviation of the kathodic rays, considerable variations take place in their intensity.

The similarity between the effects of Röntgen rays and of ultra-violet light on electrified bodies, forms the subject of a paper communicated to the Academy of Bologna by Prof. Augusto Righi, in which the author considers the influence of the pressure of the gas surrounding an electrified body on the discharge of its electrification produced by these rays. It appears that, under similar conditions, the critical pressure (that is the pressure of the gas corresponding to the maximum leakage) is greater for Röntgen rays than for ultra-violet rays. But the final charge of a conductor exposed to Röntgen radiations was found by Prof. Righi to increase with diminishing pressure of the surrounding air precisely as occurs when ultra-violet rays are brought into action instead. In another paper (*Atti R. Accad. Lincei*), the same writer dissents from Prof. J. J. Thomson's opinion that every dielectric becomes a conductor when it is traversed by Röntgen rays. Prof. Righi is of opinion that it cannot be considered as proved that a *non-gaseous* dielectric is rendered a conductor when it is traversed by these rays.

While recently experimenting with a Crookes' tube, Prof. Francis E. Nipher observed that the circular aluminium disc of the kathode became slightly loose on the aluminium wire, and that it was constantly rocking in rotary motion on the wire. After several days of use, during which it had been decided to construct a tube with discs capable of rotation, the kathode disc suddenly became loosened, and began to rotate slowly on the wire as an axis. The direction of rotation was contrary to the hands of a clock, when the disc was viewed from the point where the kathode wire pierces the wall of the tube. When the loose disc was made the anode, no tendency to rotation was observed. Up to May 4, when Prof. Nipher read a paper on the phenomena before the St. Louis Academy of Science, all attempts to produce the effect in air of ordinary pressure had failed. The experiment seemed to form a basis for imposing a term representing a rotation into the equations for force and potential within a wire conductor; but in a letter received a few days ago, Prof. Nipher suggests that a circular or elliptical vibration of the kathode wire might possibly account for the rotation of 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.